The UK Forestry Standard

The governments' approach to sustainable forestry

Forestry Commission
Scottish Forestry
Coilltearachd na h-Alba
Cyfoeth Naturiol Cymru
Natural Resources Wales
FOREST SERVICE

4. Forests and Climate Change

Climate change is one of the greatest challenges facing the world today and there is mounting evidence that it could create substantial, abrupt and irreversible impacts on our environment. The UKFS response to climate change is through both mitigation (establishing new forests and managing existing forests and wood products in a way that enhances their potential as a sink of greenhouse gases) and adaptation (reducing the vulnerability of forests and using forests to increase society's resilience to climate change). In other words, long-term climate change mitigation is not possible without short-term adaptation. Forest managers must plan and implement changes as a matter of urgency to adapt their forests in the context of rapid climate change.

Carbon in forests

Forests play an important role in the global carbon cycle, accounting for almost three-quarters of the annual exchange of carbon between the land and the atmosphere. Sustainably managed forests perform a vital role as carbon stocks and sinks, and are an important means of removing carbon dioxide from the atmosphere (Figure 4.1).

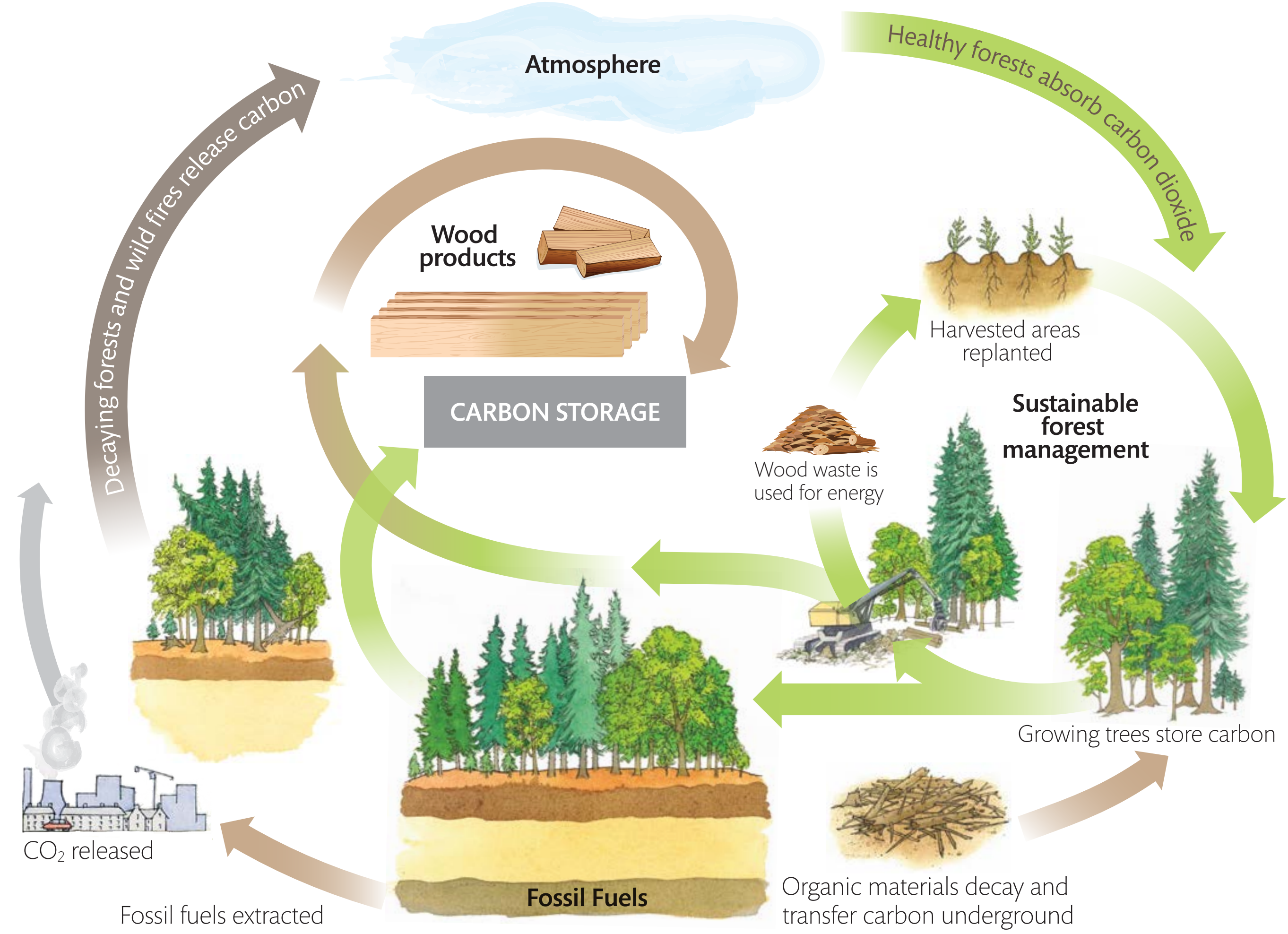
A particular carbon balance may be described as a 'sink' if there is a net transfer of carbon from the atmosphere. Combined, forest biomass and forest soils and litter contain more carbon than the atmosphere. Carbon in forest soils is particularly important as a greater proportion can be stored here than in the tree biomass, especially on peat-based soils. However, the accumulation of carbon by a forest can be lost through natural disturbances such as storms, floods or fire, and through the removal of material during management such as thinning or harvesting. If these natural and managed carbon sinks were lost as a result of forest degradation or climate change, the rate of accumulation of carbon dioxide in the atmosphere would rise dramatically.

