

CARBON ISSUES IN IRISH FORESTRY

Introduction

Climate change is widely recognised as the greatest environmental challenge facing the world today. There is a general consensus among scientists that climate change is due to the concentrations of certain greenhouse gases (GHGs) in the atmosphere rising, and that this is mainly the result of man's activities. The two main causes of the rise in GHG concentrations (globally) are the burning of fossil fuels and land use change, particularly deforestation.

The purpose of this article is to explain the impact that trees and forests can have on GHG emissions, in an Irish context. It looks at the way carbon is stored in forests and wood products as well as the direct and indirect fossil fuel savings from using wood. It also makes some suggestions on how management practices can be adjusted to improve the carbon performance of Irish forests.

The Carbon Cycle

Carbon dioxide (CO₂) is the most important GHG, representing around 66% of Ireland's annual GHG emissions in terms of global warming potential. Understanding the carbon cycle is key to understanding the role that forests and forest management can play in reducing net carbon emissions, see Figure 1. Trees capture carbon dioxide (CO₂) from the atmosphere during photosynthesis while releasing some during respiration: overall there is a net accumulation (sequestration) of carbon as they grow. Every tonne of green wood contains between 15% and 30% of carbon, depending on wood density and moisture content. Carbon continues to be locked up in wood products after harvesting, and is eventually returned to the atmosphere through decay, or combustion when used as a fuel. The growing, harvesting and manufacture of wood products also uses energy and therefore generates carbon emissions.

Forest soils are a very important store of carbon. Forest operations can result in a reduction in soil carbon, particularly on peaty soils through a lowering of the water table and oxidation of the peat. However emissions of methane (another GHG) may fall as a consequence of this process: overall, soil carbon is a complex area.

Landfill also constitutes a substantial carbon store with wood products surviving for several decades underground. As they decay these products produce methane which can be (but often isn't) tapped to generate power. There are no Irish estimates for the size of this store but in the USA studies have indicated that the amount of carbon in landfill exceeds the amount actively in use in wood products!

Provided it is practised sustainably, forestry makes a positive contribution to reducing our carbon emissions. In summary the amount of CO₂ in the atmosphere can be reduced by:

- Increasing the amount of carbon stored in forests and forest soils
- Increasing the amount of carbon stored in wood products
- Using wood as a fuel, replacing fossil fuels
- Using wood to replace materials with high embodied energy
- Creating new forests on agricultural land

