Sustainability Committee
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Inquiry into Carbon Reduction in Wales: Evidence from Forestry Commission Wales on Rural Land Use Management and Carbon Reduction

Purpose

1. To set out the key concepts and some specific issues in relation to the role of forestry and timber/fibre in helping to reduce Welsh carbon emissions.

Key messages regarding forestry and carbon

- Welsh forests and forestry has a small but not insignificant role to play in helping to reduce Welsh carbon emissions. The powerful narrative around trees, forestry and deforestation in the wider international climate change discussion further enhances this role.
- The primary focus for Welsh forestry is to adapt the 20th century plantation forests to ensure their longer-term health, resilience and contribution to the delivery of public benefits.
- Land use policy aimed at reducing GHG emissions should take into account the impacts beyond the forest/farm gate for both inputs and outputs. ‘Substitution’ is as important as ‘sinks’ for forestry.
- Timber/fibre production from Welsh forests is finite and there are precautionary strategies that should be adopted for maximising the positive emissions reduction impacts in the absence of detailed life-cycle analysis evidence.
- Emissions reduction is part of a wider set of policy drivers for land use and sustainable forest management is a useful framework for reconciling these drivers.

Background

2. **Forest carbon stocks and fluxes –** The total UK forest carbon stock in trees is approximately 550 Mt CO2 equivalent compared to annual total CO2 emissions of 544 Mt CO2 (provisional Defra figures for 2007). Therefore, even dramatic increases in the woodland area, in carbon stocks per area, in woodfuel substitution for fossil fuel energy and in timber substitution for carbon-intensive materials, will not make a major contribution to emissions reduction. However, as Kyoto commitments are for reductions in emissions of 12.5% of 1990 values (i.e. 74 Mt CO2), changes in the fluxes in CO2 and other GHGs into and from forests and forest activities could make a small but worthwhile contribution to the UK GHG balance.

3. The pattern of accumulation of carbon in a stand of trees over its life cycle reflects the growth of timber (the “increment”), since the dry weight of wood comprises 50% carbon and stem wood comprises a large part of tree

biomass. Models or tables providing forecasts of timber growth and yield of forests can thus be used to estimate carbon stocks and accumulation rates. Much empirical data has been collected on the characteristic time course of stemwood (or sometimes total biomass) accumulation within stands following planting or natural regeneration. Successive inventories of the growing forest stand, or estimates based on growth and yield models such as BSORT, show increased carbon indicating that the stand is a *sink* and that there is *carbon sequestratio*n.

4. The time-course of carbon accumulation is generally sigmoid: the initially rate is relatively slow as the canopy develops (the ‘*establishment phase’*), but generally accumulation accelerates until the ‘*full-vigour phase*’ is reached. During this phase, a characteristic maximum rate of carbon accumulation is sustained for a number of years, the duration and magnitude of which is determined to a large extent by the combination of tree species, site characteristics (e.g. nutrient availability) and climatic conditions.

5. The full-vigour phase ends as tree sizes become so large that losses of carbon due to respiration, senescence and death, begin to approach carbon inputs from photosynthesis (the ‘*mature phase’*). Net growth and carbon accumulation in the stand slows during this phase. Eventually the tree stand may reach a state where losses of carbon more or less balance the inputs (the ‘*old-growth phase’*), and the tree stand becomes ‘carbon-saturated’, with the stand carbon stock varying about a characteristic long-term average value. Small amounts of carbon may continue to accumulate in the soil, with the time for soil carbon to reach equilibrium being much longer than that for forest biomass.

6. The above leads to two important general points:

   - Planting a stand of trees on an area results in a change in the carbon density of that area. Carbon sequestration only occurs for a limited period while the carbon density is increasing, and the rate is at its maximum in the full vigour phase. Stands of trees alone do not continuously and indefinitely sequester carbon from the atmosphere (but there may be continuous sequestration in soil).

   - The duration and rate of carbon accumulation during the full-vigour phase of growth are determined by a combination of tree species, site and management characteristics and climate. The magnitude of the average carbon density maintained during the over mature phase is also determined by these factors. If tree species, site types and climatic conditions are selected to maximise the duration and magnitude of carbon accumulation during the full-vigour phase, this may not necessarily (and indeed is quite unlikely to) result in a high average carbon density during the over-mature phase. It is probably more important to select tree species, site types and climatic conditions to maximise the carbon density ultimately attained.

