Climate change and Irish forestry

Eugene Hendrick and Kevin Black[1]

Key points

- *Climate change, caused by emissions of greenhouse gases, is forecast to have devastating impacts on human society, unless emissions are checked and reversed.*
- *Deforestation (loss of forest cover) is one of the major contributors to climate change, and currently accounts for 17% of global greenhouse gas emissions.*
- *On the other hand, the forestry sector provides a range of opportunities to mitigate rises in greenhouse gas levels, including:*
  - *afforestation/reforestation;*
  - *forest management;*
  - *reduced deforestation (land use change from to forest to non-forest);*
  - *increased use of wood products;*
  - *use of forest products for bioenergy to replace fossil fuel use.*
- *The total carbon reservoir or store in Irish forests currently exceeds one billion tonnes of carbon dioxide, most of which is in the soil.*
- *Annual removal of carbon dioxide from the atmosphere by Ireland's forests exceeds 6 million tonnes per annum, or 3.6 million tonnes net of carbon dioxide removed in roundwood harvest.*
- *Kyoto forests - those established since 1990 – will sequester 11 million tonnes of carbon dioxide over the 5-year period to the end of 2012, which will have in today's terms a value to Irish Exchequer of €220 million.*
- *Pre-1990 forests also sequester carbon, and contribute to climate change mitigation, but are not currently part of Ireland's forest carbon accounting regime.*
- *Maintaining the climate change benefits of Irish forests will require continuation of the national afforestation programme at a rate exceeding 10,000 ha per annum over the next two decades.*
- *Deforestation at the national level needs to be controlled in order to protect the climate change mitigation benefits of Ireland's forests.*
- *Wood energy and wind are the most important renewable sources. Government policy foresees major growth in the use of wood for energy generation in the future, another reason to maintain a 10,000 ha per annum afforestation programme.*
- *Forests also have an important role in helping society to adapt to existing and future climate change.*
- *Forests are themselves vulnerable to the impacts of climate change, and this must be considered when planning the management of future forests.*

COFORD
Arena House, Arena Road,
Sandyford, Dublin 18, Ireland
Telephone: +353 1 2130725
Email: info@coford.ie
http://www.coford.ie

[1] *Corresponding author: FERS Ltd, 117 East Courtyard, Tullyvale, Cabinteely, Dublin 18 and School of Biological and Environmental Science, UCD. Email: kevin.black@ucd.ie.*

Climate change - causes and impacts

There is strong international scientific agreement that climate change, manifested as rising surface temperatures, increasing frequency of drought and other extreme weather events, is directly due to the combustion of fossil fuels and intensification of land use. According to the latest assessment report of the Intergovernmental Panel on Climate Change (IPCC):[2]

> *Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.*

Scientists also agree that the main contributor to climate change is the accumulation of greenhouse gases in the atmosphere, mainly carbon dioxide (from fossil fuel combustion and deforestation), methane (from livestock) and nitrous oxide (from fertiliser use and drainage). Energy generation from fossil fuel is the largest contributor to emissions but the combined emissions from agriculture and deforestation (clearance of forest for agriculture and other land uses) constitute the largest global source of greenhouse gases (Figure 1).

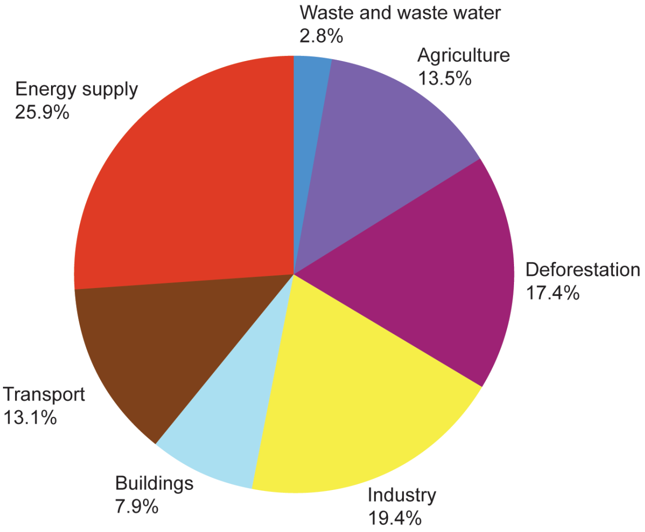


Figure 1: Sectoral share of global greenhouse gas emissions (IPCC 2007).

