COFORD

Forests and wood products, and their importance in climate change mitigation

A Series of COFORD Statements

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COFORD working group and lead authors of statements

The COFORD Working Group on Forests, Climate Change Mitigation and Adaption, which has as its aim to highlight and promote the role that forests, and forest products play in climate change mitigation and to raise awareness of the impacts of climate change on forests and forestry practice.

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Impacts and Adaptation to Climate Change: Tom Houlihan.
Wood Products and their Role in National Policy: Des O'Toole and Annette Harte.

Executive Summary

Introduction

Human activity is widely accepted as the main cause of global warming and experts predict temperatures to reach 1.5°C above pre-industrial levels between 2030 and 2052, if we continue on the current trajectory. Greenhouse gas (GHG) emissions cause long-lasting changes in our climate system, increasing the likelihood of severe and irreversible impacts for people and ecosystems.

A number of policy instruments have been developed at global, EU and national levels which set targets for emissions reduction. Under the Paris Agreement, Ireland has committed to limiting temperature rise to less than 2°C above pre-industrial levels and must pursue efforts to limit temperature rise to less than 1.5°C. The European Commission has stated its intention to raise the EU target of reducing GHG emissions to at least 55% below 1990 levels by 2030 and achieving carbon neutrality across all sectors by 2050. In line with this, Ireland aims to balance emissions and removals of GHG within the State by the end of 2050 and in subsequent years.

This series of COFORD statements aim to inform the general public and policymakers of the critical importance of forests and the forest products in the achievement of the goals of the Paris Agreement. Well planned and sustainably managed forests play an important role in sequestering and storing carbon, thereby mitigating climate change. The challenge is to enable that contribution to be fully realised over the period to 2050 and beyond. COFORD aims to address this challenge through the publication of the following statements.

Statement on Forests, Land Use and Climate Change Mitigation considers the important role of forests in addressing climate change challenges and how our forests form a significant part of Ireland's policy to tackle global warming. The statement details the role of forests as a carbon sink and store, EU land use policy, land use sustainability and carbon accounting rules for forest lands. It sets out recommendations for afforestation rates and the silvilcultural management needed to secure the long term climate mitigation benefit of forests.

The **Statement on the Impacts and Adaptation to Climate Change** considers the climate change impacts on the forest sector in Ireland, as well as adaptation responses and options. It reviews a selection of European and national policy papers, and considers relevant concepts, such as forest resilience and prioritisation of identified climate change impacts. It also focuses on recommended actions to increase resilience and target current vulnerabilities, as well as promoting co-ordinated research, policies and strategies across the forest value chain.

The **Statement on Wood Products and their Role in National Policy** considers the role of wood products in climate change mitigation and in achieving emissions reductions in our built environment. It reviews current national and international climate policy and the mechanisms required to decarbonise the construction sector. It examines modern methods of construction and models the carbon saving benefits of increased use of timber under a range of scenarios. Lifecycle analysis is also included. Recommended actions are outlined in relation to policy change and strategies to fully realise the mitigating impacts of wood products in future construction in Ireland.

Statement on Forests, Land Use and Climate Change Mitigation

All land use needs to be seen through a climate change as well as a production lens. Ireland must conserve its carbon store through the promotion of sustainable forest management, as well as promoting and co-operating in the conservation and enhancement, as appropriate, of all carbon sinks and reservoirs. Both afforestation and forest management are seen as cost-effective climate change mitigation options, in combination with deep cuts in emissions and other land-based mitigation options.

Recommendations

- COFORD concludes that a greatly expanded and sustained afforestation programme of between 8,000 and 16,000 ha per year, coupled with a significant reduction in agricultural emissions and increased carbon removals in other land uses, over the coming three decades will be necessary for Ireland to approach carbon neutrality in land use by mid-century in accordance with the Paris goals. Increased promotion and effort, allied to long-term policy change, is required to enable the increases in afforestation rates envisaged.
- Early action is critical to ensure that the land sector can deliver on Paris commitments. Today's afforestation is the future built environment and circular economy, providing low carbon materials and energy, thereby moving the land sector towards climate sustainability.
- There is significant potential for forest establishment on appropriate land types where trees will flourish and remove carbon dioxide from the atmosphere. Analysis suggests that there is an ample land base available in Ireland to approach a forest cover of 18% by mid-century.
- Allied to the afforestation programme is the need to greatly expand the use of wood products in the built environment as the use of long-lived wood products is a valuable carbon store.
- All forest types play a role in contributing to ecosystem services, biodiversity conservation, and climate change mitigation and adaptation. For conifer crops in Ireland, the range in mean carbon uptake over a rotation is between 3 and 10 tonnes of carbon dioxide per hectare, per year. For broadleaved species, the mean ranges from 2 to 5 tonnes of carbon dioxide per hectare, per year.
- Forest sinks act to constrain carbon dioxide levels in the atmosphere. If deforestation rates are reduced there will be a significant increase in net carbon dioxide removals in the forest estate. On a per hectare basis, the annual rate of carbon uptake is typically about one twentieth of the release of carbon from deforestation. Every effort must therefore be made to maintain areas in forest.
- Any loosening of the replanting obligation following clearfelling carries a risk of creating further deforestation and of potentially reducing the sink amounts to well below those indicated over the period 2021-2030.
- Forest management of the existing forest estate is an important influence on carbon sequestration and carbon stocks, and can be an important mitigation tool in reducing emissions.
- It is timely to explore the issues around the potential introduction of a voluntary carbon code in Ireland.
- Further research is required to quantify the carbon sequestration impact of tree planting, wetland restoration, hedgerow expansion or other measures in the relevant land use categories, in order to include these amounts in the national accounts.

Statement on the Impacts and Adaptation to Climate Change

By mid century the effects of climate change in Ireland are predicted to include an increase in mean annual temperature, increased length of the growing season, and an increase in heavy rainfall events. A decrease is predicted in the number of frost days, as well as spring and summer rainfall reduction. Storms will decrease in frequency but will increase in intensity. As a result, the climatic threats to forestry include growth rate changes, and increased risk of wind-throw, drought stress, fire, and harmful pathogens.

There is an urgent need to develop adaptation measures to future-proof the outputs of goods and services from Irish forests. A range of measured and evidence based new initiatives is required and should be supported by ongoing research, and frequent and careful monitoring and review. The following are some of the key recommendations for consideration;

Forest Genetics

- Further research into the use of forest genetic resources. In particular, the re-evaluation of species, provenance and origin recommendations in light of the changing climate.

- Further development of improved forest basic material. In particular, the need to target key important species and implement selection and breeding strategies aimed at increasing climate resilience.

- Further support for genetic conservation efforts, including in situ and ex situ conservation, as well as for participation in pan-European processes on genetic conservation.

- Regarding the deployment of forest genetic resources, there is a need to focus on diversity, both between species and within species, and consider the range of options for deployment that a changing climate may provide. For native species, strategies such as assisted migration may be considered. However, for native woodland establishment, or native woodland restoration or rehabilitation, the adaptive potential of our native provenances may first need to be studied in greater detail before such a strategy is recommended as the preferred option.

Forest Design

- Complementary tree species within forest stands should be combined with the use of mosaics of suitable forest types at the landscape level.
- The development and integration of appropriate Decision Support Systems and resources will increase knowledge on issues such as relative growth rates, silviculture, yields and usability for practitioners, and encourage uptake.

Forest Management

- Performing assessments of the impacts, financial and otherwise, of silvicultural choices that may be appropriate in the future should be a focus area.
- Opportunities to incorporate several ecosystem service indicators in an appropriate Forest Management Decision Support System should be investigated.

Protection/Ongoing Monitoring

- Development of suitable early warning systems through appropriate pest risk analysis will play a key role in the protection of Ireland's forest resource.
- Frequent and cost-effective monitoring methodologies will be required to achieve detection of the early onset of impacts such as pests, maladaptation, and wind damage.

Cross-sectoral interdependencies

- Further targeted research on climate change impacts for the agriculture, forest and seafood sector, including examination of cross-sectoral interdependencies, will be required to achieve the type of policy integration required for the development of a cross-sectoral adaptation plan.

Statement on Wood Products and their Role in National Policy

Energy use for heating and cooling of buildings represents 28% of global energy related CO2eq emissions (increasing to 38% when embodied emissions are included). Thus reducing the carbon footprint of our future building stock is a key part of tackling climate change.

The importance of a whole life-cycle approach to the evaluation of building emissions is now accepted as increasingly necessary to assess the true carbon footprint of what we build. The materials we choose provide an opportunity to significantly reduce this environmental impact. Wood products contribute to reducing the life cycle emissions of buildings through (i) low embodied CO2eq, (ii) carbon sequestration/storage and (iii) substitution effects where wood grown in Irish forests can substitute more carbon intensive building materials, while at the same time supporting local employment in the forestry supply chain.

House building in Ireland is mostly low-rise, with timber frame accounting for only 24%, which is low by European standards. Analysis shows that increasing the use of timber frame and adopting new engineered wood technologies such as CLT for high rise applications has the potential to reduce CO2eq emissions by 3.4 million tonnes by 2050.

Recommendations

- Central government and local authorities should promote the use of a wood first policy and should introduce whole life carbon reporting throughout the construction sector.
- An Irish-specific building carbon foot printing tool should be developed by the end of 2023.
- Producers of timber construction products should undertake Life Cycle Analysis and specify Environmental Product Declaration for their products.
- Demonstrate the fire resistance of timber buildings by fire design to European standards should continue to be allowed in the Technical Guidance Documents (TGD) to the Building Regulations.
- DAFM working with industry, third level and other state institutions to continue to improve knowledge of timber as a construction material, the design of timber buildings and whole life cycle assessment of buildings among construction professionals.
- Develop materials to inform the general public about developments in timber construction and the associated benefits of using more timber in buildings.
- Ensure that the Climate Action Plan encourages policies, steps, and measures to increase the use of wood and wood products in climate change mitigation and adaptation.

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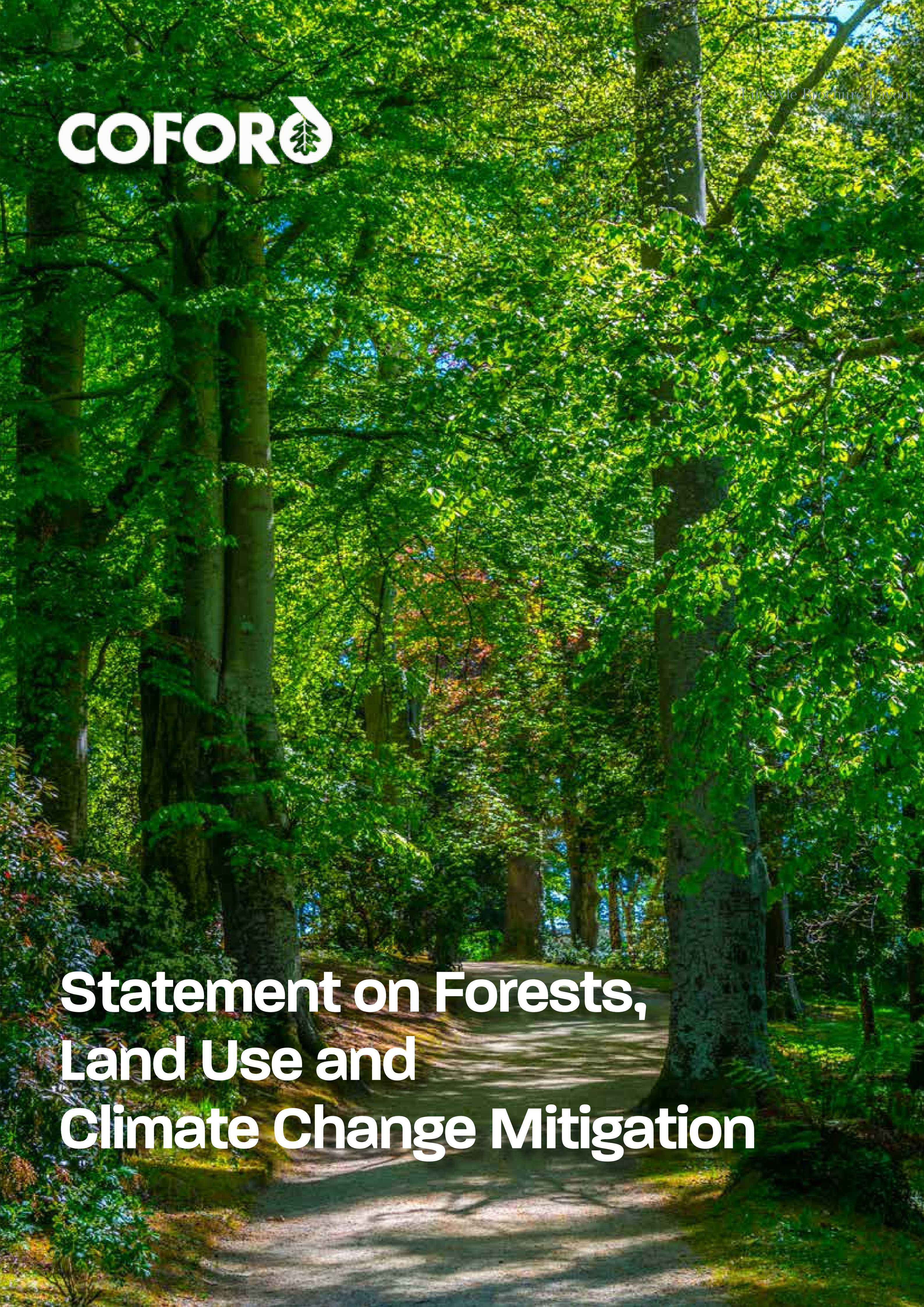


Statement on Forests, Land Use and Climate Change Mitigation

Introduction and key message

This COFORD statement on forests and climate change outlines the role that forests in Ireland, and across the globe, play in the carbon cycle.

As regards mitigation of climate change, the main role forests play is through the uptake of carbon dioxide by photosynthesis and storage of carbon in biomass and soils. The statement aims to inform the general public and policymakers of the critical importance of forests in the achievement of the goals of the Paris Agreement.

We show that Ireland can contribute to these objectives through the expansion of the forest resource, in the context of sustainable forest management. Expansion will provide for climate change mitigation, as well as a range of other ecosystem services, including a predictable and sustainable harvest of wood and other forest products.

COFORD concludes that a greatly expanded and sustained afforestation programme of between 8,000 and 16,000 ha per year, coupled with a significant reduction in agricultural emissions and increased carbon removals in other land uses, over the coming three decades will be necessary for Ireland to approach carbon neutrality in land use by mid-century in accordance with the Paris goals. Allied to the afforestation programme is the need to greatly expand the use of wood products in the built environment, and woodfuels to displace fossil fuels in heating.

It must be said that increasing afforestation rates above current low levels ranging between 2,000-3,000 ha per year, to a level approaching 16,000 ha per year will prove to be extremely challenging, but there is little doubt this level of uptake is required, along with deep reductions in greenhouse gas emissions, to move towards the carbon neutrality goal.

[1] All figures and illustrations used are in the public domain – text and comments are

Forests are an integral part of the Irish landscape

Climate change and global warming

Global warming is defined by the Intergovernmental Panel on Climate Change (IPCC) as:

> *the estimated increase in global mean surface temperature (GMST) averaged over a 30-year period, or the 30-year period centred on a particular year or decade, expressed relative to pre-industrial levels unless otherwise specified.*

Based on trends that span 30-year periods, the current multi-decadal warming trend is assumed to continue into the future. The World Meteorological Organization has stated that the average global temperature for 2015-2019 is expected to be the warmest of any equivalent period on record.