7. The long-term carbon stocks estimated for different types of forestry systems fall into two distinct groups: those associated with some form of active management for production and those involving protection of woodlands to create ‘carbon reserves or sinks’.

8. Forest soils can contain more carbon than the trees, particularly the peat-based soils common in the upland areas of the UK. Scientific literature suggests estimates of C content in forest soils can vary between 90 and 2500 t CO2eq ha-1.

Issues for Consideration

9. **Harvested wood products -** Carbon is removed from the atmosphere during tree growth and dry wood is approximately one half carbon by weight. Some of this wood, and the carbon within it, can be harvested and turned into useful products. Carbon remains 'fixed' within these products throughout their useful lifespan and is only released back to the atmosphere if the wood is oxidised as a result of combustion or decomposition.

10. **The dynamics of carbon in harvested wood -** Harvested wood is used to make what may be referred to as *primary products*. When primary products come to the end of their useful lives, the wood may be reused in *secondary products*. Both primary and secondary wood products make a contribution to carbon dynamics.

11. The main processes that determine the carbon dynamics of harvested wood products are fundamentally different to those at work in forest ecosystems. The carbon content of the forest ecosystem depends on the balance between the process of photosynthesis and respiration by trees, the accumulation and loss of organic matter in soil, disturbances such as forest fires and windthrow, and interventions by humans (tree planting, thinning and deforestation). Most of these processes are biophysical. In contrast, C stocks and flows associated with wood products depend principally on socio-economic forces.

12. The size of a particular wood product pool is a direct consequence of the number of units of the product in use at a given time and the average amount of wood contained in individual units of the product. In principle, measures that encourage use of more wood products should result in C stocks in wood products increasing, so that C is sequestered in products. Quite a large proportion of the harvested wood has a relatively short lifespan, for example wood processing factories often burn a significant fraction of off-cut wood to provide heat and electricity for the manufacturing process. The remaining harvested wood goes to make longer-lived primary wood products in construction, insulation, packaging and fuel. Generally these will have service lifespans ranging from one or two years up to forty years. Exceptionally, primary wood products may remain in service for a100 years or more.

13. Modern house designs often involve relatively small amounts of structural wood, so by changing designs, the quantity of wood contained in a house

could be increased. It should also be noted that, as with trees, carbon sequestration in wood products is potentially reversible. If existing or new wood products are replaced with non-wood products at some point in the future, C stocks in wood products will decrease, with implied emissions of carbon to the atmosphere, if wood products taken out of use are burned or decay.

14. **Carbon in secondary wood: bury, recycle or burn? -** When people finish with a wood product, it can be buried in a landfill, recycled into a secondary product, or burned. These three options have different positive and negative carbon balance impacts and all require transport of wood, which requires energy.

15. When these are considered alongside other factors, often it is difficult to clearly distinguish the most environmentally beneficial option. Of the three options, the C dynamics of 'fixed' carbon are most simple for burning wood: C fixed in wood is released back to the atmosphere immediately. The mix of carbon-based gases released depends on how efficiently the wood is burned. If this is efficient, most of the carbon returns as CO2. For less efficient cases (e.g. poorly tended open log fires), a proportion is returned as more complex hydrocarbons. The C dynamics of recycled wood products are similar to primary products - the main determining factor is the requirement for the particular product being manufactured. However, there is no clear picture about the interactions in consumption of virgin and recycled wood. Quite high uncertainty also surrounds the C dynamics of landfilled wood. The quantity of C in wood in landfill could be significant, but estimates are based on many assumptions and it is not clear if, when or by what process landfilled wood will decay.

16. **Substitution potential -** Harvesting trees reduces the carbon stock in the forest and thus reduces C sequestration, dependent on the use of the harvested tree and the regrowth at the site. However, even if there is a net removal of C from the forest, it may help reduce C emissions from fossil fuel use through substitution, either *directly* (use as an energy source) or *indirectly* (through use in place of other, more energy intensive materials such as steel, bricks or concrete). In many instances, wood products may deliver multiple substitution benefits. For example, waste wood created when machining logs into products may be used as energy to drive the manufacturing process, or an article of furniture may be disposed of by burning and recovery of the energy.