The role of forestry in climate change

Land use and land-use change contribute substantially to global greenhouse gas emissions, but they also offer significant potential to reduce emissions. The authors of the forestry chapter of the IPCC Fourth Assessment Report state:

> *Unlike many other sectors, forestry can contribute both to reducing emission sources and to increasing sinks. Due to the direct link between land-use decisions and sustainable development, forestry plays a key role when addressing the climate change problem in the broader context of global change and sustainable development.*

The report identifies the potential of forestry to reduce greenhouse gas emissions at the global scale as some 1,180 million tonnes of carbon dioxide per year by 2010. However, technical and institutional barriers such as land availability and the ability to finance forestry projects will reduce the potential to a fraction of the potential. The report identifies the following key mitigation technologies and practices in the forestry sector:

- afforestation/reforestation;
- forest management;
- reduced deforestation;
- increased use of wood products;
- use of forest products for bioenergy to replace fossil fuel use.

All the measures identified in the IPCC Fourth Assessment report are of direct relevance to forest policy and practice in Ireland. However, in order to develop and implement policy, baseline and forecast forest sink data are needed. Good quality data for the forest sector in Ireland are now available from the national forest inventory completed in 2007, the COFORD-funded CARBWARE[3] project, and statistical information on wood harvest and wood product use in Ireland.[4]

[2] *Climate Change 2007: Synthesis Report, Summary for Policymakers, based on the Fourth Assessment Report of the Intergovernmental Panel on climate change.*

[3] *CARBWARE is the national forest carbon reporting system and associated software. It is also the name of the COFORD funded project that develops the system and provides annual forest carbon stocks and stock change in Irish forests to the UNFCCC. The project also carries out projections of the national forest sink on behalf of the EPA, as well as scenario analysis for the Forest Service, government departments and other agencies. Data inputs are provided by the EPA, Forest Service, Coillte and other agencies, as well as other COFORD-funded projects such as CARBiFOR and FORESTSOILC. CARBWARE also extends to the development of forest growth models, and ascertaining levels of uncertainty associated with estimates. COFORD-funded climate change research is coordinated under the CLIMIT programme.*

[4] *The Joint Forest Sector Questionnaire (EUROSTAT/FAO/ITTO), compiled annually by COFORD.*

Irish forests - carbon reservoirs and sinks

Box 1: Reservoirs and sinks

It is important to distinguish two key concepts in terms of forests and climate change:

- A **reservoir** is defined under the Climate Change Convention as: *a component or components of the climate system where a greenhouse gas … is stored.*
- A **sink** is defined as: *any process, activity or mechanism which removes a greenhouse gas … from the atmosphere.*

Under these definitions, **forests** are a carbon reservoir and **forestry** (afforestation and forest management) is a carbon sink.

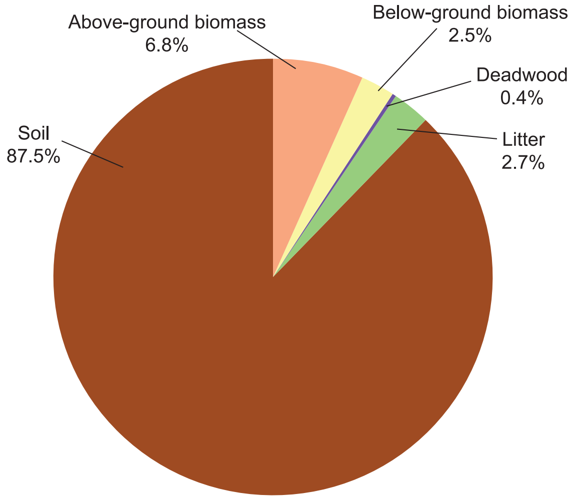


Figure 2: Proportionate carbon dioxide store in different pools in Irish forests in 2006.

Under the definitions in Box 1, forests are a carbon reservoir and forestry (afforestation and forest management) is a carbon sink.

The total carbon reservoir or store in Irish forests[5] currently exceeds one billion tonnes of carbon dioxide. By comparison, Ireland's total emissions of greenhouse gases in 2006 was 69.8 million tonnes of carbon dioxide equivalent, or less than 7% of the amount stored in forests.

Forests currently occupy just 10% of the land cover of Ireland, they are relatively young and productive, and research indicates that a doubling of forest cover is well within technical reach. So, in the future, there is significant scope for adding to the forest reservoir and enhancing the mitigation effort by forestry sinks.