Atmosphere

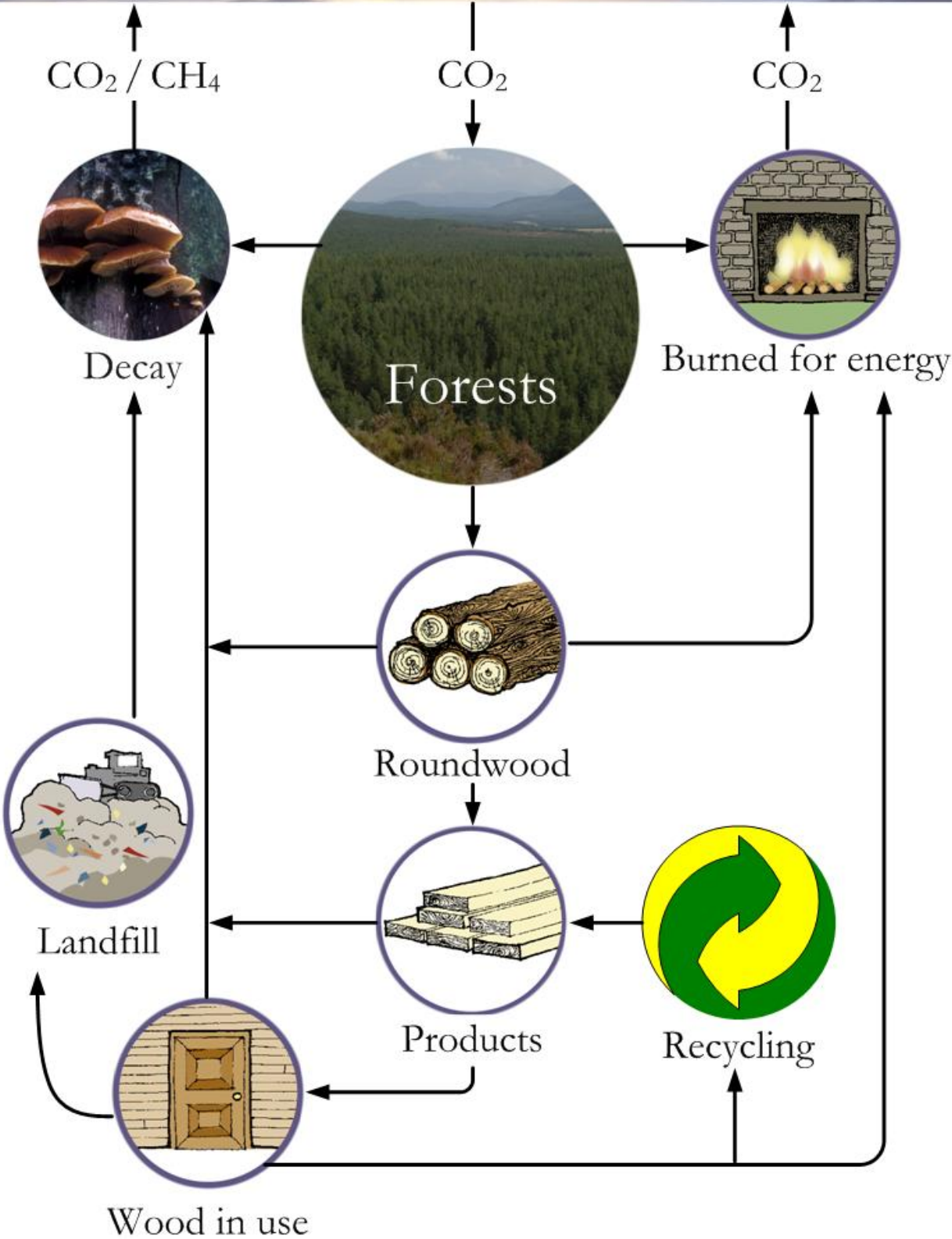


Figure 1. Simplified carbon cycle: arrows show flow of carbon

Carbon in Irish Forests

Atmospheric gases circulate freely: climate change is a global issue and a tonne of CO₂ sequestered or emitted in Ireland is no more significant here than anywhere else in the world. However under the Kyoto protocol most developed countries have made commitments to reduce (or in Ireland's case contain) net carbon emissions. So what does the carbon budget look like for the Ireland and what difference can, and does, forestry make?

Table 1. Carbon Estimates for Irish Forestry

Carbon stored in Irish forests (excluding soil)
- 40 million tonnes
Carbon stored in Irish forest soils
- 281 million tonnes
Increase in carbon stored in forests (excluding soil)
- 0.9 million tonnes per annum
Carbon in wood products removed in harvesting
- 0.5 million tonnes per annum
Current GHG emissions in Ireland (carbon equivalent)
- 19 million tonnes per annum

A number of key points emerge from Table 1. Nearly 90% of the total amount of carbon stored in Ireland's forests is in the forest soils. The total amount of carbon stored in Ireland's forests (excluding forest soils) is about two times the nation's annual GHG emissions. Due to the young age of the forest estate they are actively sequestering carbon, with the amount of carbon stored in the forests increasing by nearly 1 million tonnes each year, although around half a million tonnes of carbon are removed each year in wood products.

Creating new forests, providing there is no loss of soil carbon, increases sequestration. One hectare of Yield Class 16 conifer plantation will sequester around 3 tonnes of carbon per annum over a rotation. Given that the land area of Ireland is around 7 million hectares the whole of Ireland would have to be planted with conifers to offset current emissions. Carbon sequestration in newly planted broadleaf woodland is significantly lower than that in conifer woodland due to the lower growth rates, but as explained in the next section the difference, in terms of overall carbon benefit, is less than might be expected.

Carbon Storage in Trees and Forests

Carbon is stored in the stem, branches, leaves, needles and roots of trees. As a young woodland develops the amount of stored carbon increases until an equilibrium is reached when the amount of carbon stored through photosynthesis is matched by the carbon lost through respiration and decay. It may take several hundred years to reach this point. Nearly all forests in Ireland are managed with trees felled and timber (and therefore carbon) removed at regular intervals so the maximum potential level of carbon storage in the woodland is never reached. This does not mean that felling trees is a bad thing if the objective is to maximise carbon storage: the important question is what happens to the wood, how long do the wood products go on storing carbon and what other direct and indirect benefits accrue from the use of the wood products?

