

Technical Appendix 7: Carbon sequestration in biomass and biomass-based products

Green plants use carbon dioxide and water to create organic compounds generically known as 'biomass'. Generally this is in solid and liquid form and can be said to store or 'sequester' CO₂. Most biomass that is generated is quickly metabolised back to CO₂ and water, but some remains in the biosphere and can accumulate, forming a carbon-sink. Technical Appendix 5 deals with the special case of organic matter in soils. In this Technical Appendix we deal with biomass stored in living plants, which we call 'in-situ' sequestration, and biomass in products used within the 'technosphere' of human artefacts, which we also sometimes refer to as 'ex-situ' sequestration.

In-situ Biomass Sequestration in above ground biomass

Although all kinds of plants store biomass, more than 90% of the British biomass stock is in trees, estimated at around 400 million tonnes CO₂e (FAO, 2010).

Forest wood sequesters effectively but is very variable. Under good conditions a youngish woodland can accumulate carbon at 5-15 tonnes/hectare/year CO₂e (Brainard *et al.*, 2003). As the trees age, their accumulation rates decrease towards zero, but they do represent a reservoir from which permanent products can be drawn.

Brainard *et al.* (2003) review a wide range of studies examining the accrual of biomass in various tree species, yield classes and site types. It is generally assumed that sooner or later the wood will be harvested and the fixed CO₂ transferred to the technosphere, but it is reasonable to assume that the total quantity of biomass in existing woodland is slowly increasing, and the scenario assumes that with a high carbon-price incentive this will be optimised. Rates of carbon-fixation reported by Brainard *et al.* range between 5 and 10 tonnes CO₂/ha/year. On the assumption that broadly speaking, existing forests are accumulating rather than losing biomass, we suppose it reasonable to allow 10% of the fixation as accumulated biomass. Existing woodland is allocated an in-situ sequestration credit of 0.5 tonnes CO₂/ha/y in addition to products actually harvested.

Active sequestration in young UK forests is recognised by the UNFCCC methodology as about 3 million tonnes CO₂e/y, and declining (Forestry Commission, 2009).

The scenario assumes that woodland will be planted and managed with carbon in mind, to maximise either in-situ or ex-situ sequestration, depending on circumstances. Read *et al.* (2009) have explored some of these scenarios. They remark:

"woodlands planted since 1990, coupled to an enhanced woodland creation programme involving planting 23,200 ha (14,840 ha over and above the business as usual assumption of 8,360 ha per year) of forest per year over the next 40 years, could deliver abatement of c. 15 million tonnes CO₂ per year by the 2050s, providing the substitution benefits of wood and timber products are taken into account"

Depending on the scenario chosen, this figure of 15 million tonnes/y could be either energy or in-situ sequestration. This supposes a total increased forest area of 928 thousand hectares over 40 years.

The **zerocarbonbritain2030** scenario envisages 1,370 thousand hectares in 20 years, starting around 2015. By 2030, given high levels of incentivisation we would expect similar levels (15 million tonnes CO₂ sequestration per year) to be achievable. Little is used for energy production, so we are justified in assuming 15 million tonnes CO₂e sequestration per year will be occurring in situ in new planted forest in 2030. Over the following years this will reduce as the forest turns from sink to reservoir.

Read *et al.* (2009) give a more detailed estimate of the effects of planting 150,000ha managed for in-situ sequestration, illustrated above. This gives about 1.5 million tonnes CO₂e per year, rising to 2.5 by 2050. Pro rata, the **zerocarbonbritain2030** scenario's reforestation programme of 1370 thousand hectares would give about 9.1 times as much, or 13.7 million tonnes CO₂e/year by 2030, rising to 22.5 by 2050. This is in addition to the existing "official" rate of about 3 for the 'Kyoto Forests' (although there is some reason to believe that this figure is an underestimate). This approximately concurs with the earlier figure of 15 million tonnes CO₂e/ y, but the scenario adopts a figure of 13.7 million tonnes CO₂e for 2030.