Human activity resulting in greenhouse gas emissions (occurring in recent years at rates higher than ever before), is widely accepted as the main cause of warming. According to the 2018 IPCC Special Report on Global Warming of 1.5°C (IPCC SR1.5):

> *Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.*

On impacts, the IPCC Fifth Assessment Report states:

> *Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks.*

Importance of wood product use in a circular economy

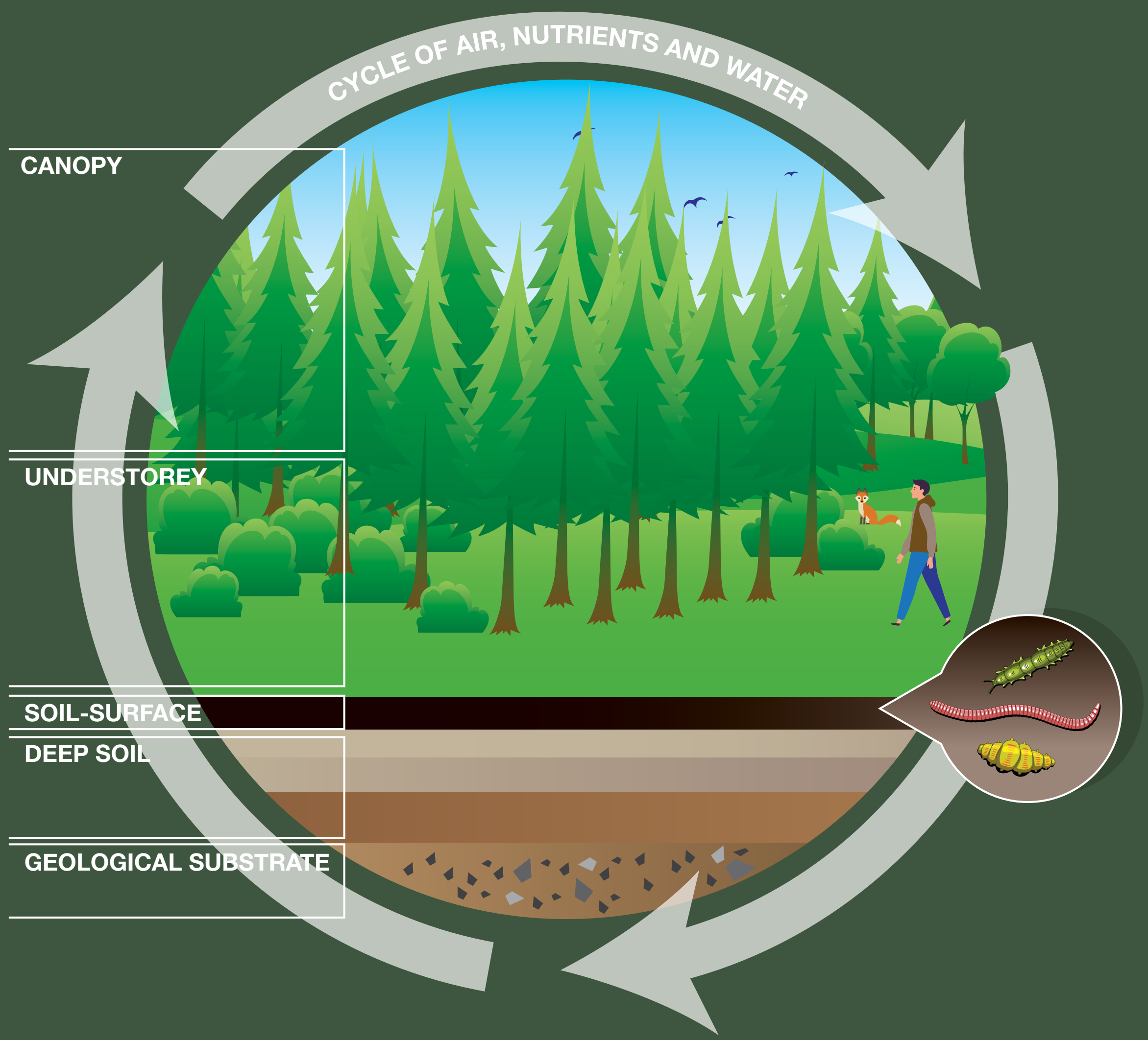
Wood and other forest products also contribute to mitigation of climate change through the displacement of fossil fuels and the substitution of a wide range of synthetic materials derived from oil, as well as cement and steel in the built environment. A separate COFORD statement deals with the role of wood products in climate change mitigation. This statement focusses on the role of forests in climate change mitigation.

Cladding and structural applications of sawnwood

Climate change mitigation – one of a range of ecosystem services from forests

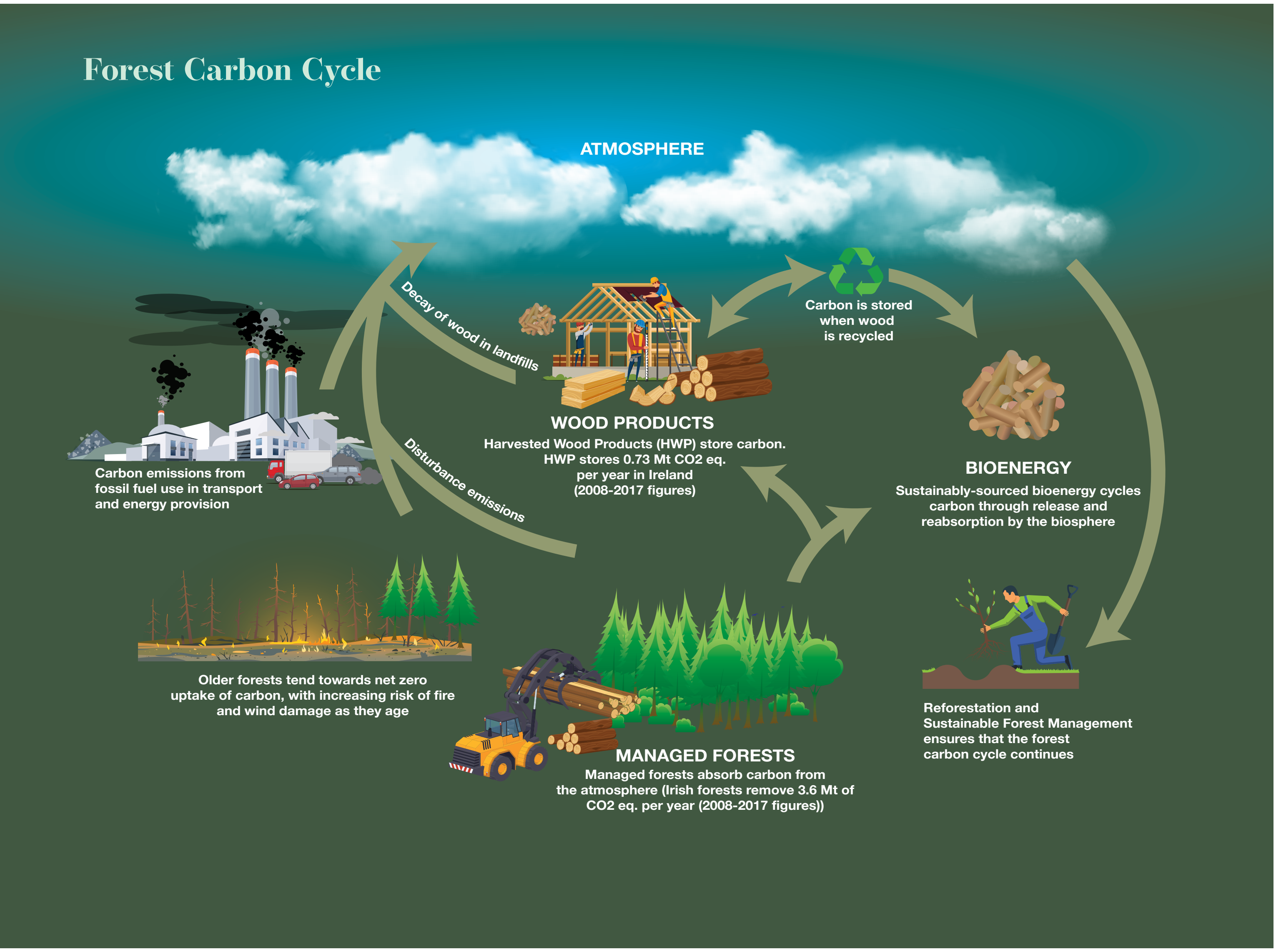
The main imperative in tackling global warming is on reducing emissions, especially from fossil fuel combustion, which includes oil, gas, coal and peat.

Forest ecosystem functions and supporting services



Climate change mitigation – one of a range of ecosystem services from forests

Across the landscape, well planned and sustainably managed forests play an important role in biodiversity conservation and enhancement – and in protecting water quality through riparian woodlands. These aims are now part of forest policy and practice which recognises the need for a balance between production, biodiversity, and the role of forests in sequestering and storing carbon and thereby mitigating climate change.



All forest types (broadleaf, conifer, and mixed forests) have a role to play in contributing to the range of ecosystem services required by society. The challenge is to enable that contribution to be fully realised over the period to 2050 and beyond.

Forest policy and expansion of the forest estate

Ireland has a large area of agricultural land devoted to food production. However, there is also significant potential for forest establishment on appropriate land types, and where trees will flourish and remove carbon dioxide from the atmosphere. Conservation, management, and harvest of forests provide skilful and sustainable employment, across a wide range of disciplines.

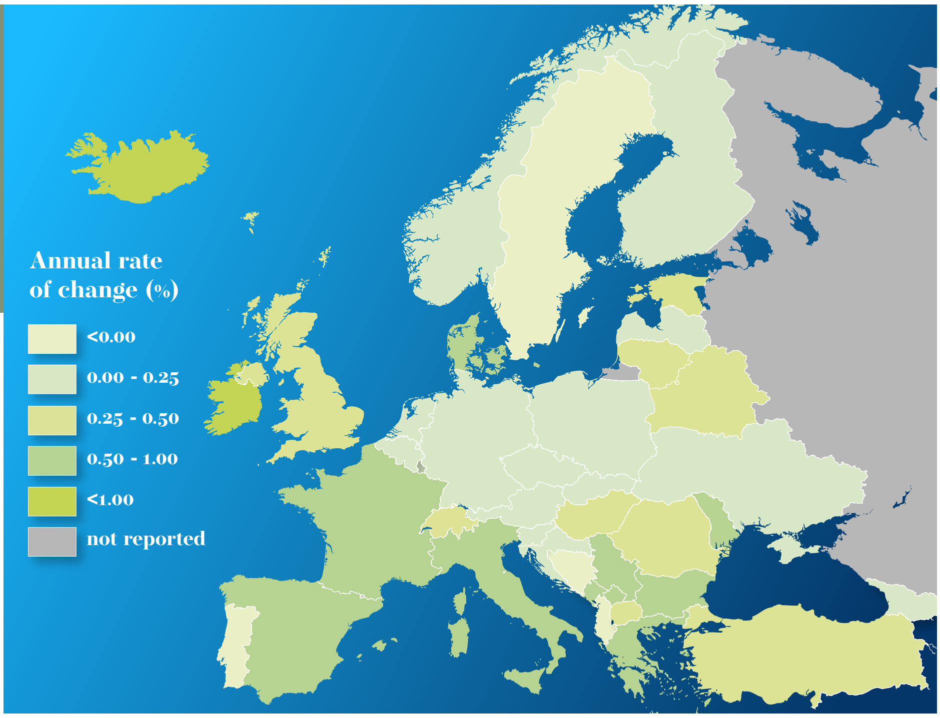
Ireland's forest area currently stands at around 770,000 ha or 11% of the land area. The current policy target is to increase forest area over the coming decades to reach 18%. Such an expansion would require 480,000 ha of new forest by 2050.

Forest resources – global and local

According to the 2020 *Forest Resource Assessment* from the Food and Agriculture Organization (FAO), global net forest area continued to decrease by some 4.7 million ha/year over 2010–2020. The rate of forest loss has decreased however - having reached an average of 7.8 million ha/year over the decade 1990-2000. Reductions in deforestation in some countries, plus increases in the forest area in others through afforestation and the natural expansion of forests are the main reasons for the decrease in the rate of net forest loss.

In Europe, net forest area is increasing due to a combination of afforestation and natural forest colonisation. By 2015 the total forest area had reached 1,015 million ha, storing some 45 billion tonnes of carbon in above and below-ground biomass. Forest area increased at 0.08% per annum over the period 1990-2015. Ireland's forest area also increased over the period to 2015 at an annual rate of 2%, or two and a half times faster than the European average. Over the past century, Ireland's forest cover has increased tenfold.

Annual (%) rate of change in forest area 1990-2020 (Forest Europe, 2020)



Carbon sinks and stores

Land and ocean sinks act to constrain global warming, though the persistence of the effect is uncertain due to climate change and other risks. Most forest carbon is found in the living biomass (44%) and soil organic matter (45%), with the remainder in deadwood and litter. At the global level, the total carbon stock in forests decreased from 668 billion tonnes in 1990 to 662 billion tonnes in 2020.

Carbon stocks, sinks and rates of uptake in Irish forests forest estate

Stocks

The stock of carbon in forests at a particular time can be used to illustrate the role of forests in removing and storing carbon. For example, as a result of forest expansion over the preceding century, Ireland's forests by 2017 comprised a store of close to 56 million tonnes of carbon (205 million tonnes of carbon dioxide) in living biomass. Should this resource be removed for whatever reason it would represent over three years of greenhouse gas emissions from the entire country (emissions in 2019 estimated as 59.9 million tonnes of carbon dioxide equivalent (CO_2eq) by the EPA.) Hence the importance of conserving forest carbon stocks, and by extension, the area of forest.

When deadwood and forest litter (decaying leaves, needles and small twigs on the forest floor), and soil carbon, were included, the total stock reached 312 million tonnes of carbon (National Forest Inventory, Forest Service 2017). The required action here is to conserve the carbon store, in line with Article 4 (d) of the United Nations Convention on Climate Change (UNFCCC) *... Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs ...*

Sinks

Another approach to understanding the role of forests in climate change mitigation is by reference to what is called the forest sink. Often confused with a carbon stock, a sink is a rate of carbon dioxide uptake over time by processes such as photosynthesis or ocean uptake. It is usually expressed as a net number, for as forests grow and take up carbon dioxide, they also release the gas through natural growth processes, and through the activities of soil organisms in breaking down organic matter. For carbon accounting purposes, the sink also nets off emissions as result of forest harvest for energy use, and from harvested wood products arising from harvest in the accounting country. As outlined, forest sinks act to constrain carbon dioxide levels in the atmosphere.

Forests and climate impacts

It is the sink that matters most for climate - the net annual exchange of carbon dioxide between forest and the atmosphere. This is entirely analogous to the way that emissions from fossil fuels are counted – the immediate concern is not how much carbon is stored in oil reservoirs, but rather the rate at which it is being released to the atmosphere.

Typical rates of carbon uptake in Irish forests

For forests the carbon sink is often expressed on a per hectare, per year rate. Values are highly dependent on the age of the forest, its productivity and species composition. As a rule of thumb, for conifer crops in Ireland the range in mean carbon uptake over a rotation is between 3 and 10 tonnes of carbon dioxide per hectare per year. For broadleaved species the mean ranges from 2 to 5 tonnes of carbon dioxide per hectare, per year (provisional estimates from Department of Agriculture, Food and the Marine).

The policy context of forests and climate change mitigation

In a policy framework, effective climate change mitigation depends on the setting of emission reduction targets relative to a base year, to be achieved by a certain date. Including forests in the framework provides incentives to retain and expand forest cover, thereby protecting stocks and enhancing sinks. Sustainable management of forest resources is also incentivised. Rules to account for forest carbon are essential to provide for transparency and the setting of a level playing field between countries, where there is an agreed common goal, such as in the Paris Agreement.

As forests take up carbon over several decades, the broad policy thrust of forest expansion and Sustainable Forest Management needs to be maintained to 2050, and beyond, in order to enable domestic forest policy. It will also help to secure the investment needed to realise the climate change mitigation benefits arising from forest expansion and management.

Both afforestation and forest management are seen by the IPCC as cost-effective climate change mitigation options, in combination with deep cuts in emissions and other land-based mitigation options. Pathways limiting global warming to 1.5°C (the Paris goal), require rapid and far-reaching transitions across energy provision, land use, and urban and industrial systems.

According to the IPCC, the scale of forest cover increase needed at the global level in order to stay within the Paris limits will be difficult, though not impossible, to achieve. One of the main constraining factors is competition with food production for an expanding population. In the context of rates foreseen, Ireland's proposed afforestation programme under the Climate Action Plan 2019 – some 8,000 ha per annum by 2030 – can be seen as an ambitious target. However even this rate is not likely to be sufficient, especially in the context of the recently announced EU's targets, to move Ireland towards carbon neutrality by 2050. Even in the context of significant emission reductions in other land uses, the 8,000 ha per anum rate will be insufficient.

Increased promotion and effort, allied to long-term policy change, is required to enable the increases in afforestation rates envisaged.

How is land use carbon taken into account in policy?

In the Irish context, carbon stock changes apply to the full range of land uses and related activities, including cropland, grassland and forestry. Today, all land use needs to be seen through a climate change as well as a production lens. For example, activities now extend to rewetting and restoration of harvested peatland in the Midlands region and elsewhere.

As part of the European Green Deal, the EU has set itself a binding target of achieving climate neutrality by 2050. In order to deliver this increased level of ambition, an intermediate target of 55% net emission reduction by 2030 is planned. The European Commission has launched its 'Fit for 55%' measures which includes proposals for LULUCF that sets targets for carbon removals by natural sinks.

In Ireland, afforestation could potentially contribute at least 9 - 15 million tonnes of LULUCF removals over the 2021-2030 period when taking into account current afforestation and deforestation rates. The actual contribution will depend on a number of factors, including future harvest and deforestation rates, and the level of afforestation[2]. If deforestation rates are reduced there will be a significant increase in net carbon dioxide removals in the forest estate. Every effort must therefore be made to maintain areas in forest.

Over the coming decade and beyond, forestry (and forest products) will be the single largest land-based climate mitigation measure available to Ireland. This is particularly relevant as we face a future where carbon emissions will be greatly constrained under EU climate law, with its emphasis on achieving carbon neutrality across all sectors by 2050. Depending on site preparation, species and site conditions, accountable levels of carbon uptake from afforestation will take a number of years. In fact in many cases there will be a small level of emissions at establishment. Early action is therefore critical to ensure that the land sector can deliver on Paris commitments by moving towards zero carbon by mid century. Today's afforestation is the future built environment, and circular economy, providing low carbon materials and energy, thereby moving the land sector towards climate sustainability.

[2] Projected deforestation rate of 900 ha per year is assumed based on 2006-2017 NFI data.

Counting forest carbon – the rule set

Forest sink accounting rules matter for national climate change policy formulation in relation to forests, and frame the level of accountable climate mitigation that can be achieved through afforestation and other LULUCF activities.

Current rules place a high importance on new forests less than 30 years of age and contribute significant compliance credits over the period 2021- 2025. However post 2025 accounting and reporting rules are set as outlined in the recent "Fit for 55" proposals. The impact of these rules will be important to consider once finalised.