Climate change mitigation

Forests capture carbon and store it as a component of wood itself (in stems, roots, branches and twigs), and this is a key mitigation measure of the UKFS. Over time, forests can also slowly enrich the soil carbon content through the addition of organic matter from leaf, seed and fruit litter, branch fall, root exudates and root death. It follows that the rate of carbon capture is closely related to the growth rate of the trees, and UK forests are among the most productive in northern Europe. However, the amount that is captured and stored depends on planting rates and management as well as the impacts of climate change, and on the number of trees being thinned or harvested. Sustainable forest management, which includes harvesting to transfer carbon from the forest to wood products and the regrowth of the forest, will maintain net carbon uptake.

In general, forest soils that experience low and infrequent levels of disturbance, particularly when managed under a LISS such as continuous cover forestry and for a given soil type, will have a higher total carbon content per unit area than agricultural soils. Some forest operations, such as ground preparation to establish trees, may result in a short-term loss of

Figure 4.1 The role of forestry in the carbon cycle.



Carbon released
Decaying vegetation and trees and forest fires release stored carbon into the atmosphere. In addition, human activities that use energy in the form of fossil fuels – for example transport and manufacturing – generate carbon dioxide which is released into the atmosphere.

Carbon absorbed
Sustainable forest management is an effective way to store carbon. Young, healthy forests absorb carbon more rapidly than older, dense forests.

Carbon stored
Carbon is stored in the trunks, branches and roots of trees as they grow. Sustainably managed forests continuously store carbon over long time periods. Carbon continues to be stored in wood products after trees are harvested. Harvested forests are replanted and the cycle begins again.

carbon from the soil until this is replaced as forests grow. The aim of the UKFS is to minimise short-term losses while recognising that some level of disturbance is necessary for successful establishment and management, which will go on to deliver the benefits of carbon capture over the longer term.

In addition to carbon sequestration, forests contribute to climate change mitigation by providing a source of renewable energy and sustainable wood products that continue to store carbon. Carbon comprises about 50% of the dry weight of wood. Timber and wood products can be used for a variety of purposes, and the longer they remain in use, the longer the carbon is stored.

Carbon substitution benefits also arise when wood is used as fuel instead of fossil fuels such as coal, gas or oil. Although burning wood generates carbon dioxide, an equivalent amount of carbon dioxide was relatively recently sequestered from the atmosphere as the trees grew. Trees planted specifically for use as woodfuel and managed on short rotations can provide a substitute for fossil fuel over a shorter timescale than conventional forests, but may not provide as wide a range of other benefits such as biodiversity and recreation.