17. **Direct substitution: woodfuel -** Several points about woodfuel use and its potential for substitution need to be made:

    - If forests regrow after harvest and re-fix C lost during woodfuel combustion and energy generation then potential emissions from fossil fuel combustion are avoided. Thus a sustainable cycle of woodfuel harvesting and forest re-growth continues to avoid fossil fuel C emissions. This is unlike measures to cause additional sequestration in forests, which reach saturation, determined by the environmental and forest characteristics at a site.

- The potential for woodfuel for direct substitution is determined by the biomass productivity.
- The calculation of the net reduction in fossil fuel consumption avoided by bioenergy obviously needs to take into careful account the fossil fuel use in harvesting, processing and transport of woodfuel. However these are unlikely to be greater than for comparable fuels, most of which have high carbon extraction costs as well as tending to be transported long distances via heavily carbon-intensive infrastructure.

18. **Indirect substitution: use of wood products -** GHG emissions may also be reduced by using wood in place of other more energy expensive (and carbon-intensive) materials. This will only contribute to emission reduction if:

- Product consumption patterns are actively modified,
- Existing energy-intensive products are not replaced with wood products until end of life,
- Opportunity for substitution of materials for particular products or uses is real, and that product life times are taken into account in the assessment,
- Material substitution does not lead to creation of alternative markets for the materials not being used (i.e. ‘leakage’).

19. There has been considerable work on the opportunities for materials substitution in the building industry, including Life Cycle Analysis (LCA), which attempts to account for the specific mix of GHG emissions arising from the use of different materials and methods of manufacture, the maintenance and disposal and the service life. Although the estimates show considerable variation, depending on the types of buildings assessed and the methodologies used, lower C emissions are associated with woodbased construction in all cases. A more recent study by ECCM has provided a ‘carbon calculator’ for the building industry, using various emission factors for materials, for example from the Building Research Establishment (BRE).

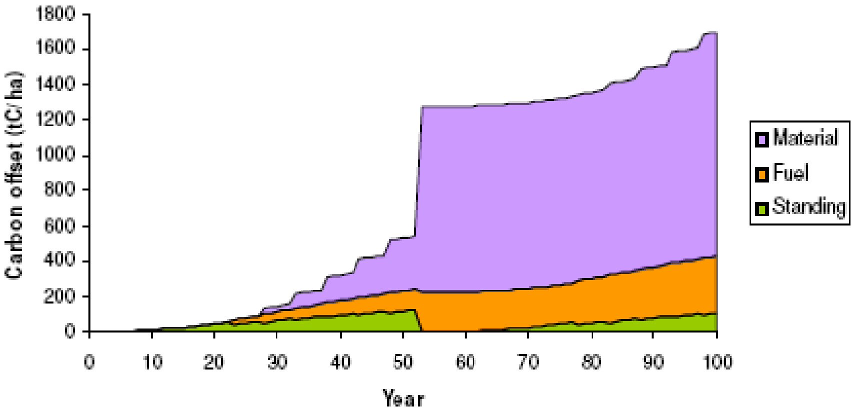

Figure 1. Carbon dynamics in an average (yield class 12) stand of Sitka spruce in Britain as estimated based on calculations referring to outputs of the BSORT model, showing the contributions due to carbon stocks in trees and emissions reductions achieved through utilisation of harvested wood for fuel and materials. The stand is assumed to be planted on bare ground with an initial spacing of 2 m, thinned according to the standard Management Tables (Edwards & Christie, 1981), then felled and replanted on a 55-year rotation. The largest contributions are observed to be due to the emissions reductions from fuel and material utilisation, which accumulate over time at average rates of roughly 4.5 tC ha^{-1}y^{-1} and 20 tC ha^{-1}yr^{-1} respectively. By contrast, the carbon stock in woodlands cycles over rotations between approximately 0 and 100 tC ha^{-1}, maintaining a long-term average carbon stock of 50 tC ha^{-1}.