The data from Read *et al.* (see Figure 1) suggest that even higher values can be claimed if the woodland is managed for both in-situ sequestration and for substitution products. These authors suppose that the 'substitution' would be in the form of bio-energy displacing fossil fuels. In the **zerocarbonbritain2030** scenario this does not apply: although energy would be useful in balancing the overall energy system it would not gain a sequestration credit as there are no fossil fuels to displace. However, if it is used for structural or other permanent purposes it would be credited as genuinely net negative. This is fairly likely in the scenario, but for purposes of calculation we shall neglect it.

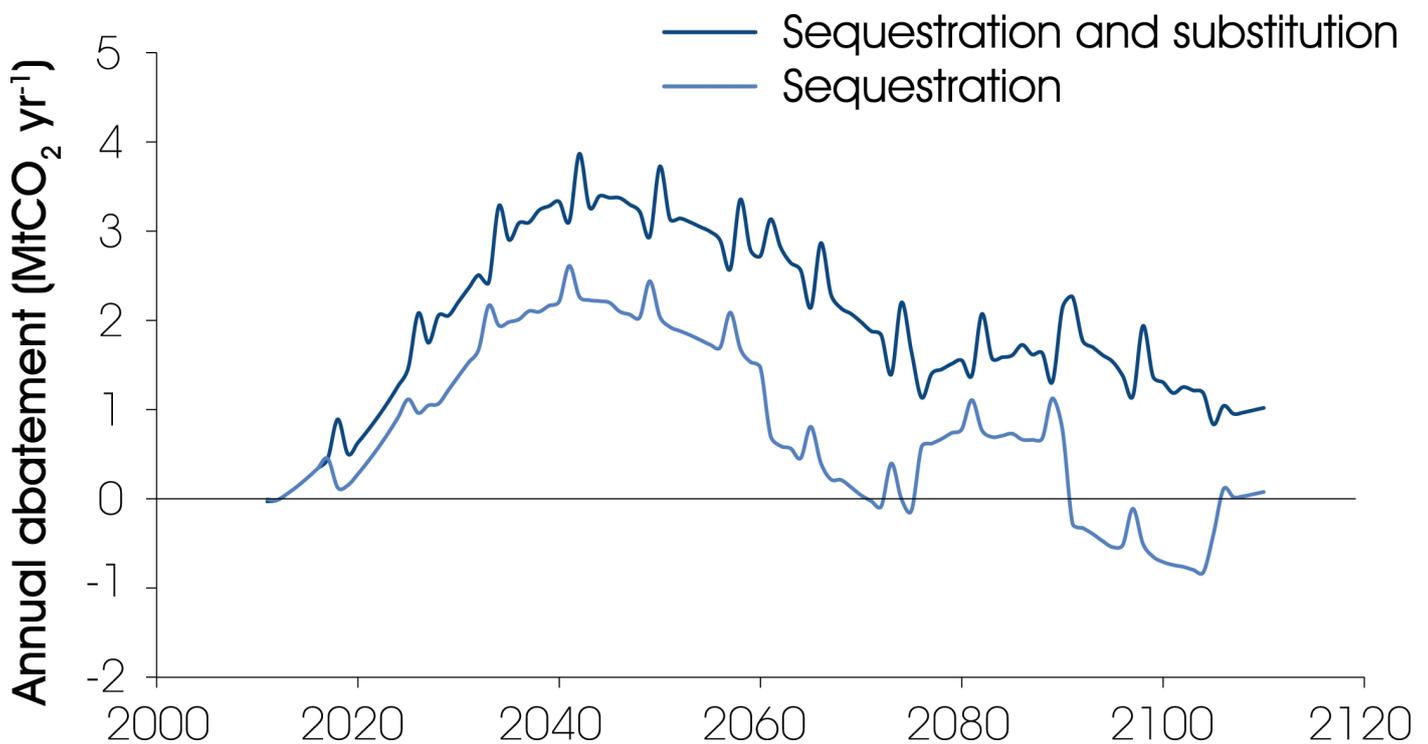


Figure 7.1: The carbon sequestration effects over time of planting 150,000 hectares forest managed for in-situ sequestration.