Standards for carbon sequestration

The Woodland Carbon Code is a standard in the voluntary carbon market for UK woodland creation projects that make claims about the carbon they sequester. It sets robust standards for carbon accounting and management in addition to the sustainable forest management practices set out in the UKFS, and it facilitates payments for provision of the ecosystem service of carbon sequestration. Projects that comply with the Woodland Carbon Code directly help the UK to meet its targets for both woodland creation and reducing greenhouse gas emissions.

There is also the UK Peatland Code, a voluntary standard for UK peatland projects that provides a mechanism for private investment to reduce emissions from peatlands through restoration projects.

Climate change adaptation

Improving the resilience of forests is key to climate change adaptation. However, in developing resilience, a balance is required to ensure that, as far as possible, the integrity of existing ecosystems is maintained.

As the natural distribution of tree, plant and animal species changes, it is likely that regional differences in adaptation measures will be required. Thought should also be given to the prevailing risks at specific sites. This could include an increased frequency of drought at some sites or an increased risk of flooding at others. As well as using an appropriate choice of tree species and origin, improving the connectivity of existing forests through woodland creation and developing and maintaining a range of tree ages, classes, and diversity in canopy structure can increase resilience to climate change. These measures will also develop the management flexibility required for forests to thrive in a changing environment.

Further information is given in the UKFS Practice Guide *Adapting forest and woodland management to the changing climate*.

Climate change projections

The climate is changing already and projections suggest that we should prepare forests for an increase in mean temperature in the long term. Temperatures of 40°C were experienced for the first time in the UK in 2022 and it is likely that this temperature will be reached more frequently in the future. Summer rainfall is projected to decrease, potentially making summer droughts more frequent and severe, and winter rainfall is projected to increase, extending the duration of winter waterlogging. Flooding is projected to become more severe, alongside increasing windthrow, soil erosion and the frequency of landslips.

Impacts on tree growth and forest productivity

Carbon dioxide has a direct impact on tree function and forest productivity, as well as being the most significant greenhouse gas. An increased concentration of carbon dioxide in the atmosphere stimulates photosynthesis and is likely to result in an increase in growth rates and leaf area. Other changes in the atmospheric environment may also have impacts, including changes in nitrogen and sulphur deposition and increased levels of ozone pollution. There will be a number of new and indirect effects on forests through changes to the frequency and severity of pest and disease outbreaks, increasing populations of mammals that may do damage, and the impact of existing and new invasive species. Planning for uncertainty is therefore the key consideration when developing approaches to adaptation, especially in the case of the long timescales associated with forest management.

An increased frequency and severity of summer drought is likely to represent the greatest threat to forests from climate change. Drought is already a problem on shallow, freely draining soils, particularly in the southern and eastern areas of Great Britain, and there is a very high likelihood that this will cause serious impacts on drought-sensitive tree species. These impacts will be widespread in established stands, so that the suitability of species for use in commercial forestry in all regions will need to be reassessed.

UKFS Requirements for Forests and Climate Change

Climate change mitigation

The climate change programmes operating within the UK seek to encourage activities that will reduce greenhouse gas emissions while allowing sustainable economic development to proceed. This approach is reflected in these UKFS Requirements, which aim to protect and extend the carbon resource in the forest environment over the long term, as well as the carbon stored in wood products.

A long-term view of the forest carbon stock (e.g. beyond the first rotation, when trees are being grown for timber) is important and recognises that short-term losses of carbon stocks associated with forestry operations, such as thinning, felling, site preparation and civil engineering, may be countered by gains over the rotation.

1 Woodland creation and forest management should contribute to climate change mitigation through the net capture and storage of carbon in the forest ecosystem and in wood products, through appropriate management objectives.