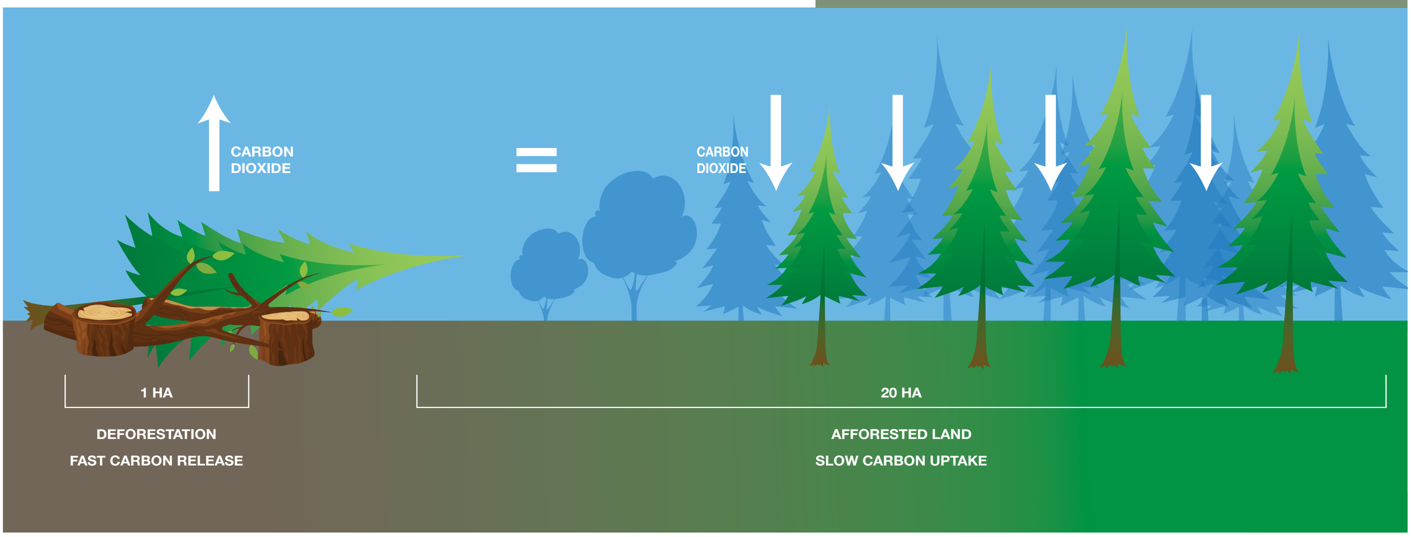
Transition of afforested land to managed forest land

Deforestation rules are also critical to how carbon stock changes in forests are accounted. The current annual rate of deforestation is estimated as 900 ha. It requires about 18,000 ha of afforested land to balance off the annual carbon dioxide emission arising from this rate of deforestation. In essence, the annual rate of carbon uptake is typically about one-twentieth of the release of carbon arising from deforestation.

Apart from the costs to the state of land reversion from forest, any loosening of the replanting obligation following clearfelling (in effect permitting deforestation) carries a risk of creating further deforestation and of potentially reducing the sink amounts to well below those indicated over the period 2021-2030.

There are many competing demands on public funds. Every effort should be made to further quantify the impact of tree planting, wetland restoration, hedgerow expansion or other measures in the relevant land use category, in order to include these amounts in the national accounts. Continuity of effort is also required under various grant aid schemes so they can be continually evaluated and built upon, if effective, in delivering climate change mitigation and other services. There are useful experiences and lessons learned from the afforestation experience over the period since 2008 that could usefully be applied to other LULUCF activities.

Deforestation and afforestation carbon dynamics



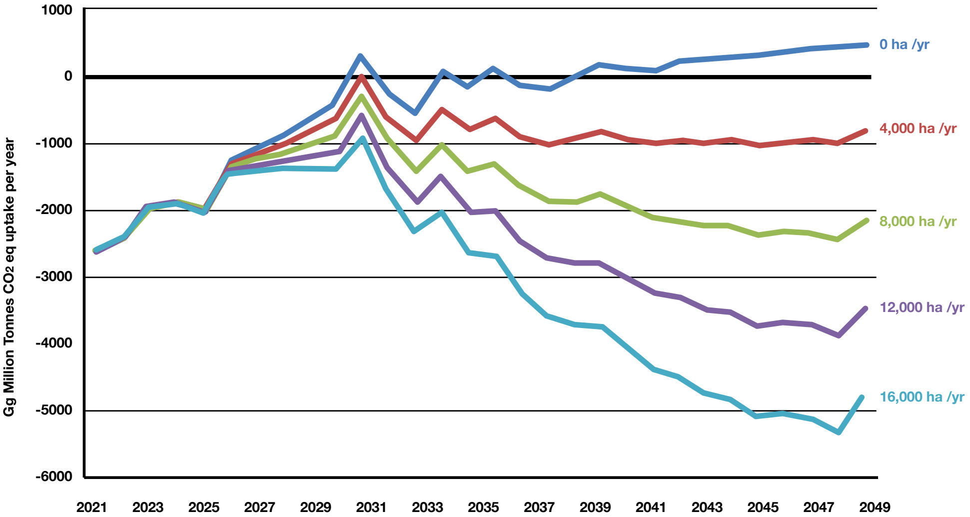
Afforestation rates and targets – target compliance and extending the climate benefits of forest carbon

The Climate Action Plan 2019 sets out clear targets for emission reductions and sets out a range of measures, including an afforestation rate of 8,000 ha per year over the period 2021-2030. The impact of a range of afforestation rates on future carbon dioxide (CO_2) emissions and removals is presented in the accompanying graph. The estimates include emissions and removals from harvested wood products, but exclude the potential impacts of deforestation and management of afforested land older than 30 years. It is clear that the future rate of afforestation will have little impact on removals out to 2025 because of initial slow growth rates of established young forests.

Going beyond the timeframe of the Climate Action Plan, the greater the afforestation rate, the greater the projected sink in 2050. Extending the 8,000 ha/annum afforestation target out to 2050 would provide for a sink of 2.2 Mt CO_2eq in 2050[3]. Increasing the level of ambition to the policy aspiration in *Forest products and people – a renewed vision* [4], some 16,000 ha per annum up to 2050, could provide a sink of circa 4.8 Mt CO_2eq.[3]

[3] Provisional estimates from the Department of Agriculture, Food and the Marine.
[4] DAFM, 2014.

Projected emissions/removals for different annual afforestation rates. Projected estimates are based on the 30 year transition period under the EU LULUCF regulation.



Bearing in mind the projected increase in the shadow price of carbon dioxide from €39/t in 2021 to €100/t by 2030 (Department of Public Expenditure and Reform[5]), the risk of a reduced sink by 2050, even with an afforestation rate of 8,000 ha per annum, shows there is a good economic case for a greatly increased level of afforestation ambition, reaching to 16,000 ha per annum in the decades leading up to 2050.

According to estimates from DAFM across a range of afforestation scenarios, a 16,000 ha per annum programme, at current costs, would require a state investment in the region of €5.5 bn over the next three decades, or approximately €150 m/year over the coming decade and rising in the succeeding decades as premium payments fall due. It is roughly double the cost of the 8,000 ha/annum programme in the Climate Action Plan.

Set against the costs of the programme are potential compliance cost savings, as well as economic activity generated from roundwood sales. Even if the EU's land-use accounting framework maintains the current caps on compliance crediting from afforested land, or other categories, increasing forest cover could be regarded as a no-regrets policy. Especially given the benefits outlined in the forest policy in terms of stabilising wood supply to support the increasing demand for wood and wood fibre in both existing wood processing and emerging sectors of the bioeconomy. Also, the marginal abatement cost of afforestation estimated by Teagasc[6] at €45/t carbon dioxide is below the shadow price of carbon credits at €50/t carbon dioxide, indicating that forestry is a cost-effective measure in tackling climate change.

[5] https://assets.gov.ie/19749/77936e6f1cb144d68c1553c3f9ddb197.pdf

[6] Lanigan GJ and Donnellan T (eds.). 2019. An Analysis of Abatement Potential of Greenhouse Gas Emissions in Irish Agriculture 2021-2030. Teagasc, Oak Park, Carlow.

Securing the climate mitigation benefit – the role of Managed Forest Land

As outlined, afforestation plays an important role in extending carbon uptake and storage by a forest estate. Older forests (called Managed Forest Land), and their management and regeneration, have an identified role in tackling climate change across a range of activities. These include site preparation to enable rapid regeneration, species and provenance selection, and ongoing silvicultural operations (such as thinning and harvesting).

Forest management of existing forests also have a significant influence on carbon sequestration and carbon stocks, and can be an important mitigation tool in reducing emissions. There are a range of forest mitigation actions that could have large and immediate impacts in the short term (2021-2030) on carbon removals from existing forests. This includes alternative management techniques such as increasing the rotation age of forests. For example, increasing rotation age to the maximum mean annual increment could result in an increase in removals of circa 9Mt CO_2 over the period 2021-2030. These removals could be accountable under the EU LULUCF regulation and would make a significant contribution in the short term. Ireland's total forest estate is currently a net sink for carbon dioxide but this will decline over the decade, mainly due to significant afforestation in the 1980s and a projected sustainable increase in harvesting.

Currently Ireland's LULUCF sector is a net source of CO_2 of approximately 4.4 Mt CO_2 eq in 2019. Reaching carbon neutrality in the land use sector will be extremely challenging. Ireland's gross LULUCF emissions are estimated to rise to approximately 8 Mt CO_2eq in 2030, mainly due to temporal shifts in the age class structure of the national forest estate. This will result in a reduction in removals potential and a net emission from the total forest area over the decade and before 2030. In addition, new research on forested organic soils show larger emissions than previously estimated and will mean an update to the inventory to take account of higher emissions on peat soils. Although the historical age class legacy has a temporary negative influence on the national forest sink, the Department of Agriculture, Food and the Marine's National Forest Accounting Plan demonstrates that forest sinks are maintained into the second half of this century as required under the Paris agreement.

Silvicultural (management) operations such as thinning impact on the allocation of carbon in forests between soil, the standing trees, and on into long-lived forest products. Thinned forests result in a higher amount of valuable sawlog compared with forests that are left unthinned, although unthinned forests can also have beneficial impacts on increasing carbon stores. Sawlog used in the manufacture of long-lived wood products is a valuable carbon store. Long lived wood products also displace emissions arising from the manufacture of cement and other extractive materials. Maintaining high carbon uptake in existing forests and wood products therefore depends on rapid establishment, and the management and harvesting of trees at appropriate ages and times.

A managed forest landscape comprises a mosaic of stands at different states in the harvesting cycle, transforming standing trees into wood products, while capturing carbon as they grow. Forest management practices which increase forest growth will in turn increase the rate of carbon sequestration. As long as growth across the landscape exceeds harvest, carbon stocks will increase or reach a long term equilibrium.

Sustainably increasing harvest levels can have overall positive climate benefits, mainly through materials substitution. Its precise nature will depend on the type of wood product, the type of non-wood material that is replaced, and the use of wood at end life-cycle.

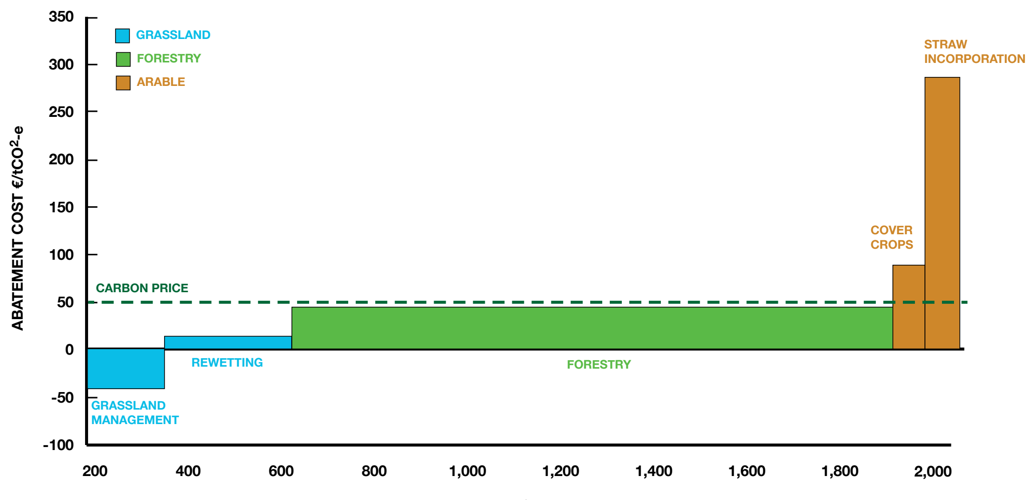
Agriculture and forestry – moving towards carbon neutrality in land use

Agriculture accounted for 35.4% of non-ETS greenhouse gas emissions in 2019, some 21.15 Mt CO2eq, which is 9.4% above 1990 levels. Efforts to reduce agriculture emissions through a range of Teagasc MACC-based measures such as the use of improved dairy economic breeding index (EBI), appropriate fertiliser formulation and low emission slurry spreading continue. The Department of Agriculture Food and the Marine Ag Climatise roadmap foresees that these and other measures will result in emissions in the sector reducing by 1.5-2.0 million tonnes of CO2eq emissions by 2030.

Even allowing for technology deployment it is difficult to see agriculture emissions falling below 10 million tonnes/annum by mid-century. Balancing an optimistic sink of 4-7 million tonnes of carbon dioxide per annum from a combination of afforestation (assuming a sustained afforestation programme of 16,000 ha per annum), wetland restoration and soil carbon measures, and full acknowledgement of this amount in a future compliance regime, there could remain 3-6 million tonnes of CO2eq emissions/annum from agriculture that would constrain the attainment of carbon neutrality in the land-use sector. Any remaining emissions in other sectors, such as transport would also have a constraining effect.

Nationally, land use and changes from grassland to forestry have not resulted in a significant reduction in agricultural emissions. In general animal herd sizes have not declined as land has transferred to forestry and this will create challenges for carbon neutrality in the land-use sector.

Land Use Mitigation



Marginal abatement cost (€/tonne CO2eq) of land use and land-use change options in Ireland (Teagasc marginal abatement cost curve)

Is there enough suitable land for forest expansion?

The availability of land for afforestation depends on a number of factors, including current land use, site suitability and the impact of other support schemes and policies. Current indication are that there should be a sufficient land base in Ireland to approach a forest cover of 18% (the forest policy aspiration) by mid-century. For example, land types that are suitable for forestry, and marginal for dry stock production, can provide a range of ecosystem services including economic wood production, climate change mitigation and others. Most land currently in beef production is highly productive from a forest growth perspective and can accommodate a wide range of species, to provide the desired range of ecosystem services across wood production, biodiversity enhancement and conservation, water quality enhancement, and not least adaptation to and mitigation of climate change.

It is important to recognise the number of land use options that are available to farmers and the importance of food production. However, farm forestry can also complement other farm enterprises. In a significant number of cases, planting part of a farm can make sound economic sense and maximise income streams.

Permanence of forest sinks, going beyond business-as-usual and consideration of carbon offsetting projects

The availability of land for afforestation depends on a number of factors, including site suitability and the impact of other support schemes and policies. Current indication are that there should be a sufficient land base available in Ireland to approach a forest cover of 18% (the forest policy aspiration) by mid-century. Such eventualities can, in certain circumstances, threaten a country's compliance with emission reduction targets. This issue of non-permanence is dealt with at the EU level through rule sets in the EU LULUCF regulations. In offset projects, non-permanence risk is generally secured against buffers or insurance systems. As far as additionality is concerned, it can be a major issue in forestry carbon offset projects, where effort beyond business-as-usual needs to be demonstrated for climate effectiveness. At country level, the framing of the rules in the EU regulation (and the Durban LULUCF agreement) seek to avoid crediting business-as-usual through the use of forward-looking reference levels for managed forest land.

A number of issues arise in carbon offsetting at the project level, including additionality. This relates to where emissions are being displaced (offset) by sequestration and carbon stock changes in the harvested wood products pool, and the consequent need to show that there is a net benefit to the climate through permanent reductions in carbon in the atmosphere. Offsetting does not work if business-as-usual removals by forests are used to account for continuing emissions, as there will be no net reduction in carbon dioxide in the atmosphere. Liability for carbon reversals (also referred to as non-permanence) through harvest, fire and other disturbances, and where it lies, also needs to be carefully considered.

Much work has taken place on assessing the impacts of commercialising forest carbon through offsetting of emissions, and other market mechanisms. A number of processes using carbon offsetting exist. For example, in the UK, the Woodland Carbon Code is a "voluntary standard for UK woodland creation projects where claims are made about the carbon dioxide they sequester. Independent validation and verification to this standard provide assurance and clarity about the carbon savings of these sustainably managed woodlands." In the US the California Air Resources Board issues forest carbon offsets to projects. Offsets are based on a forest protocol and can use improved forest management techniques to sequester carbon. Companies obliged to reduce emissions under California's cap-and-trade system may use offsets for up to 8% of their reduction requirement.

Given the need to examine ways to engage land-owners in increased levels of afforestation, it is timely to explore the issues around the potential introduction of a voluntary carbon code in Ireland. Issues to be addressed include proof of additionality, catering for non-permanence, liability for reversals, monitoring, verification and reporting, transaction costs, markets, and other matters.

Main conclusions

Ireland has a comparative advantage in growing forests. A combination of an oceanic climate and suitable soils means that some forests can begin to reach commercial maturity three decades after establishment, considerably shorter than elsewhere in Europe.

All forest types (broadleaf, conifer, and mixed forests) play a role in contributing to climate change mitigation and adaptation, ecosystem services and biodiversity conservation. The challenge is to enable the social, economic and environmental benefits - including climate change mitigation - that forests provide to be realised over the period to 2050 and beyond.