Looking at the Irish forest estate as a whole, over 90% of the total amount of carbon is stored in the soil and litter pools (Figure 2). One of the main reasons for the high level of soil carbon is that many Irish forests have been established on peat soils, which have high levels of carbon to begin with. However, the Irish situation is not unique - similar levels of soil carbon are found in many forests at the higher northern latitudes, where it builds up slowly over hundreds of years from leaf and needle decomposition.

In contrast to soil carbon, biomass carbon can accumulate rapidly in newly established forests, and will continue to do so for many decades and indeed centuries, if left undisturbed. Conifer forests rapidly accumulate carbon once they are established; broadleaves do so at a slower rate, but over time will accumulate close to the same total amount of carbon in their biomass on a unit area basis. The biomass pool in Irish forests in 2006 was estimated by the National Forest Inventory as 111 million tonnes of carbon dioxide (10% of the total).

Carbon and carbon dioxide are the units of currency in climate change, but they are sometimes used inaccurately, which confuses an already complex topic; Box 2 sets out how the terms differ and how they are used.

Box 2: What is the difference between carbon and carbon dioxide?

Carbon is the element and carbon dioxide is the gas molecule. One tonne of carbon is equivalent to 3.67 tonnes of carbon dioxide, obtained by multiplying by 44/12 (the ratio of the molecular weight of carbon dioxide to carbon). Similarly, carbon dioxide is converted to carbon by dividing by 44/12.

Where numbers are quoted as carbon dioxide equivalents, or CO_2eq, it normally means all greenhouse gases are included and expressed relative to the global warming potential (GWP) of carbon dioxide. GWP is a measurement of the impact that a particular gas has on retaining heat/energy in the earth's atmosphere. Carbon dioxide has a GWP of 1, methane is 21 and nitrous oxide is 310.

In this document carbon storage/sequestration is reported as million tonnes of carbon dioxide. Million tonnes is the same as M t or mega tonnes, which is the unit frequently used in reports.

When prices are quoted they are almost always as per tonne of carbon dioxide.

[5] *For reporting purposes forests are defined as land units with a minimum area of 0.1 hectare, a minimum width of 20 m, trees higher than 5 m and a canopy cover of more than 20%, within a forest boundary, or trees should be able to reach these thresholds (as defined in the National Forest Inventory).*

The Kyoto Protocol and Kyoto forests

The Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC) was agreed in 1997 and sets out greenhouse gas emission reduction targets for each developed country. The overall reduction target is 5% compared to 1990 levels, to be achieved over the period 2008-2012. Based on the EU burden sharing agreement, Ireland's target is +13% of its 1990 emissions. Annex A to the protocol sets out the greenhouse gases and sectors which Parties include in their annual inventory report.

Articles 3.3 and 3.4 of the protocol deal with forestry. Article 3.3 sets out the overall framework for the mandatory accounting of carbon stock changes arising from afforestation and deforestation activities since 1990, over the commitment period 2008-2012. Article 3.4 encompasses four land use activities:

- cropland management;
- forest management;
- grazing land management;
- revegetation.

Selection of the activities to be included in carbon accounting is voluntary. Forest management covers carbon stock changes in forests that were in existence prior to 1990. Countries had to choose, by the end of 2006, whether to account for Article 3.4 activities. Ireland chose not to account for any of the activities, mainly due to data uncertainties. The recent completion of the first National Forest Inventory, however, places the country in a stronger position to include forest management in accounting for carbon stock changes post 2012.

The National Climate Change Strategy sets out a series of measures that are designed to meet Ireland's greenhouse gas emission target over the period to the end of 2012. Forest sinks (afforestation since 1990 – the Kyoto forest) is by far the largest measure identified. The contribution is estimated at 2.08 million tonnes of carbon dioxide in 2008. More recent projections provided by COFORD to the EPA estimate that the average annual sink between 2008 and 2012 will be 2.2 million tonnes of carbon dioxide. Looking to the period beyond 2012, it is expected that the sink will increase on an annual basis to reach over 4 million tonnes of carbon dioxide by 2020 (Figure 3).

Based on a price of €20 per tonne of carbon dioxide, the forest sink is likely to save the Exchequer an average of €44 million per year between now and the end of 2012, or €220 million in total. Actual savings will be higher or lower depending on a number of factors, including the price of carbon, and levels of afforestation, harvest and deforestation.