Climate change adaptation and protection

Based on the science and evidence of climate change impacts, there now needs to be a sense of urgency about implementing adaptation measures. It is essential that the risks and opportunities presented by climate change for forestry and achieving management objectives are accounted for in forest management plans. Risks include tree mortality, fire, drought, extreme weather events, and pest and disease outbreaks. Opportunities include potential increases in productivity and the range of species that can be grown. Forests can help people, society and the economy adapt to climate change by providing a range of benefits such as natural flood management, slope stability and the control of soil erosion, shade and reduced temperatures in urban areas, shade and shelter for livestock, and shade over watercourses to reduce the occurrence of lethal high water temperatures for fish.

Knowledge about the impacts of climate change on forests is likely to change over time, and so forest owners and managers will need to base decisions on the available evidence and advice on good practice. Guidance and a framework for forest adaptation is provided in the UKFS Practice Guide *Adapting forest and woodland management for the changing climate*.

2 Forests should be planned, created and managed to enhance their resilience and mitigate the risks posed to their sustainability by the effects of climate change or by pests and diseases.

3 Woodland creation and forest management should enhance the potential of forests to help society and the environment adapt to the various effects of climate change at the forest management plan review stage or earliest opportunity.

UKFS Guidelines on Forests and Climate Change

Mitigation

Forest expansion enhances the capacity for mitigation and is a principal consideration in addressing climate change through forestry. Furthermore, forest management can contribute to climate change mitigation by:

- managing for products used in place of fossil fuel-intensive construction materials;
- managing for woodfuel to substitute for fossil fuels;
- maintaining and enhancing carbon stocks in forests and their soils;
- managing risks such as wind, drought, fire and damage from pests and diseases.

Carbon in forest products

In general, the faster a forest grows, the more carbon dioxide it sequesters from the atmosphere. Management intervention (such as thinning and felling) maintains high rates of growth and carbon capture. Although wood will be removed from the forest, the accumulated carbon is retained in the timber products, particularly in those that last a long time. Using timber as a substitute for fossil fuel-intensive materials such as concrete and steel also contributes to climate change mitigation.

Woodfuel is a valuable substitute for fossil fuels, such as coal, oil or gas, as a source of heat or electricity. It may be grown specifically as coppice crops and short rotation forestry, or it can be an additional product from forest management or arboricultural work. Markets for woodfuel are continuing to expand and can provide a source of revenue to help support forest management that would not otherwise be undertaken.

Both forest residues (brash) and tree stumps can be considered as a source of woodfuel. However, their harvesting and removal can have negative and unsustainable effects. The removal of such material can deplete the site of its fertility, particularly in the case of brash, where many of the recyclable nutrients are found. Moreover, when stumps are removed the overall carbon benefit of the operation is unlikely to be positive due to the energy expended in their extraction and transport and from the release of carbon from soil disturbance. These practices can therefore only be considered sustainable on a limited number of sites, where it can be demonstrated that the nutrient status will be maintained, there will be a net carbon gain from the activity over the forest cycle, and the soil is not classified as at high risk of acidification.

1 Where forests are managed for timber production, maximise carbon sequestration through effective management, consistent with the storage and substitution benefits of wood products.

2 Consider the potential for woodfuel and energy crops within the sustainable limits of the site.

Carbon in forest ecosystems

Deforestation is a major source of carbon dioxide emissions and the protection and expansion of forest cover is a global priority in mitigating climate change. The whole ecosystem is a store of carbon, and it is important to consider management implications for all forest carbon, including the underlying soils, which often contain more carbon than the trees.

The highest sustained levels of forest ecosystem carbon are found in ancient woodland, mature woods managed for conservation and forests managed for continuous cover. Standing and fallen deadwood provides a vital element of ecosystem carbon, and actions to remove forest residues for woodfuel have to be carefully balanced against the benefits of retaining them for ecosystem carbon storage. It follows that any controlled burning of forest residues for forest management reasons diminishes forest ecosystem carbon and returns carbon dioxide to the atmosphere without the compensatory gains from their use as substitutes for fossil fuel. Formal woodland carbon projects, such as those set up under the Woodland Carbon Code, are managed in line with an approved forest management plan. Adherence to this plan ensures that the agreed level of carbon benefit is delivered.