The Climate Action Plan sets out clear targets for emission reductions and sets out a range of measures, including an afforestation rate of 8,000 ha per year over the period 2021-2030. Increasing the level of afforestation, in line with the forest policy aspiration of approaching a forest cover of 18% in the latter half of the century, entails an effective doubling of the afforestation rate to approach 16,000 ha per year. Extended over three decades to 2050, this level should provide 4.8 million tonnes of net carbon dioxide removals on afforested land by mid-century, thereby making a substantial contribution to the attainment of the carbon neutrality goal.

Wood grown in Irish forests is a valuable commodity. It is used across a wide variety of applications, ranging from bioenergy to higher-value products such as wood-based panels and structural timber. These uses extend the climate benefits of afforestation and forest management through fossil fuel displacement and substitution of extractive-based materials such as concrete, steel and plastics. These extend the climate benefits from afforestation and forest management.

Forest management of the existing forest estate is an important influence on carbon sequestration and carbon stocks, and can be an important mitigation tool in reducing emissions.

COFORD concludes that a greatly expanded afforestation programme, reaching some 16,000 ha per year over the coming three decades is necessary for Ireland to approach carbon neutrality in land use by mid-century in accordance with the Paris goals.

COFORD

Statement on the Impacts and Adaptation to Climate Change

Introduction

Forests provide a range of valuable products and services to society, they contribute to climate change mitigation by sequestering CO_2 from the atmosphere, lock carbon up in the form of wood, while products derived from forests displace fossil fuels as well as building materials such as steel and cement.

However, forests are themselves vulnerable to the impacts of climate change. **Climate change adaptation** means taking action to prepare for, and adjust to, both the current effects of climate change and the predicted impacts in the future. It encompasses how to build resilience to the effects of climate change and weather-related events, reduce negative impacts, and take advantage of opportunities that may arise.

In Ireland, climate change may alter local forest site conditions, the frequency and degree of disturbances (e.g. fire, drought, extreme storms), phenology (seasonal timing of biological activity), and the distribution and abundance of invasive species and pests. This has the potential to lead to increased tree maladaptation and mortality and changes in competitive interrelationships leading to reduced forest health and economic loss. Conversely, predicted climate changes could see an increase in the suitability of some tree species and, relatedly, higher productivity levels.

In this COFORD statement, climate change impacts on the forest sector as well as adaptation responses and options are considered through:

- An initial brief review of a selection of national and European policy papers
- Consideration of important concepts such as forest resilience and prioritisation of identified climate change impacts
- A focus on recommended actions to increase resilience and target current vulnerabilities and opportunities
- Promotion of co-ordinated research, policies and strategies across the forest value chain.

National and International Policy

National Level

The **Climate Action and Low Carbon Development Act 2015** provided statutory authority to mitigation and adaptation plans envisaged in the **National Policy Position**. The 2018 **National Adaptation Framework (NAF)** set out the national strategy to reduce the vulnerability of the country to the negative effects of climate change and to avail of any positive impacts. It provided a framework for the creation of a **Sectoral Adaptation Plan** as part of a whole of Government approach.

The **Agriculture, Forests and Seafood Climate Change Adaptation Plan** (Department of Agriculture Food and the Marine (DAFM), 2019) built on previous baseline data which incorporated an impact and vulnerability assessment. It identified the need to build resilience to the effects of climate change and weather-related events in the agriculture, forest and seafood sectors, reduce any negative impacts where possible, take advantage of any opportunities, and contribute to the achievement of DAFM Statement of Strategy goals. Sectoral impacts and their consequences are also highlighted in the plan.

The Department of Communications, Climate Action and Environment (DCCAE) **Climate Action Plan** (2019) developed a range of forestry-specific actions in its annex of actions which will be revised and published annually. These include the following:

- Ensure ongoing action to manage the risk to current carbon stocks from natural disturbances, such as fires, and deforestation
- Increase productivity and resilience of the national forest estate and tree species to improve adaptation to climate change to deliver additional sequestration potential
- Continue and strengthen activity in forest health, including monitoring and surveillance of the health and vitality of Ireland's forest estate and implementation of import controls on a range of plants, wood and wood products.

A revised and updated Climate Action Plan is currently being finalised.

The Ag Climatise – National Climate and Air Roadmap for the Agriculture Sector (DAFM 2020) includes an action to encourage the planting of a range of different species to ensure forests have adaptive capacity, and are resilient to the impacts of climate change. It also seeks to maximise the contribution of existing forests to climate change mitigation and adaptation. **The Climate Action and Low Carbon Development (Amendment) Act** (Department of the Environment, Climate and Communications (DECC), 2021) recently introduced a requirement for Local Authorities to develop individual Climate Action Plans, which will include both mitigation and adaptation measures.

Policy at national and international level strengthen Ireland's adaptive capacity to climate change.

International Level

Climate change impacts and adaptation are central to a number of intergovernmental and EU policy drivers including the **Paris Agreement**, the **European Green Deal** and the **UN Sustainable Development Goals**. The Paris Agreement aims to increase the ability of countries to deal with the impacts of climate change. It established a global goal on adaptation – of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change in the context of the temperature goal of the Agreement. It aims to significantly strengthen national adaptation efforts, including through support and international co-operation, recognising that adaptation is a global challenge faced by all. It also encourages the conservation and enhancement as appropriate, of sinks and reservoirs of greenhouse gases (GHGs) including forests.

The **European Green Deal** puts a focus on how the EU's forested area needs to improve, in both quality and quantity, for the EU to reach climate neutrality and a healthy environment. It outlines how sustainable re- and afforestation, and the restoration of degraded forests can increase absorption of carbon dioxide (CO_2) while improving the resilience of forests and promoting the circular bioeconomy. Building on the **2030 Biodiversity Strategy**, the EU Commission is preparing a new EU forest strategy covering the whole forest cycle and promoting the many services that forests can deliver. It has also adopted a new **EU Strategy on Adaptation to Climate Change** which sets out how the EU can adapt to the unavoidable impacts of climate change and become climate resilient by 2050. The Strategy has four principle objectives: to make adaptation smarter, swifter and more systemic, and to step up international action on adaptation to climate change.

As part of the **European Green Deal**, the European Commission will also adopt a new EU Forest Strategy in 2021 following a consultation period. This will build on the **EU Biodiversity Strategy to 2030** and will cover the whole forest cycle and promote the many services that forests provide. It will be aimed at ensuring healthy forests that contribute significantly to biodiversity and climate goals, reduce and respond to natural disasters, secure livelihoods and support a circular bioeconomy and rural communities.

The **United Nations (UN) Sustainable Development Goals** represent a call for action by all countries – poor, rich and middle-income – to promote prosperity while protecting the planet. Goal 13 contains a range of actions linked to the environment. These strive to strengthen resilience and adaptation capacity, integration of climate change measures into policy and planning, as well as targeting and building knowledge and capacity to meet climate change.

European Policy Perspectives

In their study of challenges and opportunities relating to plantation forests, **Freer-Smith et al (2019)** outlined how European forestry already plays a significant role in meeting environmental, economic and climate needs, and that further investments could enhance these contributions. The authors identified the need for further research and policy measures to support ongoing sustainable forest management (SFM) and utilisation of plantation forests. They highlighted the continued requirement for research, guidance and regulation on the identification and production of forest reproductive material for plantations. In this regard, selection criteria should consider both production ability as well as the capacity of the future forest to adapt to climate change.

As climate change continues, adverse impacts on the stability and production capacity of European forests could undermine the role of forests and the forest-based sector as a central pillar of the **European Green Deal**. More effort is needed to mitigate increasing disturbance risks, particularly by improving the resilience of European forests and associated value chains. The **Horizon 2020-RESONATE Project** commenced in 2021 and will aim to compare the socio-ecological resilience of different management systems at the European level leading to future EU policy recommendations. Research agencies from 19 different countries are involved **(Spazzi 2021)**.

Forest owners need enhanced guidance in adapting the management of their forests to coping with climate-induced forest disturbances and changes in functioning due to growing abiotic, biotic and financial hazards (Freer-Smith et al (2019)). Forest owners and managers also need to be aware of increasing risks to their resources. Similarly, the forest-based sector will require substantial innovation capacity to respond to changes in profitability, unpredictable wood flows, and a gradual change in tree species. There is an urgent need to improve the scientific understanding of how the resilience of Europe's forests and forest value chains can be improved.

With the increasing risk to forests from abiotic, biotic and financial threats, Freer-Smith et al (2019) have advocated adaptation of forest management. The first proposed option is to improve resilience by increasing plantation diversity. In this regard, the authors suggested the option of combining complementary tree species within stands and using mosaics of different forest types at the landscape level. The second option is to reduce the exposed standing volume by intensifying thinning and harvesting regimes. The achievement of sustained yield under climate change conditions requires resilient plantations. The authors have proposed that resilience and sustainability can be achieved if regulations, incentives and practice guides specify science-based approaches to control standing stock and age class distribution in plantation forests with the use of species mixtures and other elements of risk management.

Predicted climate change patterns in Ireland and likely impacts

Threats to forests as a result of climate change include increased pests, disease and weather related events.

Forests have an important role in addressing climate change challenges and form a significant part of Ireland's climate change mitigation strategy. It is imperative that potential risks of forests being negatively impacted by climate changes are minimised, hence the need for adaptation towards resilience. To enable adaptation, we first need to consider the future likely climate change events and their associated impacts. This can help inform planning to prevent or minimise damage and build resilience to climate change. It can also help society to take advantage of any opportunities that may arise.

Climate change patterns

Lambkin (2020) presented the annual average air temperature for Ireland between 1895 and 2018 (Figure 1). Each data point represents the average temperature for that year. The trend line shows an increasing trend in temperature, indicating that Ireland is getting warmer, reflecting global trends. The temperature has increased by about one degree over the last 100 years on average.

The European State of the Climate 2020 reported how atmospheric concentrations of the GHGs CO_2 and methane (CH_4) continued to rise and reached their highest levels on record in that year. In 2020, the annual temperature for Europe was also reported as the highest on record. Winter was reported as particularly warm, setting a reported record at more than 3.4°C above average. In early spring, there was a 'remarkable transition from wet to dry conditions in north-western and north-eastern Europe', as captured in precipitation levels, river discharge and vegetation cover. Several episodes of very warm weather occurred during the summer and in November 2020. Although many temperature records were broken, the heatwaves were not as intense, widespread or long-lived as others of recent years **(Copernicus Climate Change Service, 2021).**

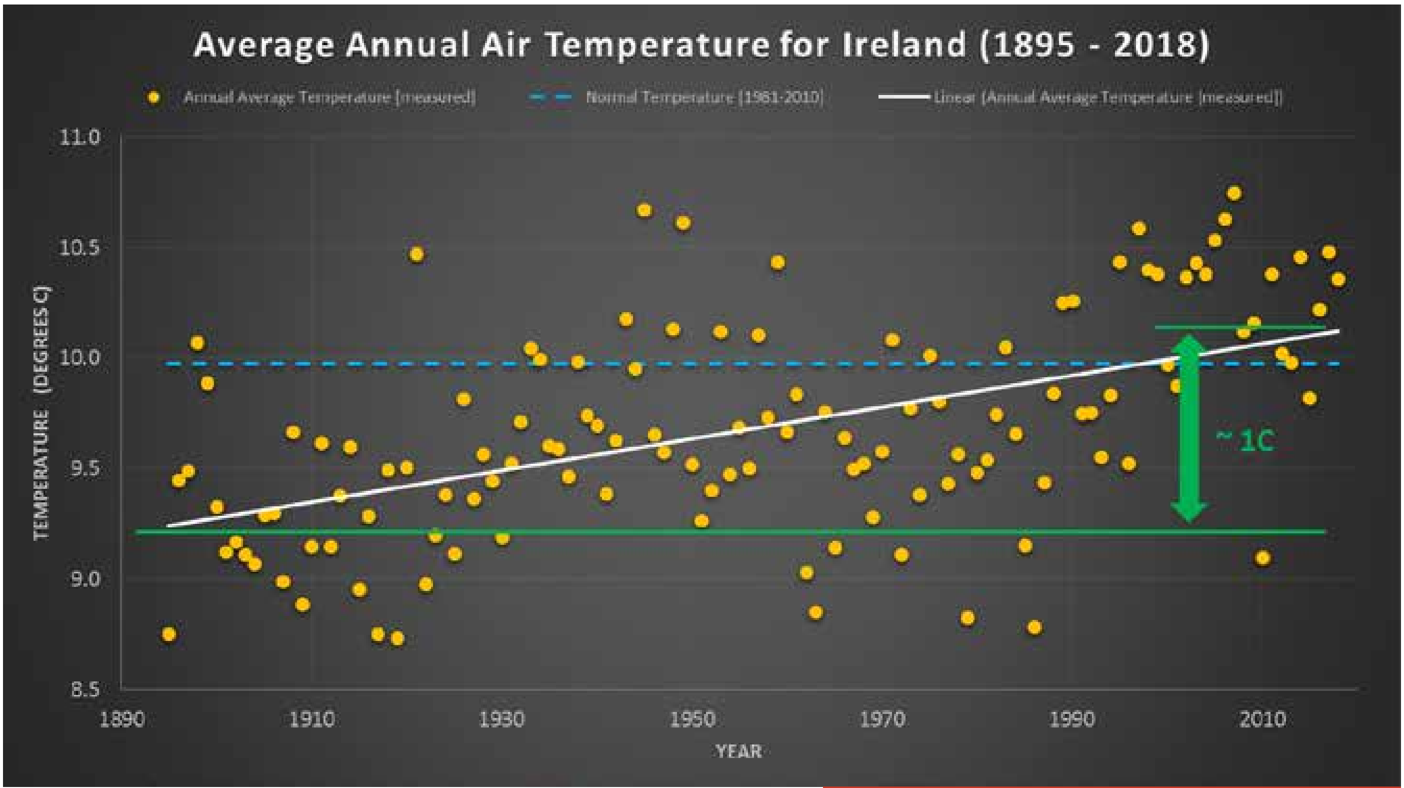


Figure 1: Average annual air temperatures for Ireland since 1895 (Source: Lambkin 2020)

The Environmental Protection Agency reports, **A Summary of the State of Knowledge on Climate Change Impacts for Ireland**, and **Ensemble of Regional Climate Model Projections for Ireland** together provided an outline of the regional climate modelling undertaken to determine the potential impacts of climate change in Ireland, based on a number of possible future scenarios. The latter report by **Nolan (2015)** on the future climate of Ireland was simulated at a high spatial resolution for the 40-year period 2021-2060. For reference, the past climate was simulated for the period 1961-2005. The difference between the two periods provides a measure of climate change.

Findings from this study indicate the following projections by the middle of this century:

- Mean annual temperatures will increase by 1–1.6°C, with the largest increases seen in the east of the country
- Hot days will get warmer by 0.7–2.6°C compared with the baseline period
- Cold nights will get warmer by 1.1–3.1°C
- Averaged over the whole country, the number of frost days is projected to decrease by over 50%
- The average length of the growing season will increase by over 35 days per year
- Significant decreases in rainfall during the spring and summer months are likely
- Heavy rainfall events will increase in winter and autumn
- The energy content of the wind is projected to decrease during spring, summer and autumn. The projected decreases are largest for summer, with values ranging from 3% to 15%
- Storms affecting Ireland will decrease in frequency but increase in intensity, with increased risk of damage

Potential impacts of climate change patterns

The main impacts will not affect forests in isolation but will combine, resulting in likely resilience challenges. **Purser et al (2004)** suggested that while it is generally accepted that rising temperatures and CO_2 concentrations will promote increased growth rates, it is uncertain to what extent this growth will be limited by water and nutrient availability, greater difficulties in forest establishment and increased risk from pests, disease and forest fire. **Broadmeadow and Ray (2005)** outlined how the impact on UK woodlands will vary between regions with likely increased productivity in favourable areas as a result of rising CO_2 levels and a longer growing season. They suggested that the character and composition of native woodland are likely to change, with new species assemblages developing. Analysing impacts on forestry in Wales, **Ray (2008)** projected an increase in forest productivity in some areas with a wider selection of species becoming suitable, but also suggests effects will vary spatially and according to species. He also projected an expected warmer climate will improve tree growth with productivity generally increasing by up to 2-4 cubic metres per hectare per year for conifers where water and nutrients are not limiting.

Overall, forest productivity is also expected to increase in Ireland as a result of climate change, especially if moisture is not limiting. This will be largely due to an increase in growing season temperature, longer growing seasons, increased CO_2 and increased atmospheric deposition of nitrogen **(COFORD 2020)**. It may necessitate the expansion of the range of tree species and provenances used heretofore. However, anticipated decreases in summer precipitation, particularly in the eastern part of Ireland, coupled with increased evapotranspiration, may limit water availability for some species and consequently reduce their productivity. For soils where moisture availability is limited or where previous crops have been subject to periodic drought events resulting in reduced productivity, provenance/species change may be warranted. A range of drought-hardy species and seed origins may be considered for regional-specific deployment **(COFORD 2020)**.

Recent work by **Nolan and Flanagan (2020)** projected a large increase in the length of the growing season over Ireland by the middle of this century. However, warmer winters can result in some species not fulfilling their winter chilling requirements (necessary for dormancy release of buds) or lengthen the time needed to satisfy the chilling requirement of plants. This is likely to result in delayed budburst for certain conifers and oceanic species **(Pletsers et al, 2015)**. For example, Sitka spruce has a high winter chilling requirement and this could significantly affect its growth patterns (**Cannell and Smith, 1983**).