Calculating forest carbon stock change at the national level is based on common reporting formats provided by the UNFCCC and on the Good Practice Guidance for Land Use, Land-Use Change and Forestry published by the Intergovernmental Panel on Climate Change (IPCC). COFORD has developed a national carbon reporting and projection system (CARBWARE), based on the UNFCCC and IPCC formats. The system is outlined in Box 3.

Applying the calculations outlined provides the following overview of the national forestry sink:

- for 2008 the forestry sink (gross uptake of Irish forests) is estimated to be 6.2 million tonnes of carbon dioxide, or
- 3.6 million tonnes net of wood harvest and deforestation,
- of the 3.6 million tonnes, some 2 million sequestered in Article 3.3 (Kyoto) forests,
- with the balance of 1.6 million tonnes being stored in the non-Kyoto forests (Figure 4).

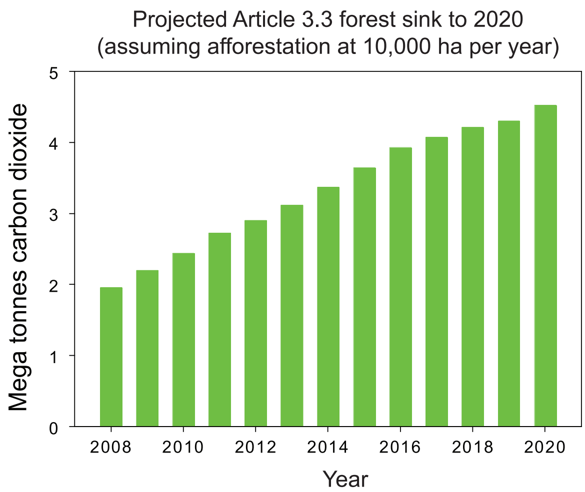


Figure 3: Ireland's annual projected forest sink to 2020 under the Kyoto Protocol.

Box 3: How is the national forest sink calculated?

CARBWARE was first developed in 2002 in response to the need to estimate and report annual changes in forest carbon stocks to the UNFCCC, as well as to gauge the impact of afforestation and deforestation rates, and the level of harvest, on future carbon stocks.

Since 2002 CARBWARE has undergone extensive refinement and improvement, at first only biomass could be estimated; now the model estimates changes in four of the five carbon pools needed for international reporting: above-ground biomass, below-ground biomass, deadwood and litter. Changes in carbon stocks in the fifth pool - soil carbon - are the hardest to detect. It is the largest pool in forest ecosystems in Ireland, but also has the slowest rate of change. Work is underway in COFORD-funded projects to estimate carbon stock changes in the soil pool of the Kyoto forest.

The gross uptake of 'Kyoto' and 'Non Kyoto' forests (Figure 4) is based on net annual stock changes in the five carbon pools (Figure 5) and by taking into account greenhouse gas emissions resulting from forest fires and fertiliser application. Total greenhouse gas emissions (carbon dioxide, methane from fires and nitrous oxide from fertilisation) are expressed as carbon dioxide equivalents. Harvest and deforestation are netted off to arrive at net uptake.

CARBWARE is being updated as new findings become available from other COFORD climate change projects, the national forest inventory and other sources.

COFORD-funded climate change projects are outlined in the COFORD Annual Report (www.coford.ie).