There is a general presumption against the removal of forests across the UK. Net deforestation would reduce the capacity to sequester carbon and is counter to several international commitments on retaining forest cover. Where deforestation is proposed, an EIA is likely to be required.

3 Woody biomass should not be removed from an approved woodland carbon project unless this is part of the agreed forest management plan.

4 Conserve and enhance forest carbon stocks in the medium and long term.

5 Retain or expand the forest area and, when required, undertake compensatory planting where forest area is lost through land use change.

6 Ensure woodland creation proposals are appropriate for the site and designed to be resilient to the effects of climate change.

Operational carbon footprint

Forest operations are mostly mechanised and (through fossil fuel use) emit greenhouse gases. However, the overall emissions associated with forestry operations are small (equivalent to 2% of the carbon sequestered by UK forests). Emissions of greenhouse gases in forestry operations are also far lower than for other productive land uses. Although they are small, reducing these emissions will reduce the operational carbon footprint and help mitigate climate change. For example, sustainable biofuels could be used instead of fossil fuels for machines and vehicles. Another source of greenhouse gas emissions is timber haulage, so shorter haulage distances to local markets and the use of rail and sea transport as an alternative to road will reduce emissions.

Energy-efficient forest buildings constructed from wood instead of less sustainable materials, and the use of renewable energy sources instead of fossil fuels, will all contribute towards reducing the operational carbon footprint of the forestry sector. Within the forest itself, minimising high energy inputs, including fertilisers and pesticides, will also minimise the operational carbon footprint. Forests can also provide sites for other sources of renewable energy generation such as wind and hydro power.

7 Plan forest operations, civil engineering and timber transport to minimise energy use.

8 Consider the use of timber for the construction of forest buildings and recreation infrastructure.

9 Consider the energy efficiency of forest buildings and the efficient management of waste, and how renewable energy might be used or generated by the forestry business.

Adaptation

Forest planning and adaptive management

Forests can help society and the environment adapt to the impacts of climate change, particularly by alleviating flooding, controlling soil erosion and moderating temperatures in towns and cities, rivers and streams. These aspects of adaptation should be considered in the design and location of new forests and individual trees, as well as the management of existing forests.

Adapting to climate change is an element of sustainable forest management that is best addressed within the broad scope and long time frame of a forest management plan and the management that follows. However, based on the science and evidence of climate change impacts, there now needs to be a sense of urgency about implementing adaptation measures, and a flexible, reactive and anticipatory approach to management.

Ensuring a forest is diverse in terms of age, structure, species and origin, genetic diversity and choice of silvicultural system is likely to give forests greater resilience to the changing climate and should also keep a wide range of forest management options open. Regular monitoring will provide an early warning of potential problems in relation to climate change. For small wooded areas, published trends and associated guidance may suffice, but for larger forests some form of monitoring will help inform management decisions.

Some of the management decisions that may need to be reviewed in response to changing climatic conditions are the:

- **Planting season** – in response to changes in dormancy and water availability;
- **Choice of species and mixtures** – in relation to the changing climate and impacts of pest and disease outbreaks;
- **Thinning regime** – in relation to wind, drought and disease risks;
- **Rotation length** – to reflect changing wind risk and growth rates;

- Timing of operations – to avoid interfering with vulnerable life-cycle stages of protected species and to protect forest soils;
- Mammal control – of deer, grey squirrels and other invasive species that threaten regeneration and growth.

LISS such as continuous cover forestry encourage structural and species diversity and evolutionary adaptation by promoting natural regeneration. Such management systems can also make forests more resilient to wind damage as there are always areas of established young trees should windthrow affect the canopy. Not all forests can be managed under a LISS, but there are still opportunities for adaptation within clearfell systems.