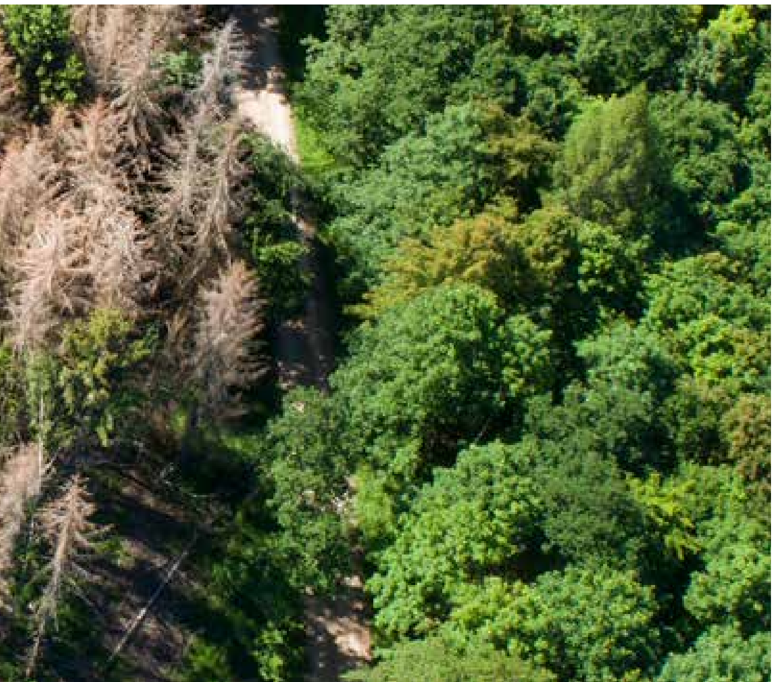
Warmer winter and summer temperatures may present conditions for more successful establishment of pests and pathogens **(Sturrock et al, 2011)**. A warming climate is also predicted to result in an increase in pests as a result of an increase in pest-growing degree days and a decrease in frost and ice days, as cold conditions are a key control mechanism for pests **(Nolan and Flanagan 2020)**.

Extreme climatic events, such as drought and storms, pose the greatest climatic threat to forest productivity (**Black et al, 2010**). A combination of increased wind and winter rain events is likely to result in a substantial increase of windthrow risk for Sitka spruce and other potentially vulnerable species. **The Agriculture, Forests and Seafood Climate Adaptation Plan (DAFM 2019)** described priority impacts which include windthrow due to stormy weather with greater risks on waterlogged soils. The reported consequences of this include damage to forest stands and reductions in forest rotations and timber quality. The plan also identified the risk of uncontrolled fire as a priority impact. The consequence of such disturbance is the risk of serious damage to forest stands with accompanying economic and environmental losses. The conditions for increases in fires and risk are associated with increased temperature, soil moisture deficits and the levels of potential fuel load. These factors can have direct and indirect links to climate variability and climate change.

Recent climate change impacts at the European level

An international study, directed by the **University of Basel**, of the consequences of the 2018 drought and heat event, showed that European forests sustained long-term damage. This 2018 event caused unprecedented drought-induced tree mortality in many species throughout the region. Unexpectedly strong drought-legacy effects were also detected in 2019. The study suggested that the physiological recovery of trees was impaired after the 2018 drought event, leaving them highly vulnerable to secondary drought impacts such as insect or fungal pathogen attacks. As a consequence, the mortality of trees triggered by the 2018 events is likely to continue for several years. **Schuldt et al (2020)** found that many common temperate European forest tree species are more vulnerable to extreme summer drought and heat waves than previously thought. They also suggested that drought and heat events were likely to occur more frequently with the progression of climate change and European forests might approach the point for a substantial ecological and economic transition.

The **University of Basel** study suggested that redesigning forests is essential based on the findings outlined. It pointed to the need to assess which tree species are good in which combinations. New analytical approaches were also recommended to study the impact of extreme climatic events.

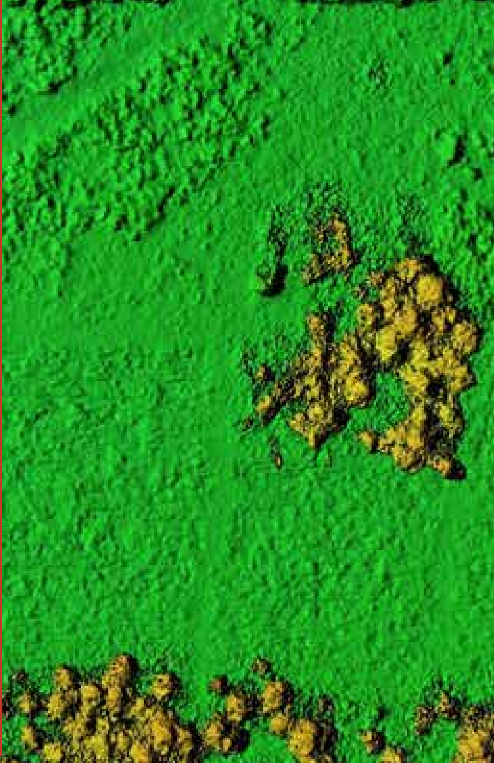


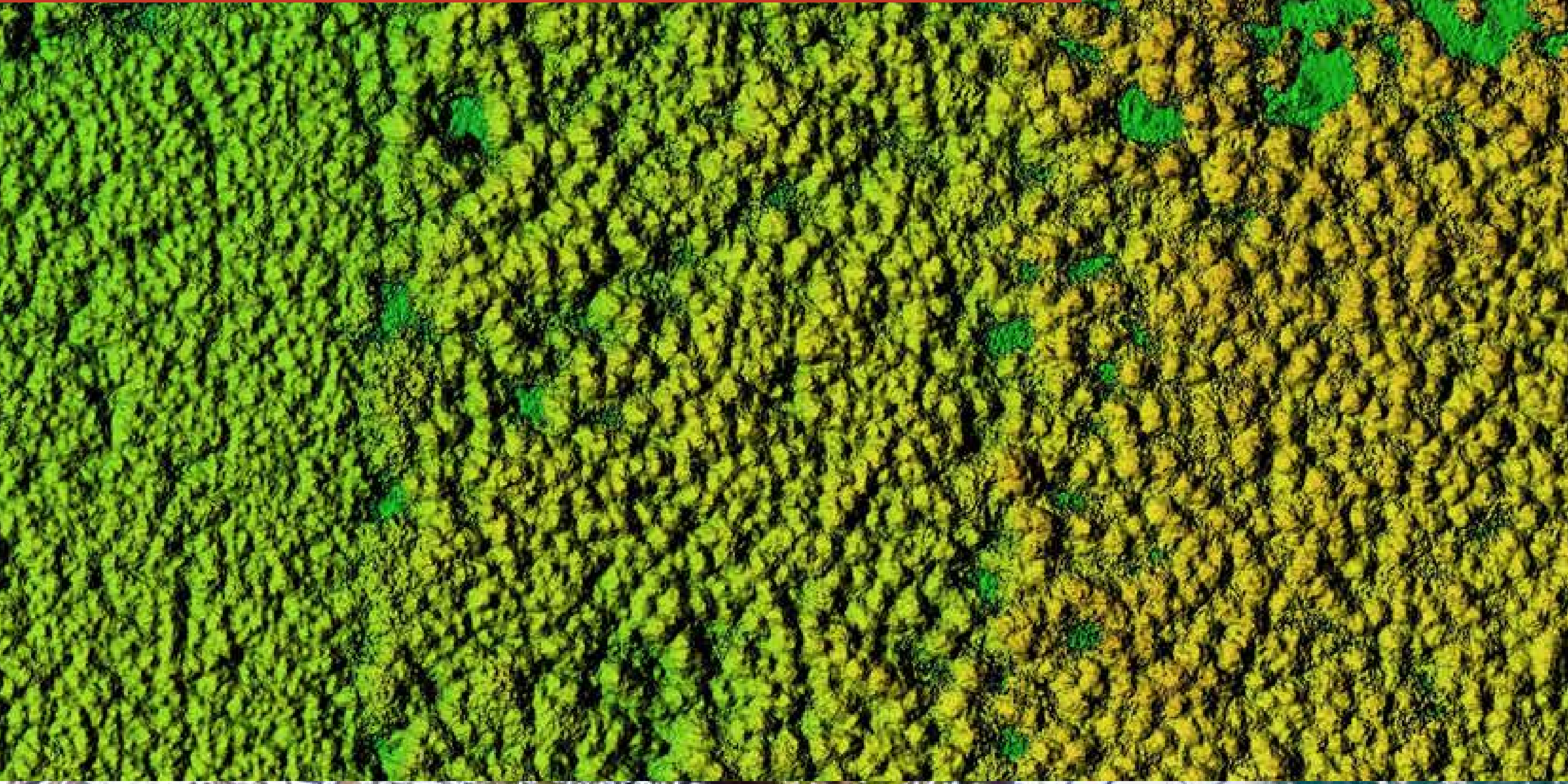
Eurasian spruce bark beetle / eight toothed spruce bark beetle

Between 2017 and 2019, over 270 million cubic metres (m^3) of standing timber was damaged in Central Europe by a combination of factors: primarily, changing climate conditions that featured hotter, drier summers and warmer winters. In combination with frequent windstorms, this created ideal conditions for the spread of *Ips typographus*, especially at lower elevations (**Global Wood Markets Info, 2020**). Bark beetle damage continues to be reported across many countries, including Poland, Switzerland, Slovakia, Italy and Sweden, but the most severe losses have been in Germany, the Czech Republic and Austria (**International Forest Industries, 2020**).

The potential for the future introduction of non-native coniferous bark beetles to Ireland is considered a serious threat to our forest industry **(Tuffen and Grogan, 2018)**. Increased log imports from a pest free area in Scotland have been required to meet timber supply deficits in 2020/2021 due to licensing issues. This area is officially maintained by the UK authorities as a pest free area for all six bark beetles for which Ireland has EU Protected Zone status. The sourcing of untreated timber from central European countries poses a particular threat. Protected Zone measures are in place to prevent introduction of species such as *Ips typographus* and *Dendroctonus micans*, the great spruce bark beetle to the island of Ireland. Wood of conifers imported from Europe must be either bark free, kiln-dried or originate from an area known to be free of the pests. Optimising the mobilisation and use of home-grown timber to ensure it is readily available to Irish timber processors is a key mechanism to minimise the risk of dangerous pests and diseases.

Adaptation measures to increase the resilience of forests and the forest sector





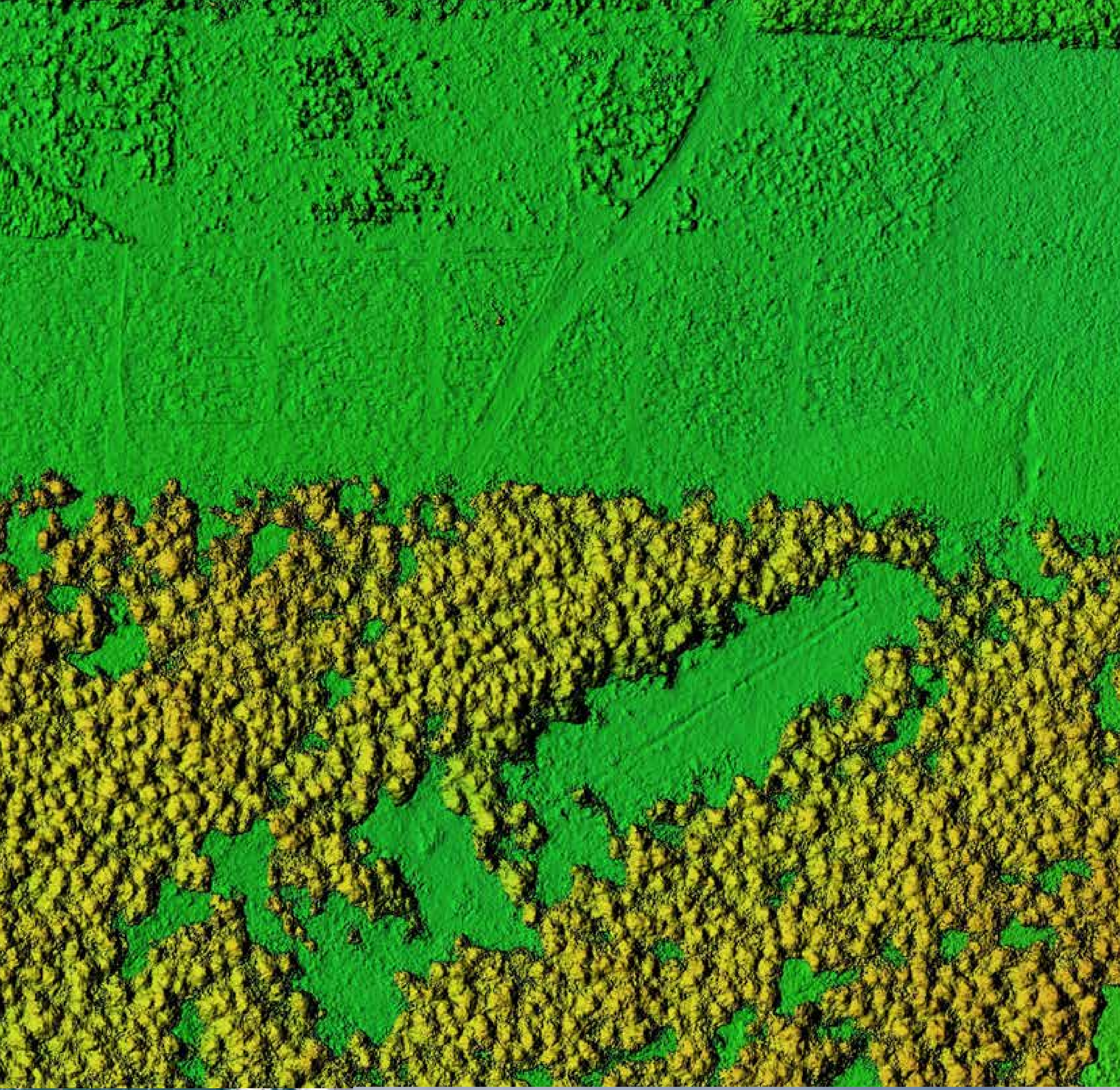


Table 1 outlines predicted changes to Ireland's forest resource due to climate change influences, and likely impacts and potential adaptation measures for future consideration and review. These measures are considered under the headings of **forest genetics, forest design** and **forest management**. Predicted changes are drawn from section 3. They include growth rate changes, increase risk of windthrow, increased pathogen risk, increased drought stress and increased risk of fire. While a range of adaptation measures are proposed according to likely impacts, there are also measures that are common to predicted impact areas.

Figure 2: Birch indoor 'Qualified' seed orchard – Teagasc, Ashtown, Co Dublin

Forest genetics

Forest genetic resources are the foundation on which the multiple benefits of forest are built and are the basis from which the actual or future value of the forest is derived. As discussed previously, forests contribute to climate change mitigation by sequestering CO_2 from the atmosphere. However, forests are themselves vulnerable to the impacts of climate change and options must be considered to increase the adaptability and resilience of the forest estate.

Key to this, is the sustainable use and conservation of the forest genetic resource. It is of the utmost importance that the genetic material that we use is suited to the site in which it is planted and that it is also sufficiently diverse to respond to future environmental conditions. This is of particular importance in Ireland, as the afforestation programme requires appropriate quantities of forest reproductive material. In addition, at the reforestation stage, planting through artificial regeneration also remains the principal method of forest establishment.

Key also is conserving the adaptive capacity of the forest genetic resource. Ireland is home to a range of native, non-native and naturalised tree species that have adapted in various ways to their environments. Some of this genetic diversity has evolved naturally over generations as species have adapted at a fine scale to local conditions. In other cases, it is the product of deliberate efforts over many years to develop varieties that are productive in Irish conditions. Genetic diversity in tree populations enables them to adapt to conditions and optimise their growth. A greater level of genetic diversity is a buffer against biotic or abiotic change, while a lack of diversity increases the vulnerability of a population or species to changing conditions and pests.
The COFORD Council Forest Genetic Resources Working Group has examined these issues in some detail and its findings are outlined in Sustainable Development and Conservation of Forest Genetic Resources 2020-2030
(**COFORD, 2020**).

Key findings made in that report are summarised below and also highlighted in Table 1.

- Continued research into the use of forest genetic resource and climate change adaptation is required. In particular, the revaluation of species, provenance and origin recommendations in light of the changing climate, including the need for new species and provenance trials were required.
- Continued development of improved forest basic material. In particular the need to target key species for tree improvement and implement selection and breeding strategies aimed at increasing climate resilience.
- The need to focus on diversity, both between species and within species, and consider the range of options for the deployment of forest reproductive material that a changing climate may provide. For instance the deployment of provenances or genotypes with resilience traits, the mixing of provenances for sites identified as likely to have an increase in growing season length, or the use of interspecies mixtures.
- For native species, strategies such as assisted migration may be considered to transfer genetic material from southern locations to northern locations, where the future climate is predicted to be warmer. However, for native woodland establishment, or native woodland restoration or rehabilitation, the adaptive potential of our own native provenances may first need to be studied in greater detail before such a strategy is recommended as the preferred option.

Forest design

The adoption of best practice in terms of forest design is a further measure for consideration. In this regard, the use of appropriate species and/or mixtures is identified as an important adaptation measure for increasing resilience to a range of climate changes (**Spiecker, 2003**; **Piotto, 2008**; **Pawson et al, 2013**). **Walsh et al (2017)** assessed the potential of alternative conifers to replace larch species in Ireland. A range of alternative conifer species including western red cedar (Thuja plicata), grand fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*), Norway spruce (*Picea abies*), European silver fir (*Abies alba*), noble fir (Abies procera) and douglas-fir (*Pseudotsuga menziesii*) were found to be suitable replacements offering similar or higher levels of productivity, acceptable timber properties, while also affording reduced levels of risk from pest/disease outbreak. Recommendations include a focus of future research on the potential for mixtures combining Sitka spruce and other Pacific conifer species (e.g. douglas-fir, grand fir, western hemlock and western red cedar) that may enhance resilience and maintain productivity.