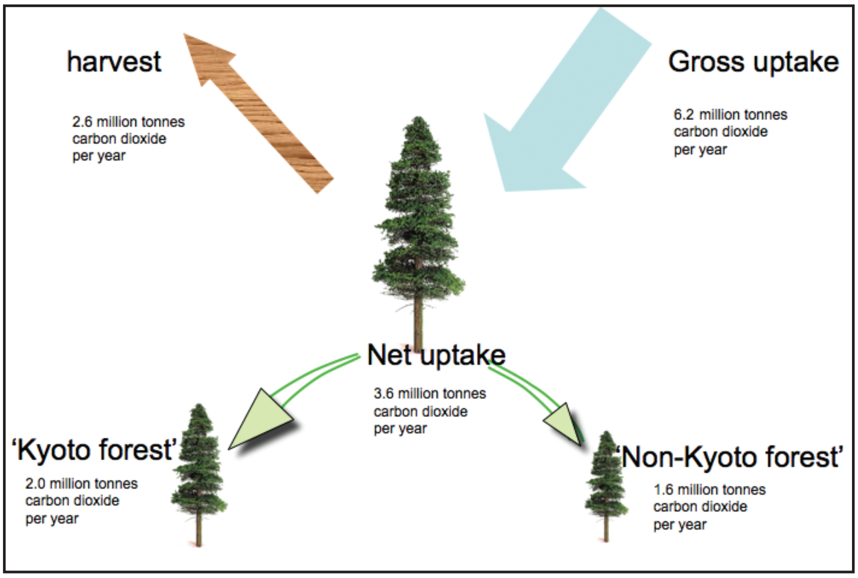


Figure 4: Simplified carbon balance of Ireland's forests in 2008.

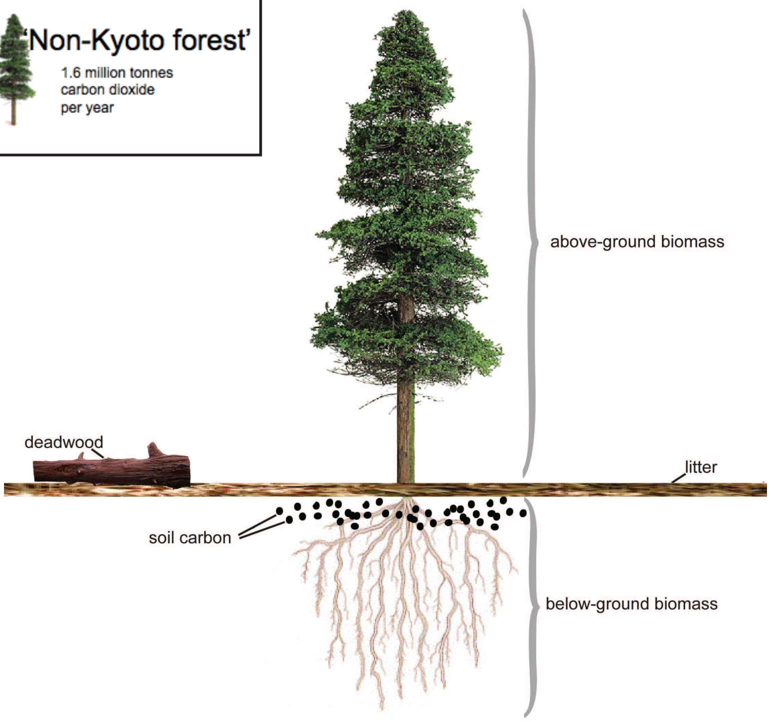


Figure 5: The five forest ecosystem carbon pools recognised in the international carbon accounting system.

Wood energy

A significant proportion of the harvest from the Kyoto forest is destined for the energy market, for heating and/or power generation. As far as the climate is concerned, combustion of wood fuel is carbon neutral, as long as the harvested wood comes from forests that are sustainably managed (Box 4). At the national accounting level, emissions from wood fuel combustion are not included in the energy emissions account, as they have already been accounted for in the forest harvest (Box 3). This means that it is environmentally sound and economically prudent to use wood biomass for energy production, particularly in applications such as heating where there is a high energy efficiency.

Long term perspective on forests and climate change mitigation

While forestry in Ireland will make a significant contribution towards emission reductions and compliance with the national Kyoto target over the next decade, it needs to be considered over a far longer time frame, given the fact that emissions from the global deforestation of the past two centuries are contributing to today's climate change problems. Forestry is a long term business and needs a consistent and far seeking policy framework for it to be a cost-effective and efficient climate change mitigation tool. Two factors are key to providing long term climate change mitigation from forests:

- a balanced age structure to deliver an even stream of goods and services over time and
- maintaining forest once it is established.

Box 4: The wood energy story

One of the key mitigation strategies identified in the IPCC Fourth Assessment Report is the use of forest biomass to replace fossil fuel. At the EU level, the Biomass Action Plan, published at the end of 2005, foresees a doubling of the use of biomass for energy (mostly wood) - to reach 8% of overall energy supply by 2010 (7.7 PJ or 185 million tonnes oil equivalent).

Ireland's most recent policy statements - the Energy White Paper and the Bioenergy Action Plan - place a strong emphasis on wood use for heat, power and combined heat and power (CHP). Sustainable Energy Ireland has estimated that meeting the targets for the three sectors will require a supply of 4.2 million tonnes of wood fuel by 2020.