Source: Read *et al.* (2009). © National assessment of UK forestry and climate change steering group.

Read *et al.* (2009) do not specify what type of land is being used for new forest development. We have supposed that their conservative 10 tonnes/ha/y is greater on better land, less on poorer land, assumptions summarised in Table 7.1.

land type	oven dried tonnes accumulated	CO ₂ e
arable	15	20
rotational grassland	15	20
improved lowland grassland	12	16
unimproved lowland grassland	8	10
upland sites	5	7
peatland	3	5

Table 7.1: CO₂e sequestered per hectare per year in new forest planted on land with different pre-existing uses, during the 'window' period 2015-2050, declining thereafter.

Ex-situ sequestration in biomass products

The scenario generates a large quantity of biomass for various purposes. Some is required for energy and chemical feedstocks, but much is reserved for building materials, and the scenario proposes using buildings as the principal ex-situ 'artefact sink'. In some ways the artefact sink already exists, since the stock of wood products in use in the UK is estimated at about 300 million tonnes CO₂e by Broadmeadow and Matthews (2003), to which is added 3.2 million tonnes CO₂e/y (TRADA, 2005).

The scenario proposes to increase this input dramatically, to about 40 million tonnes a year for at least the next 20 years, mostly for use in buildings. Imports would still be possible (say for structural timber hard to produce in Britain), but the scenario supposes that imports and exports of permanent biomass products balance in carbon terms, and therefore this aspect can be ignored. It should be noted that this arrangement displaces the present net import of wood products with a carbon content of about 50 million tonnes CO₂e.

There is some unavoidable imprecision in biomass and sequestration data, because biomass is measured and recorded in many different ways. Generally 'oven-dried tonnes' of biomass are converted to tonnes CO₂e by assuming that half the mass is carbon, so one tonne biomass = 0.5 tonnes C = 1.83 tonnes CO₂e. This does not take account of the fact that most wood products are traded with a moisture content of up to 25%, and there are some losses in the system. We have therefore adopted the figure proposed by MacMath and Fisk (2000) of 1.2 as a general conversion factor from air-dried biomass products to CO₂e.

The biomass in the artefact sink would not be preserved forever. Eventually the carbon will re-enter the carbon cycle. In recognition of this, biomass inputs are discounted by 30% to allow for losses in the next 50 years, although high carbon prices, justifying higher standards, could probably reduce this figure.

References

Brainard, J. Andrew Lovett and Ian Bateman (2003) Social & Environmental Benefits of Forestry: Phase 2: Carbon Sequestration Benefits Of Woodland, Report to Forestry Commission, Edinburgh.

Broadmeadow, M. and R. Matthews (2003) Forests, Carbon and Climate Change: the UK Contribution, Forestry Commission,

Edinburgh ISSN 1460-3802 ISBN 0-85538-595-2

FAO (Food and Agriculture Organization of the United Nations) (2010). UK Global Forest Resources Assessment 2010. FRA2010/221, Rome.

Forestry Commission (2009) Forestry Statistics [online] available at: <http://www.forestry.gov.uk/website/forstats2009.nsf/LUCContentsTop?openview&RestrictToCategory=1> [accessed 01/07/2010]

MacMath, R. and P. Fisk (2000) Method of Evaluating the Upstream Global Warming Impact of Long-Life Building Materials. Centre for Maximum Potential Building Systems, Austin, Texas. [online] available at: http://www.cmpbs.org/publications/T1.2-AD4.5-Up_Gbl_wrm.pdf [accessed 01/07/2010]

Read, D.J., Freer-Smith, P.H., Morison, J.I.L., Hanley, N., West, C.C. and Snowdon, P. (eds). (2009) Combating climate change – a role for UK forests. An assessment of the potential of the UK's trees and woodlands to mitigate and adapt to climate change, the synthesis report, Forestry Commission, The Stationery Office, Edinburgh.

TRADA (2005). Wood: The UK Mass Balance and Efficiency of Use. Biffaward Mass Balance Series, 2005.