Appropriate future tree species mixes should be tried and tested, robust and compatible. **Kerr (2020)** described a method to design robust mixtures at the establishment phase. **Mason and Connolly (2014)** identifed future research needs to examine more tree species across a range of site types. They suggested opportunities to explore the potential benefits of establishing robust mixtures with secondary production species. **Cameron (2015)** suggested that, given the considerable uncertainty over the potential long-term impacts of climate change, Sitka spruce should continue to be planted where it already grows well. However, he also suggested that new planting and restocking should be established in mixtures where silviculturally practicable, even if no-thin regimes are adopted, to spread future risks of damage. **Keane et al, (2018)** highlighted areas where gaps exist in current knowledge of mixtures. These were found to range from fundamental policy areas to the broad silvicultural area. They also identified an urgent need to examine existing field trials to determine their condition in addition to what new trials may be needed.

Griess and Knoke (2011) conducted a meta-analysis of parameters influencing the performance of mixed species stands in boreal and northern temperate biomes. A positive impact of mixing tree species was proven for resistance against windthrow and pests. Overall positive results, which included productivity in certain cases, underscore the need for a large number of additional studies to examine different silvicultural systems, and to develop optimal management prescriptions to benefit from positive interactions.

Appropriate species selection and the use of mixtures with appropriate species components may be considered to assist in the mitigation of fire threats to forests. The latter may also be facilitated through the appropriate incorporation of firebreaks at the forest design stage. The development and subsequent implementation of a National Wildfire Management and Adaptation Strategy, aligned to FAO Fire Management Voluntary Guidance, can also help to offset future threats from wildfire.

Species selection decisions should consider the option of planting drought-tolerant species in areas with predicted reduced summer rainfall. With increased productivity on certain locations and site types, there may be opportunities to consider additional commercial tree species such as Douglas-fir, Norway spruce and suitable broadleaf species, and incorporate these in appropriate site design.

CLIMADAPT is a COFORD funded web-based decision support system (DSS) based on Ecological Site Classification (ESC) developed specifically for Irish forestry. The objective is to provide a DSS for forest managers and policy makers, using soil and climatic information that can be used to assess species suitability and yield at an appropriate spatial scale under current and future climate change scenarios.

There is the capacity to enhance establishment planning and design to promote future forest stability. Such planning can include the optimisation of drainage status on afforestation and reforestation sites. It can also incorporate forest margin design, including tree spacing and species mixes to promote wind-firm edges, and reduce wind turbulence and upturning moment in the edge-to-forest transition zone (**Peltola, 1996**; **Ní Dhubháin,1998**; **Yang el al, 2006**).

Forest management

Appropriate management planning and implementation are essential to ensure future forest health and vigour. Appropriate decisions for forest thinning will be based on timing e.g. earlier thinning interventions, frequency and intensity as appropriate. **Gardiner et al (2013)**, reporting on work by Mason and Valinger in managing forests to reduce storm damage, suggested the use of a transition zone of 30-50 metres on the windward edge of a stand with a mixture of species and spacing so that the wind is gradually filtered through the trees rather than being forced upwards, thereby creating turbulence. **Cameron (2015)** described how the predicted windier climate in Scotland would require a range of management inputs, such as early cutting of extraction racks and early selective thinning, to reduce tree competition and improve stability. A no-thin approach or the use of self-thinning mixtures may be appropriate for high-risk wind sites (**Mason and Quine 1995**, **Cameron, 2002**; **Kerr and Haufe 2011**). **Ni Dhubháin and Farrelly (2018)** described a range of management actions that may be taken to reduce the risk of forest windthrow occurring.

The potential to improve resilience to particular abiotic damage through transforming suitable even-aged stands into irregular structures and limiting the overall size of the growing stock is also considered by **Cameron (2015)**.

Stokes and Kerr (2009) found that continuous cover forestry (CCF) has the potential to help adapt forests in Scotland to some of the risks of future climate change. The authors also identifed the limited amount of information comparing CCF to even-aged management for some of the factors considered and suggest detailed consideration for each risk factor when making site specific decisions. **Farrelly (2020)** outlined how management, including the harvesting of timber, serves important functions in the life of a forest. It can allow the forests to be re-juvenated to maintain their vigour with "fresh material", this material may be more adapted for the environmental and biotic challenges of future decades.

Brang et al (2014) suggested many attributes of close-to-nature silviculture (CNS, also known as CCF management) can increase the adaptation capacity of European temperate forests to a changing climate. However, they also identified some deficiencies in relation to adaptation principles of maintaining and increasing tree species richness, and replacing high-risk forest stands. They suggested CNS should make increased use of a range of regeneration methods, in order to promote light demanding tree species, non-native species and non-local provenances.

Table 1: Impacts and Adaptation Measures

Predicted Change:	Likely Impact:	Genetics[1]:
Growth rates changes: The combination of changes in temperature, CO_2 and precipitation are likely to lead to changes in current tree growth rates and flushing patterns which will be both species and site dependent.	• Maladaptation: e.g. reduced tree health or growth rate, change in phenology / late frost issues	• Opportunities for species or provenance change • Consider diversity, both between and within species • Appropriate use of forest reproductive material from provenance trials and past experiences
	• Increased productivity (increased yield class and vigour) • Enhancement of carbon stocks and sequestration capacity • Potential opportunities for additional tree species and varieties	• Review the recommended species and provenances determine adaptability to future climatic conditions • Prioritise species for tree improvement based on their current, or probable, future importance to the national planting programme
Windthrow risk increase: A combination of increased gusts, extreme wind speed and increased winter rain events, combined with changes in water and soil regimes, is likely to result in a substantial increase of windthrow risk	• Increase in damage to forests and forest road infrastructure	
Increase pathogen risk: A number of factors will likely increase stress to trees (e.g. summer water deficit, winter waterlogging) and make them more vulnerable to pests, while also increasing pest populations due to warmer winters	• Increased tree mortality and reduced vitality • Increased damage to plantations and biodiversity	• Prioritise diversity, both between and within species • Implement breeding programmes for disease / pest tolerance

[1] COFORD, 2020. Sustainable Development and Conservation of Forest Genetic Resources, 2020 – 2030. COFORD, Kildare St. Dublin 2.

Adaption Measures	
Design:	**Management:**
• Species/ provenance selection and mixes suitably adapted to site conditions	• Timely thinning regimes to reduce tree competition
• Adaptive land use planning • Good forest design • Species/ provenance selection and mixes to optimise productivity	• Appropriate management to enhance growth and vigour • Opportunities for earlier thinning and harvesting • Review standard thinning practices
• Identify sites at risk • Species/ provenance selection and mixes suitably adapted to site conditions. • Enhanced establishment planning and practices to promote forest stability • Appropriate forest design including tree spacing, species mixes and road construction specifications • Improvement of drainage status, where required, in reforestation	• Appropriate thinning decisions, regimes and practices specific to site and crop conditions • No thin approach or self-thinning of mixtures for high-risk wind sites • Adjusting rotation length as a preventative measure in stands with high disturbance risks to allow an adaptation to changing tree growth conditions • Implement best practice management for wind-firm buffers.
• Establish robust mixtures with secondary production species	• Manage compatible mixtures using continuous cover systems on suitable sites • Robust horizon scanning to inform future forest protection measures • Robust monitoring of forest condition • Increased pest vigilance/ controls at ports • Contingency planning and deployment of emergency response to pathogen outbreaks

Table 1: Impacts and Adaptation Measures

Predicted Change:	Likely Impact:	Genetics[1]:
Increased drought stress risk: Increased summer temperature and accelerated growth is likely to increase evapo-transpiration coupled with reduced availability of summer rainfall	• Increased tree mortality and reduced vitality	• Use appropriate forest reproductive material to optimise productivity opportunities • Implement selection and breeding strategies to increase climate change resilience
Increased risk of fire: (from reduced summer rain and increased temperatures)	• Increased damage to plantations and biodiversity	

Adaption Measures	
Design:	**Management:**
• Identify sites at risk • Appropriate selection of species / species mixes	

• Appropriate selection of species / species mixes
• Incorporate firebreaks / water points in forest designs
• Development of a National Wildfire Management and Adaptation Strategy
	• Implement a national Wildfire Management and Adaptation Strategy
	• Promote awareness, training and uptake with regard to:
	  • Prescribed controlled burning
	  • Forest fire prevention and warning systems

Conclusions and recommendations

Building resilience to the effects of climate change, reducing negative impacts where possible and taking advantage of opportunities that a changing climate may bring, is key to ensuring the future viability of the forest resource. However, there is uncertainty in terms of the speed, extent and impact of future climate change, and also the effectiveness of adaptation measures. There is an urgent need to develop adaptation measures to future-proof the outputs of goods and services from our forests. A range of measured and evidence-based new initiatives is likely to be an appropriate way to progress. This approach should be supported by ongoing research and frequent and careful monitoring and review. Partnerships that integrate researchers from multiple disciplines with forest managers and local actors can build a shared understanding of future challenges and facilitate improved decision making in the face of climate change (**Keenan, 2015**). The following proposed research areas are based on current literature reviews and insights from Table 1.

1. Forest Genetics

1.1 There is a need to re-examine the range of species, provenances and origins recommended for use in Irish forestry. Where knowledge gaps occur, new provenance trials should be established to assess the adaptive potential to respond to ongoing changes in environmental conditions **(COFORD, 2020)**.

1.2 Target key species for tree improvement and implement selection and breeding strategies aimed at increasing climate change resilience (**COFORD, 2020**).

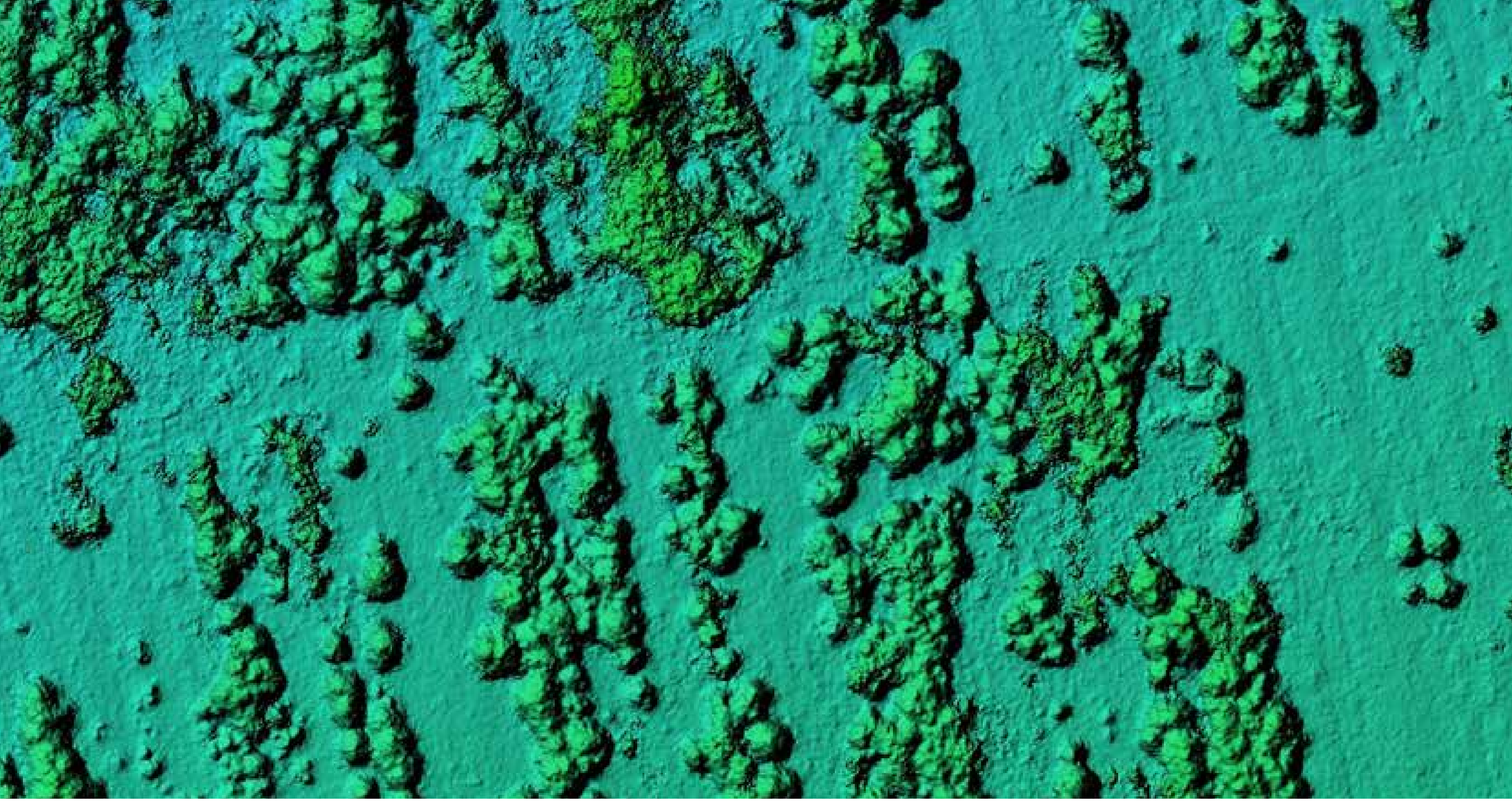
1.3 The DAFM National Forest Inventory and knowledge gleaned from the NATFOREX project should be used to derive further insights on the performance of existing mixtures and species.

1.4 For native woodlands, provenance selection should be investigated as a means of increasing climate change resilience. Such an investigation should also include further study of the adaptive potential of native trees and consideration of a desirability / needs framework to assess the risk of maladaptation **(COFORD, 2020)**.

2. Design

2.1 Complementary tree species within forest stands should be combined with the use of mosaics of suitable forest types at the landscape level.

2.2 The development and integration of appropriate decision support systems and resources will increase knowledge on issues such as relative growth rates, silviculture, yields and usability for practitioners, and encourage uptake.



3. Management

3.1 The assessments of the impacts, financial and otherwise, of silvicultural choices that may be appropriate in the future should be a focus area.

3.2 It is also important to build understanding on the impacts of site condition and competition as forests mature.

3.3 Opportunities to incorporate several ecosystem service indicators in an appropriate Forest Management Decision Support System should be investigated. Such indicators can support the analysis of impacts, such as varying forest management intensities and future timber market developments in the context climate change scenarios.

4. Protection/Ongoing Monitoring

4.1 Robust horizon scanning of potential forest pests arising from global changes and development of suitable early warning systems through appropriate pest risk analysis will play a key role in protection of our forest resource.

4.2 As policy will need to be adaptive and reactive to changes in real time, frequent and cost-effective monitoring methodologies will be required to achieve the following:

- Detection of the early onset of impacts (pest, maladaptation, wind damage) is a key focus area.
- Options for effective monitoring may include a combination of remote sensing combined with ground validation through new cost-effective ground survey methodologies, coupled with an appropriate "citizens science" approach.

5. Cross-sectoral Interdependencies

In order to make progress, further targeted research on climate change impacts for the agriculture, forest and seafood sectors, including examination of cross-sectoral interdependencies, will be required to achieve the type of policy integration required for the development of cross-sectoral adaptation plans **(DAFM, 2019)**. This can facilitate appropriate cross-sectoral adaptation planning.

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COFORD

Statement on Wood Products and their Role in National Policy

Introduction

Decarbonising construction

Rising global temperatures due to human activities have led to the declaration of a Climate Emergency in many countries including Ireland. The impacts of rising temperatures are already evident with rising sea levels and more frequent and increasing severe weather events resulting in flooding and wildfires. Emissions of greenhouses gases (GHGs) to the atmosphere, due primarily to the burning of fossil fuels, have been identified as the primary driver of global temperature increases. Climate change is the greatest challenge facing the planet today.

Reducing GHG emissions, referred to as carbon emissions, to net zero will be the most significant factor in attempting to slow down or halt climate change. The reduction in carbon emissions will also contribute to reducing pollution, with consequential health benefits, and to limiting resource depletion.

International and national targets to achieve net-zero emissions by 2050 are now in place.