All young plantations have a characteristic growth pattern of rapid growth after establishment, slowing through middle age and almost stopping altogether in old age. Under a clear felling silvicultural system, foresters will normally plan to fell a plantation, or a stand of even aged trees within a larger forest, at around the age of maximum mean annual increment (MAI), thus maximising total volume production. Of course the felling age is likely to be influenced by market conditions and environmental considerations, or the desire to have a wider distribution of age classes in a particular forest. An objective of maximising carbon storage would point to felling and replanting stands at around the age of maximum MAI, provided the wood produced had an indefinite lifespan. When the direct benefits (eg use of wood as a fuel) and the indirect (material substitution) benefits are taken into account a more complicated picture emerges.

Figure 2 provides an illustration of how the carbon benefits accumulate with time. The estimates are for a hectare of yield class 6 mixed oak/ash woodland planted on agricultural land, over a 100 year period. The wood is thinned at 5 yearly intervals from the age of 20 with all the less than 18 cm diameter material used as fuel, and the over 18 cm material going for sawn timber.

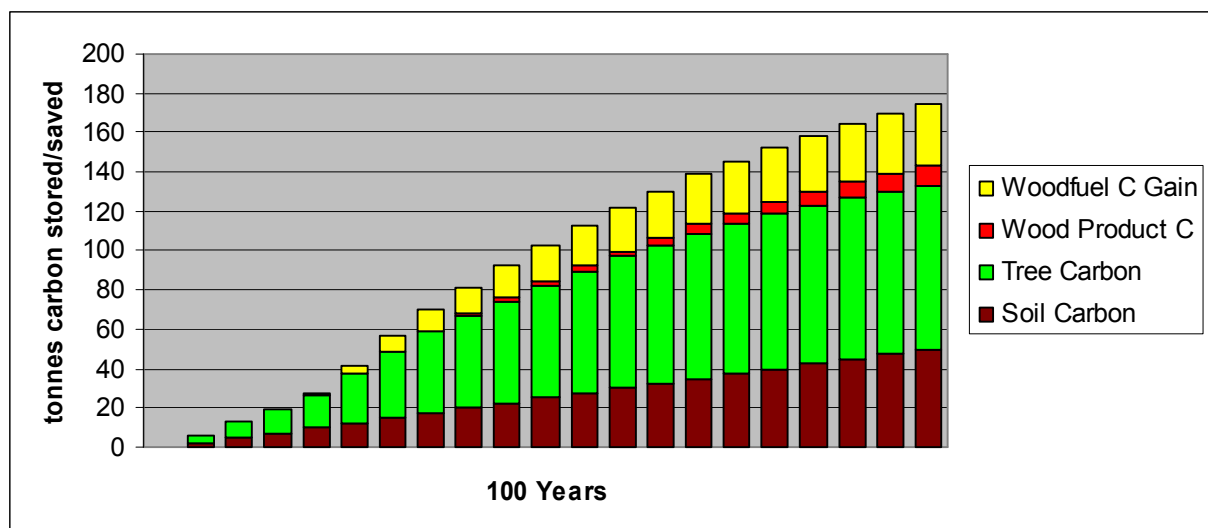


Figure 2. Carbon benefits for an oak/ash mixed woodland over 100 years

In Figure 2 the largest carbon store after 100 years are the trees themselves. If all the trees were felled this store would disappear and there would be a substantial increase in the wood product store and the woodfuel carbon gain. The increase in soil carbon, given

woodland creation on agricultural land with low initial soil carbon levels, could be expected to continue for several decades.

Figure 2 does not include the indirect benefit from material substitution or from the reduction in GHG emissions from agriculture.

Projections of carbon storage and carbon benefits can be produced for new and existing forests but the further they look into the future the less certain they become. Comparisons can also be made between different types of woodland. Table 1 shows the estimates of carbon storage and carbon benefits for three new woodlands (each 1 hectare) including the oak/ash mixed woodland in Figure 2.