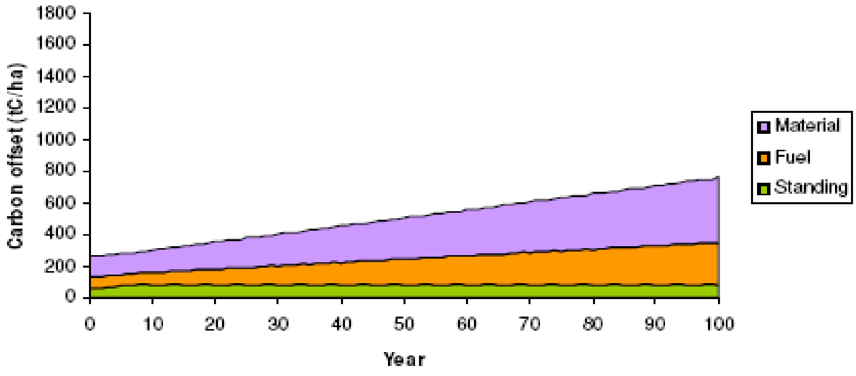

Figure 2. Carbon dynamics in an average (yield class 4) stand of oak in Britain as estimated based on calculations referring to outputs of the BSORT model, showing the contributions due to carbon stocks in trees and emissions reductions achieved through utilisation of harvested wood for fuel and materials. The stand is assumed to have been in existence but not originally in active management. It is assumed that LISS (selection) management was introduced in the stand in year zero, involving periodic thinnings. The largest contributions are observed to be due to the emissions reductions from fuel and material utilisation, which accumulated over time at average rates of roughly 2 tC

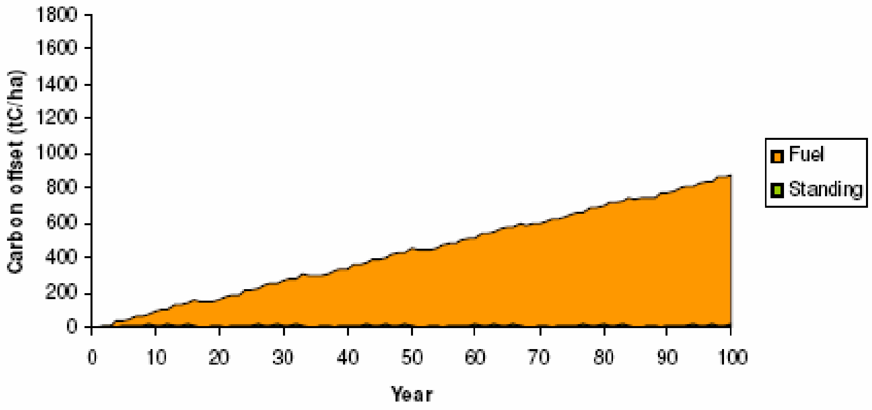

Figure 3. Carbon dynamics in short rotation coppice with an assumed productivity of 8 odt ha^{-1}yr^{-1}. The stand is assumed to be planted on bare ground with a stocking density of approximately 10,000 stools per hectare, cut back on a 3-year cycle. The largest contribution is observed to be due to the emissions reductions from fuel utilisation, which accumulates over time at an average rate of roughly 8 tC ha^{-1}yr^{-1}. By contrast, the long-term average carbon stock in the coppice is negligible, as roughly 4 tC ha^{-1}.

Summary

20. The above analysis suggests a number of strategies for using forests and forestry to reduce carbon emissions. These could be summarised as:

(i) increasing forest area;
(ii) increasing carbon content per unit area (so-called “carbon density” at stand and landscape scale;
(iii) expanding use of forest products to substitute for carbon-intensive materials and fossil fuels;
(iv) maximising the use of solid timber through re-use before it is recycled or burnt; and
(v) reducing emissions from deforestation and degradation.

These options are not mutually exclusive and all could be pursued in tandem although the relationship between (ii) and (iii) is more complex to manage. These two options, along with appropriate timber/fibre use (option iv) offer most potential for Welsh forestry in helping to reduce or mitigate carbon dioxide emissions, with (i) also having some merit in the context of a delivering a wider set of sustainable development outcomes from increasing woodland area.

Forestry Commission Wales
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