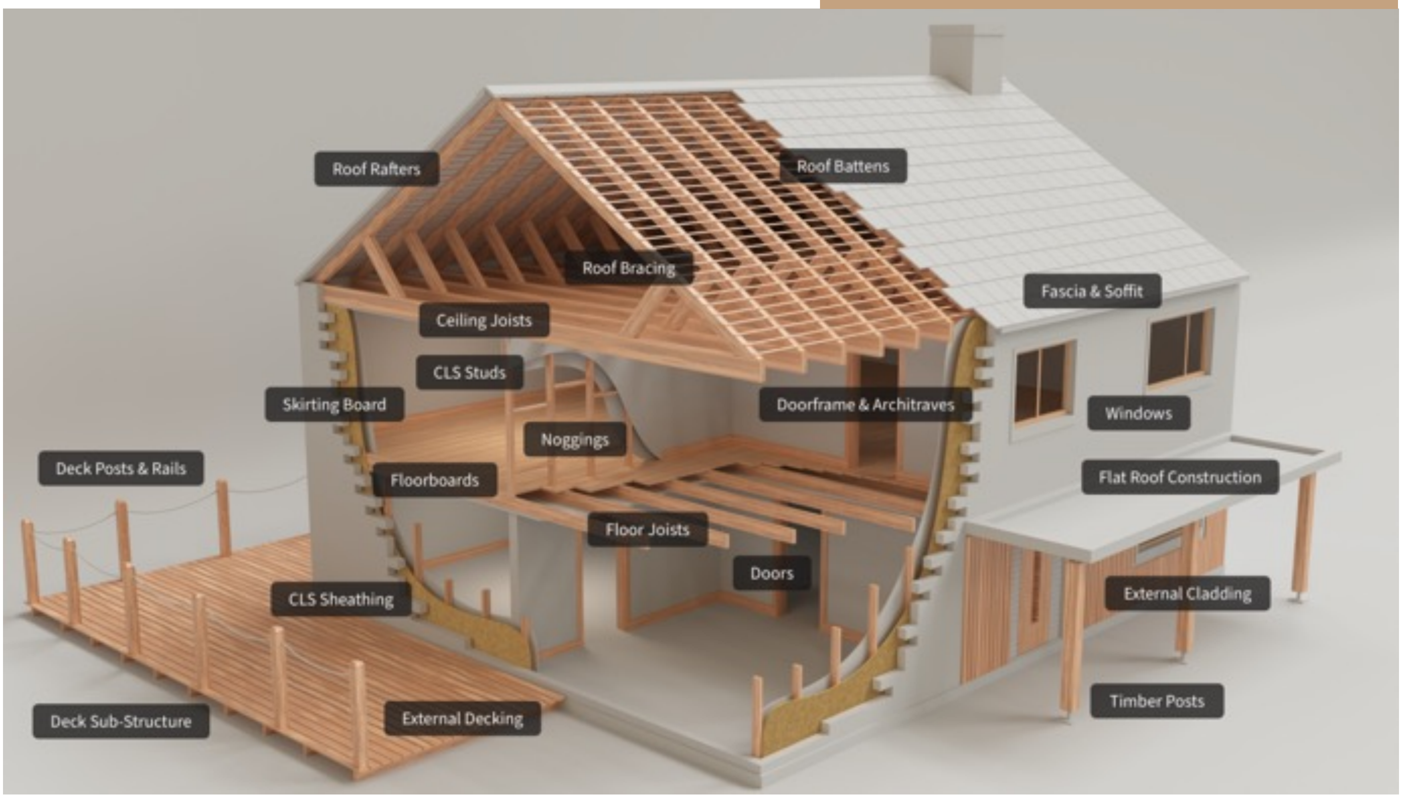
As one of the **largest contributors** to global carbon emissions, the built environment has a key role to play in achieving emissions reduction targets. Carbon emissions from the construction sector are mainly attributable to operational emissions from energy consumption required for day-to-day running of buildings and embodied emissions arising from the production, installation, and maintenance of the building fabric. Different policy instruments have been introduced to address the operational emissions from the existing building stock and from new buildings. However, policy and strategies for reducing embodied emissions have lagged. The importance of a whole life-cycle approach to the evaluation of building emissions is now accepted as increasingly necessary to assess the true carbon footprint of buildings. As most of the embodied emissions arise upfront before a building is even occupied, failing to address this issue will make it very difficult to achieve the current emissions reduction targets.

The role of wood

Increased use of wood products provides an opportunity to significantly reduce the embodied emissions of buildings. Sawn wood and more advanced engineered wood construction products such as Oriented Strand Board (OSB), Cross-Laminated Timber (CLT), Glued-Laminated timber (glulam) and Laminated Veneer Lumber (LVL) offer a sustainable alternative to site based high CO2 producing construction materials such as masonry, concrete and steel (Figure 1). These high-performance wood products have now been used in multi-storey construction up to 24 storeys tall.

For low-rise construction, light timber-frame is a sustainable alternative to conventional masonry construction. Benefits of using timber products in buildings include **long-term carbon storage** in buildings, low embodied emissions associated with sustainably managed forests and the manufacture of wood products, and avoided emissions by displacing higher embodied energy materials such as concrete and steel. In addition, specifying more sustainable materials is a better use of natural resources, and as environmental awareness begins to influence consumer choice, it is expected that this will then begin to impact the future value of our building assets.

Figure 1: Use of timber and wood-based panel products in domestic construction



Policy (Global/ EU/ National)

In order to tackle climate change, policy instruments have been developed at global, EU and national levels which set targets for emissions reduction over the coming decades.

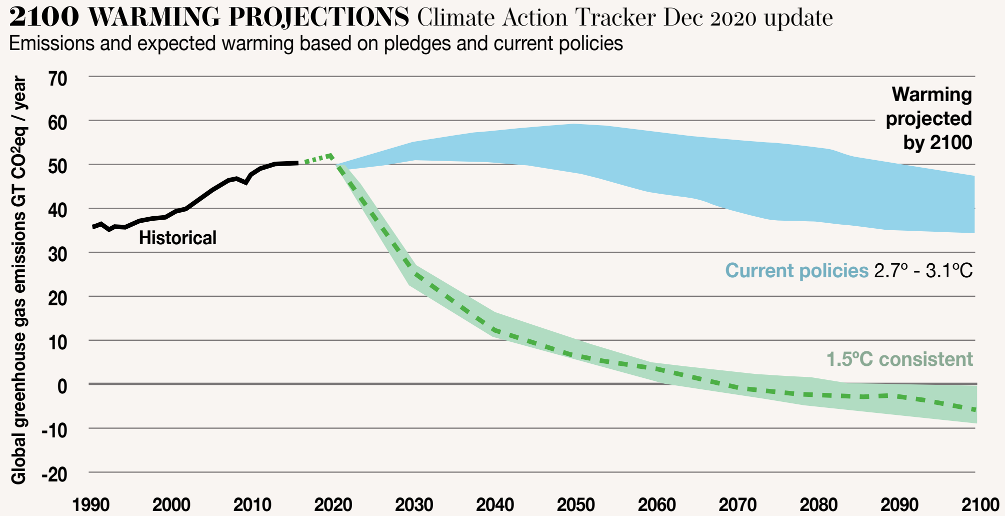
The **United Nations (UN) Sustainable Development Goals** [1] are part of the 2030 Agenda for Sustainable Development adopted by all UN member states. Goal 11 to 'make cities and human settlements inclusive, safe, resilient and sustainable' and Goal 13 to 'take urgent action to combat climate change and its impacts' are directly relevant to sustainable construction.

The **Paris Agreement** (COP21) [2] aims at holding the global average temperature rise to well below 2°C above pre-industrial levels. Under Article 4, the agreement aims to "achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century". Figure 2 estimates the impact of historical and of a range of future emission pathways on expected global warming to the end of the century.

The European Commission, through the **European Green Deal** [4], aims to raise its 2030 greenhouse gas emission reduction target to at least 55% compared to 1990, so that the EU becomes the first carbon-neutral region in the world by 2050. The European Green Deal includes a new strategy for a sustainable built environment and circular economy plan, including a life-cycle assessment approach for product and building assessments. The Commission will also consider the possibility of including emissions from buildings in the EU Emissions Trading System (ETS).

In Ireland, to align with the Paris agreement, the **Programme for Government** [5] published in October 2020 made a commitment to an average 7% per annum reduction in overall GHG emissions in between 2021 and 2030, which represents a 51% reduction over the decade, and to achieving net zero emissions by 2050. To give effect to this policy, the **Climate Action and Low Carbon Development (Amendment) Act 2021** [6] establishes this 2050 emissions target and a system of 5-year economy-wide carbon budgets, which will set ceilings on the total GHG emissions. This Act also introduces

Figure 2: Global greenhouse gas emissions pathways [3]



a requirement for Local Authorities to develop individual Climate Action Plans, which will include both mitigation and adaptation measures. The Government Climate Action Plan published in 2019 provides a detailed annex of actions across all sectors which will be revised and published in 2021.

Based on emissions projections produced by the **Environmental Protection Agency** [7], Ireland is set to miss its target for non-Emissions Trading Scheme emissions (non-ETS) in the short term. Early and full implementation of the Climate Action Plan measures, while availing of Land-use, Land-use Change and Forestry (LULUCF) flexibilities, will be needed to achieve its 2030 target.

The Department of Agriculture, Food and the Marine (DAFM) on foot of extensive engagement with industry, research, policy, farmer and environmental stakeholders, developed the roadmap **Ag Climatise** [8] designed to help all stakeholders to work together to tackle climate change and air pollution. Action 14 states: *Increase afforestation levels and maximise the contribution of existing forests to climate change mitigation and adaptation; Examine new opportunities for the forestry sector through the replacement of unsustainable raw materials in construction and packaging with bio-based materials, polymers, fibres and composites and for providing more sustainable innovations in sectors such as forest-based textiles, furniture and chemicals, and new business models based on the valuation of forestry ecosystem services.*

The **National Planning Framework** – Project Ireland 2040 [9] sets out 10 goals or National Strategic Outcomes (NSOs) to shape the future growth and development of Ireland to 2040 when the population of the country will have grown by one million people. NSO1 Compact Growth identifies the need to develop more compact higher-density urban centres and specifically highlights urban regeneration and redevelopment initiatives. NSO8 Transition to a Low Carbon and Climate Resilient Society highlights the 'development of a circular economy and bioeconomy'.

The **National Energy Efficiency Action Plan** #4 [10] set out targets for reductions in the operational energy efficiency of buildings of 20% by 2020 and 33% improvement in energy efficiency for the public sector. This plan includes measures to ensure that energy efficiency of products is considered in government procurement framework agreements.

Carbon and construction

Emissions from the built environment

GHG emissions of a product or system across its life cycle, from raw material extraction through production, transport, use and disposal or reuse at end of life is often referred to as the carbon footprint. As carbon dioxide (CO_2) is the most significant GHG, to facilitate assessment and comparison between different products or systems, all GHG emissions are expressed in terms of mass of CO_2 equivalent (CO_2eq).

The **carbon footprint** of the construction sector, including building construction and its operations, is very significant, as highlighted in the annual status reports of the UN Environment Programme and the Global Alliance for Buildings and Construction. The 2020 report [11] states that **38% of the total global CO_2eq emissions** came from this sector (Figure 3). The **manufacture and use of construction products** represent **11% of global CO_2eq emissions**, with 8% from cement production alone [12]. To be on track to get to net-zero carbon building stock by 2050, the International Energy Agency (IEA) estimates that by 2030 direct building CO_2eq emissions need to fall by 50% and indirect building sector emissions by 60%.

EU and National strategies to reduce building sector emissions have until recently focussed on increasing energy efficiency through changes to building regulations and the introduction of a Building Energy Rating system. As the energy efficiency of buildings is increased, the absolute and relative contribution of embodied emissions from the building materials to the overall carbon footprint is increased [13].

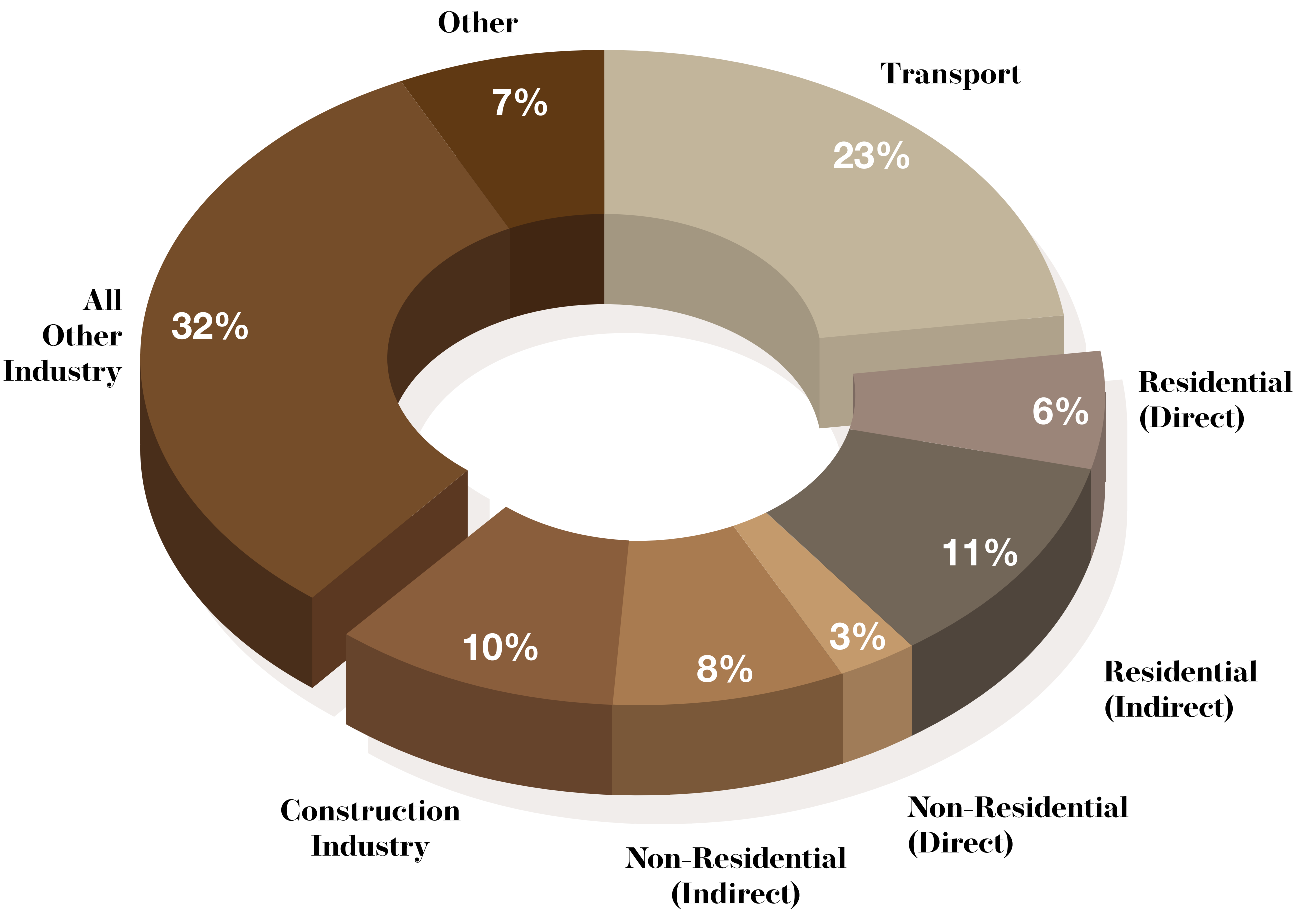


Figure 3: Global share of buildings and construction emissions 2019 [11]

Understanding carbon – embodied, operational, and whole-life carbon

Assessment of the overall CO_2eq emissions is carried out using **Life Cycle Assessment** (LCA) methodology, which is a standardised method to quantify the environmental impact of products or processes throughout a building's life cycle. The principles are described in the EN ISO 14040 series of international standards. [14-16].

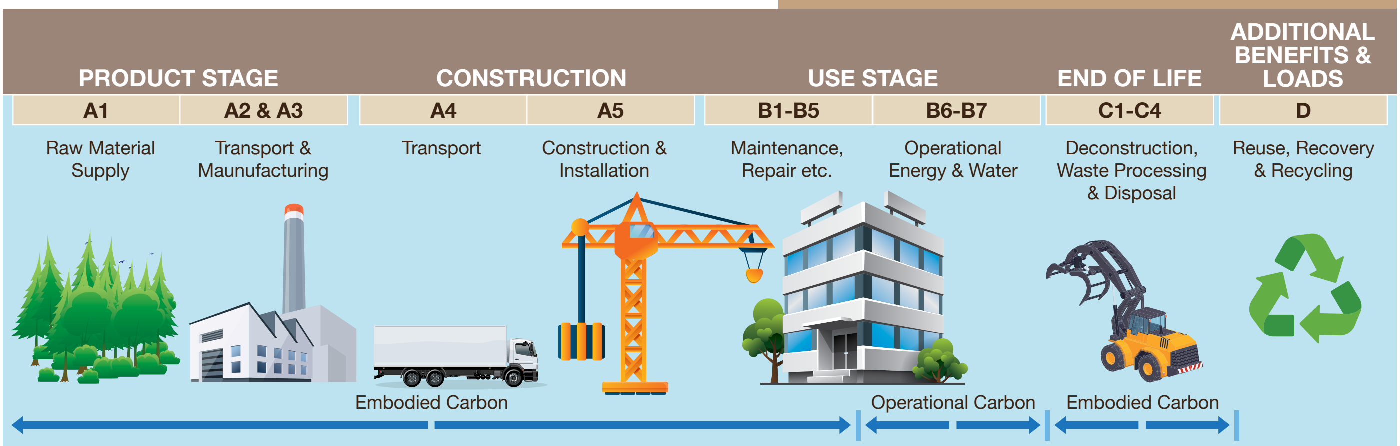
Specific rules for products and buildings are given in EN 15804 [17] and EN 15978 [18], respectively, to assess their carbon footprint. Carbon Footprint is defined as the total amount of GHG, particularly CO_2, emitted as the result of a specific activity. Both standards are organised in modules covering different life cycle stages and include seven impact categories. Referring to Figure 4, **Embodied carbon** emissions are those associated with stages A1-A5, B1-B5 and C1-C4. **Operational carbon** emissions are associated with stage B6. **Whole-life carbon** emissions cover all life cycle stages from A to D.

Life cycle stages A1-A5 include raw material extraction, transport to the manufacturing plant, product manufacture, transport to the building site, and construction of the building. Life cycle stages B1-B7 cover the use phase of the building including the impacts associated with the operation and maintenance of the building and refurbishment of the building fabric. Life cycle stages C1-C4 cover end of life impacts and finally, stage D covers impacts beyond the end of life that, via reuse or recycling, links to the circular economy with its attendant benefits. Care must be exercised when comparing results of different studies as these typically cover different subsets of these stages.