The latest year for which data are available, 2006, shows wood energy contributing 9 PJ or just over 1% of the Total Primary Energy Requirement of 666 PJ. Since 2006, wind has probably overtaken wood in terms of installed energy generation capacity. Nevertheless, wood energy use is also growing rapidly, in line with schemes administered by SEI, particularly the Renewable Heat Deployment Programme (ReHeat), which has approved the installation of 76 wood fuelled boilers, with an installed capacity of 36 MWheat, delivering emission savings of 47,500 tonnes of CO2 per year, or around €1 million in terms of emissions savings.

Displacing emissions from fossil fuels by using wood only makes sense if the forests the wood comes from are sustainably managed: the carbon dioxide released from combustion of wood is effectively taken up by the forests as they regrow following harvest. A small proportion of the energy obtained from wood fuel is used in harvesting and transport, but it is generally well below 10%. Forest fuels are one of the most efficient biofuels – little energy is expended in the growing of forests, unlike first generation liquid biofuels such as rape seed oil or ethanol derived from maize, where most of the energy output is cancelled out by energy inputs in the form of fertilisers and pesticides, and other inputs at sowing and harvesting and refining.

Calculating wood energy

- Energy value of wood is usually expressed in Giga Joules (GJ) per tonne or per cubic metre. The average energy value of a fresh green tonne of Sitka spruce is about 6 GJ.
- There are 1 million GJ in a PJ.
- Hence, to generate 9 PJ or 9,000,000 GJ of energy would need a supply of 1.5 million tonnes of fresh Sitka spruce per annum. In practice, the wood energy supply in Ireland comes mainly from board manufacture and sawmilling residues, the recycled wood stream, and a growing contribution from forest-derived energy assortments.

Forests in Ireland are generally worked on rotation periods (between planting and final harvest) of 40-50 years. When the forest is felled at the end of, say, 50 years most of the carbon is removed in the harvest. If, at the national level, there is an even age structure of forests following on (more or less the same area of forest in each age class from 1-50 years), then the overall level of carbon stored, and being stored, will not diminish (provided all felled areas are regenerated to the same carbon stock). If there is less forest following on, then it will be unable to fully replenish the carbon removed in harvest.

What has happened in Ireland is that since 1985 there has been a rapid expansion in private sector afforestation until 4-5 years ago when it began to tail off (Figure 6). If this downward trend continues, forests that come under Article 3.3 will, at the national level, become a net source of emissions (due to harvest and associated disturbance).

COFORD has carried out an analysis of the afforestation trend and the implications it will have for the future climate change contribution of forests that come under the Article 3.3 umbrella. It shows that if afforestation falls to around the 7,500 ha per annum level (the recent rate), then by 2035 or so these forests will become a net source of greenhouse gas emissions, under current rules (Figure 7). Not only will the carbon sink turn negative, but the level of wood energy supply will also fall off as the forests mature and produce larger tree sizes, destined for higher value markets than fuel.

The second key factor is that climate change mitigation by forests depends above all else on maintaining the land use as forest - if not the carbon sequestered will be lost back to the atmosphere, and the sustainability of wood energy is called into question. In terms of policy and investment it makes little sense to first establish forest (at considerable cost to the state and the land owner) and then to remove it (at considerable cost to the state in terms of emissions accounted for).

Carbon accounting works on the principle that carbon in the wood harvest is immediately emitted to the atmosphere, and in the absence of replanting it is not replaced. An annual rate of deforestation of 1,000 ha would reduce the allowable sink by close on half a million tonnes of carbon dioxide – or a cost in the region of €10 million.

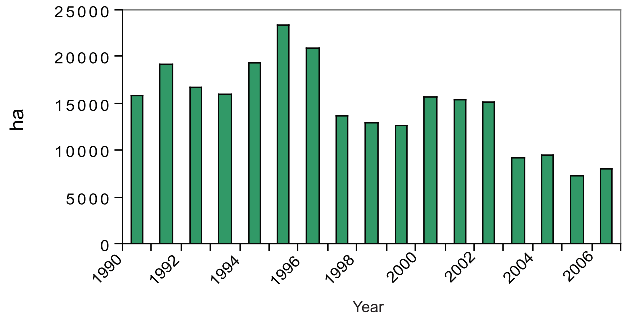


Figure 6: Annual afforestation rate in Ireland, 1990-2007.