Table 1. Carbon storage and benefits for three woodland types

Woodland Type	Soil Carbon	Tree Carbon	Wood Product Carbon	Woodfuel Carbon Gain	Total
Mixed oak/ash	50	83	9	30	172
Mixed bdl/con	50	93	29	15	187
Conifer (YC 16)	50	100	44	3	197

(All numbers are tonnes carbon per hectare. The conifer model is mixed Douglas fir and Sitka spruce and assumes the first rotation was felled and replanted at age 50. All models include a 20% allowance for open space)

Overall Table 1 shows less difference than might be expected between the conifer and broadleaf models, despite the difference in yield class. The reasons for this are:

- The inclusion of soil carbon, assumed to be equal
- The greater wood density of broadleaves (ie more carbon per cubic metre)
- The greater longevity of hardwood timber
- The inclusion of a 20% open space allowance for all woodland types

Fossil Fuel and Material Substitution

Wood and wood products can have both a direct and an indirect impact on fossil fuel use and therefore carbon emissions. Provided it is grown sustainably, wood is a renewable and (very nearly) carbon neutral fuel. With fossil fuel prices rising, interest in the use of wood as a fuel in Ireland is increasing rapidly. This is supported by Government, concerned about energy security and with renewable energy targets to meet. But wood can have an even more important rôle to play in substituting for materials such as concrete, steel, brick and plastic that require a lot of energy in their production (or in the case of plastics use fossil fuel as a feedstock). There is considerable scope for increasing the use of wood in Ireland, for example in housing where around 30% of new houses are timber frame compared to 60% in Scotland and 90% in North America. Estimating the extent of these savings takes us into the complex world of life-cycle analysis. A recent study (ECCM 2006) indicated that it is possible to achieve up to an 86% reduction in GHG emissions associated with the embodied energy of building materials by maximising the use of timber in buildings. The same study states that the production of cement and steel alone account for over 10% of global GHG emissions.

There is then an interesting question on whether it is better, in terms of GHG emissions avoided, to use wood directly as a fuel or use it to substitute for energy intensive materials. The answer will depend on the circumstances (woodfuel boiler efficiency, fuel being replaced, wood product) but in general energy production has less associated GHG benefit than material substitution.

Carbon Emissions in Forest Operations

Carbon emissions will occur whenever vehicles and machinery are used, for instance in establishment and maintenance operations, tree harvesting, road making, road haulage and supervision. In addition the manufacture and use of pesticides and fertilisers will involve emissions. However the amounts of carbon emitted are small – work in conifer forests in the UK has indicated total annual emissions of less than 4 kg of carbon per cubic meter harvested, compared to the 170 kg of carbon per cubic meter stored in harvested wood products.

Practical Steps: Carbon Conscious Forest Management

Forest managers are becoming increasingly carbon conscious in their management. This requires a good understanding of the carbon stores and how they can contribute to national goals of reducing net carbon emissions. Clearly any changes to policy or practice, taken with a view to improving carbon sequestration, must remain within the overall framework of sustainable forestry. The capacity of forests to absorb carbon dioxide and store it in wood products is only one of the environmental benefits they can provide, to be considered alongside their social and economic (as well as other environmental) values. There are potential conflicts, particularly with environmental standards, which should sensibly constrain any drive to maximise carbon sequestration. Climate change itself will bring challenges and require adjustments to the way that forests in Ireland are managed. The new forests we create, and our existing forests, will have to be diverse and robust enough to cope with an uncertain future.

Within this wider imperative of ensuring the long term sustainability of Irish forests, the following suggestions are made for carbon conscious forest management:

Tree Establishment

- Higher yield species and sites preferred;
- Avoid deep peats;
- Minimise fertiliser and pesticide use;
- Minimise cultivation and drainage.

Maintenance and Management

- Protect the forests' productive potential;
- Seek to minimise losses to fire, windblow, pests and diseases;
- Keep threatening wildlife populations under control.

Harvesting

- Maximise volume outturn; thinning is good!
- Minimise fuel use in harvesting operations;
- Minimise soil disturbance

- Site roads to minimise disturbance to peaty soils

Utilisation

- Minimise transport distance for raw material, develop local markets;
- Long lived timber products preferred.

Forestry and Land Use

Provided new forests are carefully designed and good environmental standards are maintained during establishment and management operations, they can make a significant contribution to reducing GHG emissions. Agriculture in Ireland is responsible for some 28% of annual GHG emissions (ruminants being the main culprits) and agricultural soils tend to be low in carbon so there is potentially a double benefit from afforestation. But we do have to be a little careful – we all need food and there is no net gain if more woodland in Ireland is at the expense of de-forestation in another country.

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