The future climate may include more extreme weather events, and contingency plans will be valuable in the event of fire, wind or the outbreak of pests and diseases. A range of decision support tools are available to assist with forest planning. Changing rainfall patterns, indicated by the UK Climate Projections of the Met Office, will be relevant to operational planning, including the design and specifications of forest roads, culverts and bridges to ensure appropriate forest drainage and that infrastructure releases water slowly after heavy rainfall.

The potential for fire is a particularly important consideration in the context of climate change as it can lead to uncontrolled release of carbon from the forest ecosystem and may result in forest loss. Fire risk is currently highest in areas with high recreational pressure, in young trees, in forests with accumulations of dead vegetation, and in areas adjacent to heathland or where moor (muir) burning takes place. The risk of fire needs to be assessed in the forest management plan; it can be reduced through forest design, for example, by introducing diversity in age classes. Contingency plans in the event of fire will help ensure that damage is contained should it occur.

10 Ensure management and contingency plans address the impacts of climate change.

11 Consider projections of changes to rainfall patterns when specifying designs for culverts, drainage systems and roads, to ensure they have sufficient capacity to manage increased volume.

12 Consider the impacts of climate change on current silvicultural practices, and modify them as necessary; for example, adjust rotation lengths and planting seasons.

13 Consider the susceptibility of forests to pests and diseases and develop appropriate strategies for protection; review practice as further evidence becomes available.

Tree and shrub species selection

Climate change will lead to shifting climatic regimes and more frequent extreme weather events, presenting risks and opportunities for trees and the pests and diseases that attack them. The resilience of forests to deal with these changes can be improved by increasing the species and genetic diversity of trees and shrubs. Achieving species diversity in forests is a UKFS Requirement, and forest management plans will need to address tree species composition of the whole FMU. In addition, there are specific policies in relation to species diversity which are detailed at a country level.

The impacts of climate change will vary across the UK and so a range of adaptation strategies will be required. Establishing a variety of species, either in mixtures or in pure stands, can enhance the resilience of forests to projected climate change. For productive forests, a broader range of timber species than have typically been planted in the past must now be considered. For native woodland, augmenting the current range of species with others associated with the woodland type will often help meet biodiversity objectives in addition to increasing the resilience of woods.

Climate change projections suggest that, on some sites, growing conditions will become more challenging in the future for some species, especially where summer drought coincides with freely draining soils. Where a new forest is established in these situations, careful thought needs to be given to the choice of species and to the origin or provenance of the planting material. This may mean planting a more drought-tolerant species that is better matched to a drier site, or planting material of a more southerly origin that may be better adapted to the future climate. The ESC decision support tool can help with appropriate species selection. The comparatively long generation time for trees makes it important that populations contain sufficient genetic diversity to be able to adapt to climate change and develop resistance to pests and diseases.

14 Where timber production is an important objective, consider a wider range of tree species and genetic diversity than has been typical of past planting, and consider planting these in mixtures; consider the limited use of planting material from more southerly origins.

15 Choose trees or shrubs which are drawn from a sufficiently wide genetic base of parent trees to promote future adaptation.

16 Encourage natural regeneration and colonisation of native tree and shrub species to promote natural selection and climate change adaptation, and conserve distinctive genetic patterns – especially in and around semi-natural woodland.

Urban woodland

Urban woodland can help society adapt to a changing climate by:

- providing cooling through evaporation and reflecting solar radiation;
- providing shade for comfort and reducing the incidence of health problems related to ultraviolet light;
- reducing solar gain of buildings in summer;
- reducing wind speeds, and consequently heating requirements, in winter;
- absorbing pollutants and improving air quality;
- contributing towards urban ‘wildlife corridors’ to aid species movement;
- contributing to sustainable urban drainage systems;
- providing recreational opportunities close to where people live and work.

However, the risk of new pests or diseases becoming established in urban areas is high because of the range of exotic tree and shrub species found in parks and gardens, and because warmer urban climates may help some imported pathogens become established – a risk that is magnified by urban trees being frequently found in a more stressed environment, experiencing air pollution, soil compaction and water shortages.

17 In urban areas, consider the potential benefits of woodland in reducing the impacts of climate change and supporting a range of ecosystem services.