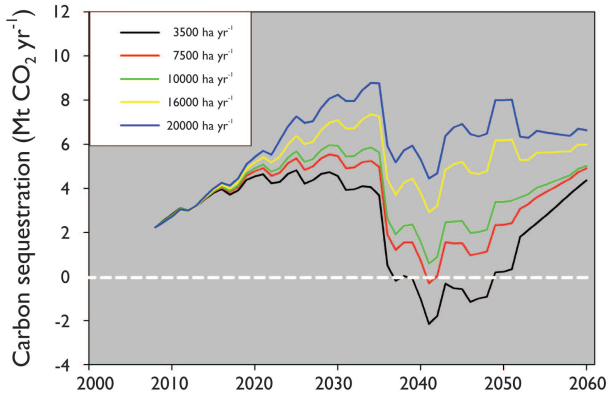


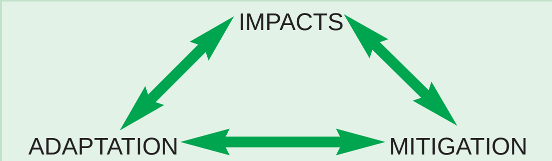
Figure 7: Projected sequestration of carbon dioxide by Kyoto forests to 2060, based on afforestation rate (note emissions for 3,000 and 7,500 ha per annum rates post 2035).

Adaptation to climate change

Policies for adapting to climate change are closely related to carbon sequestration and mitigation. For example, a country using new forests to mitigate climate change needs to consider how climate change itself will impact on the species used, and whether different species may be more appropriate in terms of future rainfall and wind patterns. Mitigation measures also provide opportunities for adaptation, and increasing forest cover may provide some level of protection against extreme weather events such as flooding.

The IPCC Fourth Assessment Report has highlighted the interaction between the impacts of climate change, adaptation for sustainable forestry and mitigation options. Future climate change policies and actions in relation to forests need to consider these factors (Box 5).

Box 5: Climate change impacts, their mitigation and relationship to adaptive strategies



Climate change and its interaction with forests is an interrelated process involving:

1. the effect of climate change on forests (impacts),
2. how afforestation and forest management can be used to reduce (through uptake of carbon dioxide) the rising level of greenhouse gases in the atmosphere (mitigation), and
3. how adaptive strategies will help to address threats from impacts of climate change, through for example, changing species composition.

Forests can also contribute to adaptation of vulnerable areas to climate change, for example by the establishment of new forests to stabilise soils prone to erosion.

Overall, understanding the potential impact of future climate change is key to developing adaptation and mitigation strategies. Over the past two decades much has been learned from national and international research on the impact of climate change on forest growth and productivity, the contribution of forests to carbon sequestration and emission reductions, changes in the potential distribution of species and the impacts of extreme events. This research forms the basis for formulating effective mitigation and adaptation policies, in the context of the interactions outlined in the diagram:

- if mitigation or adaptation actions are not taken, forests will be more vulnerable to climate change and this will be exacerbated by further global climate change, but
- the introduction of adaptation policies in the forest sector will reduce the risk of these potential impacts, and
- mitigation of climate change also contributes to a weakening of future impacts and the level of adaptation required.

Forecasted changes in Ireland's climate will have a significant influence on the productivity of managed forests and woodlands. Given the long term nature of forestry, the selection of suitable provenances or genotypes and adaptable management practices under future climate change scenarios are essential for sustainable forestry in Ireland. A COFORD-funded project CLIMADAPT[6] is currently investigating potential impacts of climate change on forest productivity, in order to identify and provide adaptation measures. These include species and provenance selection, natural regeneration, shorter rotations, and how to deal with increased incidences of windthrow and pests.

Summary and conclusions

Forests provide a range of raw materials for industry as well as services to society. In order to sustain production and service provision a well balanced age structure is needed at the national forest level. One of the main services provided by forests - climate change mitigation - is strongly dependent on having young age classes to balance out harvest and other decreases in carbon stocks. In the Irish context this entails the need to continue afforestation at a 10,000 ha plus level for the next two decades. Achievement of this goal will not only sustain the ability of the national forest estate to remove carbon dioxide from the atmosphere, it will also provide a renewable energy resource and a sustainable raw material for construction and a range of other uses. Expansion of the national forest estate should therefore be a key component of national climate change and land use policy.

[6] *A description of the CLIMADAPT project is available at www.coford.ie and in the most recent COFORD Annual Report.*