The environmental impacts of individual products can be provided by manufacturers in an **Environmental Product Declaration** (EPD). This is a standard LCA report that allows specifiers to make informed choices based on environmental emissions associated with different materials. For products, the carbon emissions are normally expressed in terms of mass of CO_2eq per unit mass or per unit weight of the material.

For a building LCA, the overall carbon footprint is determined from the quantities of materials used and the associated emissions from the product EPD or generic databases such as Ecoinvent [19] or ICE [20]. The Irish Green Building Council [21] has developed the EPD Ireland platform that allows EPDs for building products to be interrogated. A weakness is that at present it does not have data for most Irish timber products.

Figure 4: Building life cycle assessment stages and modules

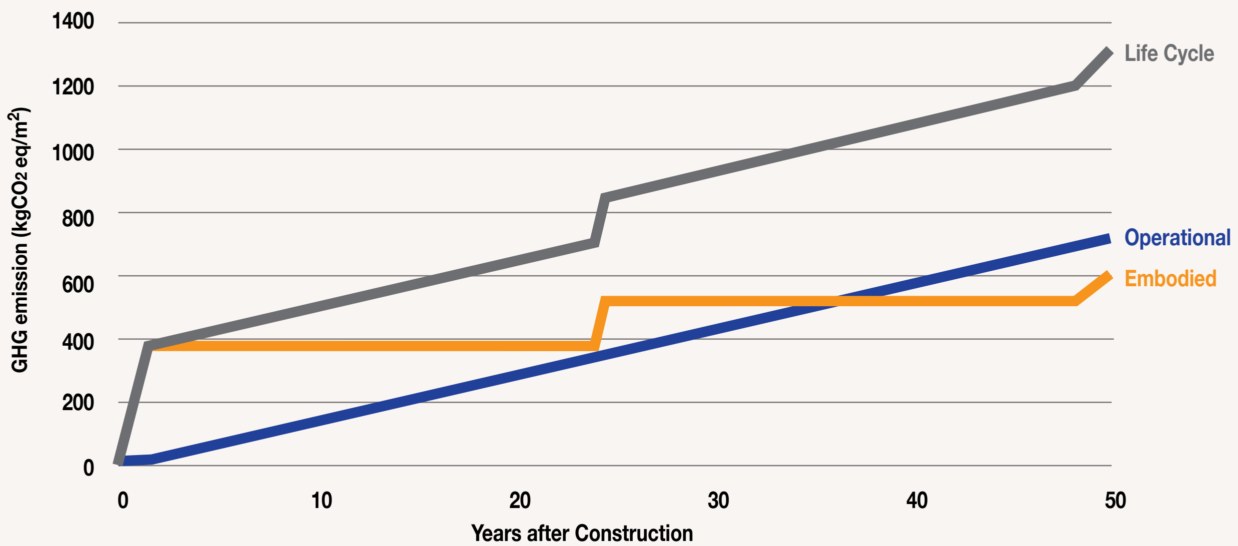


A major review of building LCA studies was undertaken as part of the International Energy Agency's Energy in Buildings and Communities (IEA-EBC) programme covering 238 buildings [13].

These included residential and office buildings with different energy performance classifications. The findings clearly demonstrate the increasing importance of accounting for embodied emissions as the building energy efficiency increases. For residential and office buildings, the contribution of embodied emissions to the whole life cycle emissions increases from about 20% for existing buildings built to 1970's energy efficiency standards, to almost 50% for low-energy or Nearly Zero Energy Buildings (NZEB) due to the reduction in operational GHG emissions. Embodied emissions for low-energy buildings were higher due to additional insulation measures. For a 50-year reference period, the average embodied emissions of existing residential buildings were 6.7 kg CO2eq/m2/a, but this increased to 11.2 kg CO2eq/m2/a for low-energy buildings. Within each building class, there was significant variability in both operational and embodied emissions. The study showed the potential to design buildings to minimise embodied emissions without compromising energy efficiency.

A key difference between the embodied and operational emissions is the time over which they occur (Figure 5). Most of the **embodied emissions are upfront and occur at the start of the building's life**, with only small contributions from maintenance and repair at later stages in the life cycle. **Operational emissions**, on the other hand, **are zero at the start of the building's life and occur over the full life cycle**. It is clear that upfront embodied emissions due to materials manufacture and building construction must be assessed and optimised as a matter of urgency, in order to achieve the emissions targets, set out in international and national policy.

Figure 5: Operational and embodied CO2eq emissions over the life of passive house standard building (adapted from [13]). Embodied emissions exceed operational emissions up to year 35.



The role of wood products in climate change mitigation

The role of bio-based materials such as wood in addressing climate change is now being increasingly recognised. EU President Ursula von der Leyen, in her 2020 State of the Union address to the EU Parliament, stated "We know that the construction sector can even be turned from a carbon source into a carbon sink if organic building materials like wood ... are being used".

Wood products contribute to reducing the life cycle emissions of buildings through (i) low embodied CO2eq, (ii) carbon sequestration/storage and (iii) substitution effects.

Embodied carbon emissions of timber construction

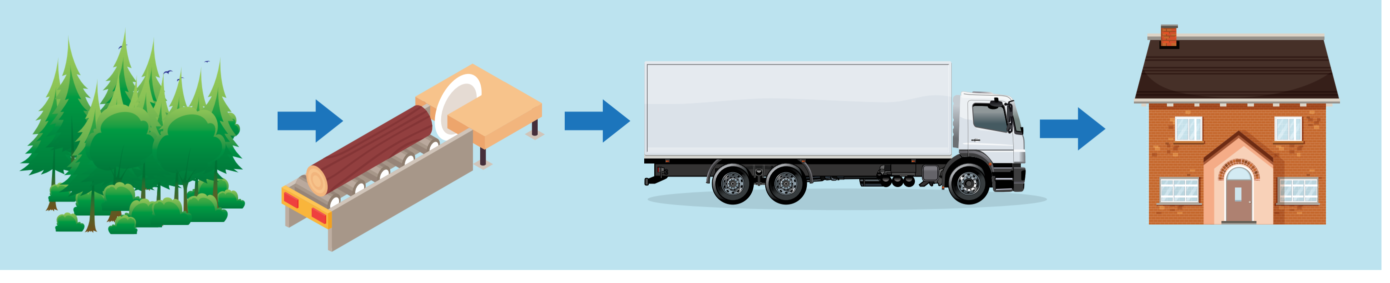
The production of the raw material for wood products and the harvesting and extraction to a production facility do not require significant energy resources. Processing of sawn timber is also a low energy intensity process. Most of the energy required is for kiln drying which is provided by the co-products generated in the sawing process.

The manufacture of engineered wood products generally involves connecting smaller timber pieces together using adhesives or metallic fasteners, both of which contribute to the embodied impact. However, their volumes are relatively low and do not overly impact on the environmental performance. In addition, the light-weight nature of timber building components favours smaller foundations, and their good thermal properties can lead to a reduction in the thermal insulation requirements, contributing to the low embodied emissions of timber buildings. There is also excellent potential for end-of-life reuse and recycling of timber building elements as demonstrated in the current EU ForestValue *InFutUReWood* project [22].

Carbon storage in wood products

When wood from sustainably managed forests is used to manufacture products, the sequestered carbon remains stored in the product until the end-of-life of the product. Products with long-service lives, such as construction products, maximise the carbon storage potential. The life cycle of some wood products can be further extended after the end-of-life of the building via reuse and recycling in other cascade uses. Thus, the life span of wood products can be extended indefinitely leading to a situation where the carbon sequestration is theoretically infinite. In reality, there will be some losses during deconstruction, but current research is focussed on minimising these losses [22]. Furthermore, any losses during recycling can be used as bioenergy in combined heat and power (CHP) generation or boiler combustion to offset the use of fossil fuels.

Figure 6: Embodied Carbon within the Forest products Supply Chain



Carbon stored in wood products, derived from the domestic harvest, is accounted under the land use, land-use change and forestry regulation EU 2018/841. All harvest is debited in the forest pool. The portion of harvest transferred to the harvested wood products (HWP) pool is decayed over time, depending on the service life of the product. Where the amount of carbon entering the pool exceeds emissions, a sink is accounted. This creates an incentive to continue to increase the level of use of wood products derived from the domestic harvest in line with sustainable forest management. Increasing the use of these long-lived wood products will decrease the decay rate and increase the sink, all other things being equal.

The rate at which harvest is transferred to the HWP pool, as we have seen, needs to be considered in policy development, and there are a number of other reasons why carbon storage is accounted: it gives time for technological development and adaptation, some radiative forcing is avoided, and some temporary storage may become permanent through circular use of wood.

With an extensive use of wood, the sequestered carbon stored can more than offset the life cycle embodied emissions resulting in carbon negative buildings (see Figure 7) [23].

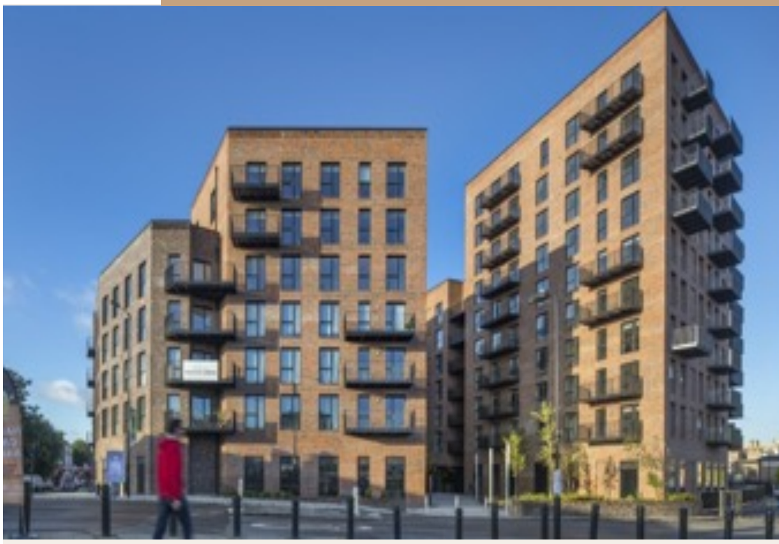
In Ireland, where forests are managed with relatively short rotation lengths, the harvested timber is ideal for increasing the carbon storage in building products. As the building life span is generally longer than the rotation length of the forest, carbon remains stored in the buildings while newly planted trees grow to maturity. Thus the HWP carbon pool continually increases once it is replenished through new construction and refurbishment.

Substitution effects or avoided emissions

Currently, most of the increase in global building stock is achieved using steel and concrete. The significant embodied emissions from these buildings could be significantly reduced or avoided if timber building products were used instead. For the Dalston Works building (Figure 7), an equivalent concrete frame design would have an estimated carbon footprint of +2,000 tCO_2eq, which was avoided in favour of the timber solution with a footprint of -2,600 tCO_2eq at the project level [23]. Thus, substitution could be the basis for encouraging increased use of timber in construction as is the case with incentives for biofuels as a substitute for fossil fuels.

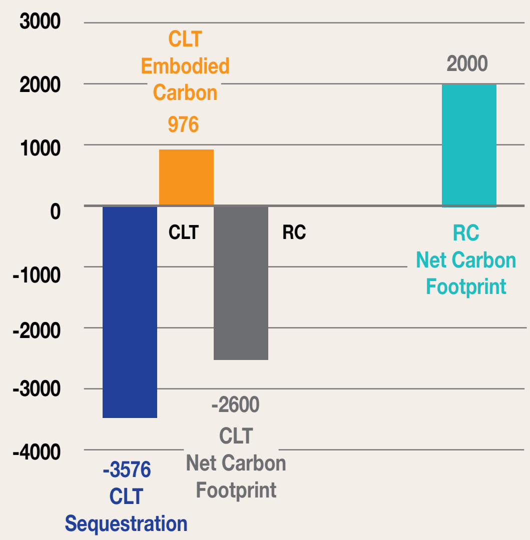
Figure 7: Dalston Works, London

(Photo credit: Ramboll UK)



Dalston Works, London: 10-storey 121-unit apartment building made from CLT stores sequestered carbon of 3576 tCO_2eq and produces embodied carbon of 976 tCO_2eq, giving a net carbon footprint of -2600 tCO_2eq.

An equivalent concrete frame design (RC) would have an estimated carbon footprint of +2000 tCO_2eq. [23]



Modern methods of construction

Modern Methods of Construction (MMC) [24] is a term used to describe a range of innovations in materials technologies, offsite manufacturing, and the broad use of digital technologies, which is changing the way construction works and which can help to overcome some of the issues faced by the sector including skills shortages and weather delays.

MMC includes Design for Manufacture, Assembly and Disassembly (DfMAD), an approach that facilitates offsite construction by focusing on the manufacture and assembly of products in a controlled environment that can make use of advanced technologies to increase efficiency and maximise the potential for disassembly and reuse at the end of building life. This can be achieved using a Building Information Modelling (BIM) process and associated technology that allows the digital design of buildings and management of all the relevant information throughout the entire building life cycle. Offsite manufacturing, using computer-numerical controlled (CNC) technology, results in improved productivity, precision, quality, and safety, together with more efficient use of materials and reduced waste.

Offsite construction systems range from two-dimensional panellised systems manufactured in the factory and assembled on site to full three-dimensional volumetric units, mostly fitted out offsite, or a hybrid of both. Timber construction lends itself readily to these types of modular construction and their low weight relative to other materials is particularly advantageous for lifting and assembly. Light timber-frame and structural insulated panels, manufactured offsite in Ireland, have been used for low-rise residential construction and school building for many years (Figure 8). Currently, about 24% of Irish homes are built using timber frame. This compares with 70% in Scotland so there is significant potential to increase the use of timber frame

Figure 8: Offsite light timber frame construction
(Photo credit: Derome AB, SE and Cygnum, IE)

construction in Ireland [25]. Mass timber engineered wood building elements, such as glulam, CLT and LVL, are high-performance structural materials with properties equivalent to those of steel or concrete elements and are suitable for floor, wall and roof elements as panellised or full volumetric units (Figure 9). Mass-timber, especially CLT, is being increasingly used across the globe in the construction of mid-rise buildings to 20 storeys or more, but its use in Ireland has been limited to a small number of low-rise applications. With the move to high-density, taller urban development, CLT construction can provide a sustainable solution for residential, commercial, and retail developments.

The importance of the transition to MMC in achieving the extensive targets for housing and infrastructure, set out in Project 2040, has been highlighted by the Department of Public Expenditure and Reform in its report on Building Innovation [26]. While some of the larger companies in the construction sector have begun to transition to offsite construction and digital technologies in recent years, the promotion of a greater culture of innovation across the SME sector has been identified as having the potential to deliver substantial gains for the industry. This presents an opportunity to significantly grow the timber-based construction sector in Ireland.

Figure 9: Offsite prefabricated mass timber being used in construction

Impact of increased use of timber in Construction

Decarbonising our built environment is a key focus of the European Green Deal and this will require investments across the EU in new forms of sustainable and off-site construction, which timber products and timber building systems can help to address due to their environmental, sustainable, and embodied carbon credentials. Specifically, there are a number of **challenges facing the Irish government**, as set out in the National Strategic Outcomes [9], which our forest and forest products sector is well positioned to address:

- The need to drastically reduce GHG emissions or reduce carbon emissions in construction in the context of the forecast population growth and the need for 500,000 new homes by 2040 (32,000 per annum on average)
- The need to increase forest cover in Ireland to address climate change
- The need to shift towards sustainable investments
- The need to create viable, long term green jobs, across the island, including rural Ireland.

Further investment in product and process innovation, skills enhancement and market diversification is now required if the forest and forest products sector is to react appropriately to the projected increase in fibre supply and its role in the drive to reduce carbon emissions in construction. This will help to strategically position the whole supply chain, from timber growers to the end-market, to advance the sector's international competitiveness.

Underlying demand for new homes

Ireland is currently not building enough homes to meet demand. Growth in population has significantly exceeded the increase in the housing stock since 2011 [27]. The Central Statistics Office (CSO) predicts that the population will grow from 4.74 million in 2016 to between 5.6 and 6.7 million by 2051 [28]. Over this period, the population structure will change with an increasing proportion of people falling into the age groups 40 years and older. Based on these population trends, it is estimated that the number of households will increase from just over 1.75 million in 2018 to about 2.8 million by 2051 [27]. This corresponds to an average **requirement of almost 32,000 new houses per annum** between 2019 and 2051. By 2051, over 67% of the housing requirement will be for one- or two-person households, with about 20% of the population living in apartments. The projected housing demand of 32,000 new houses represents a significant increase over dwelling completions in the last decade, which varied from less than 5,000 units in 2013 and just over 21,000 units in 2019. Additional built infrastructure, such as schools, hospitals, and places of work and leisure will also be required to support the needs of a growing population.

Modelled net carbon benefits of increased use of timber

A recent study [29] by the BioComposites Centre at Bangor University, commissioned by the **UK Committee on Climate Change**, presented data on embodied and sequestered carbon for a range of dwelling types, including those that are typical of current Irish construction, such as concrete block and timber frame houses (Figure 10). All dwellings were designed to the same thermal standard, so the operational carbon was not included. They also considered multi-storey dwellings built using concrete, timber frame and CLT. The study showed that for all dwelling types, there was a lower carbon footprint for timber construction with the greatest benefit in the case of high-rise apartments.
Using this data, which covers LCA modules A1-A3, and adjusting for Irish dwelling unit types, different

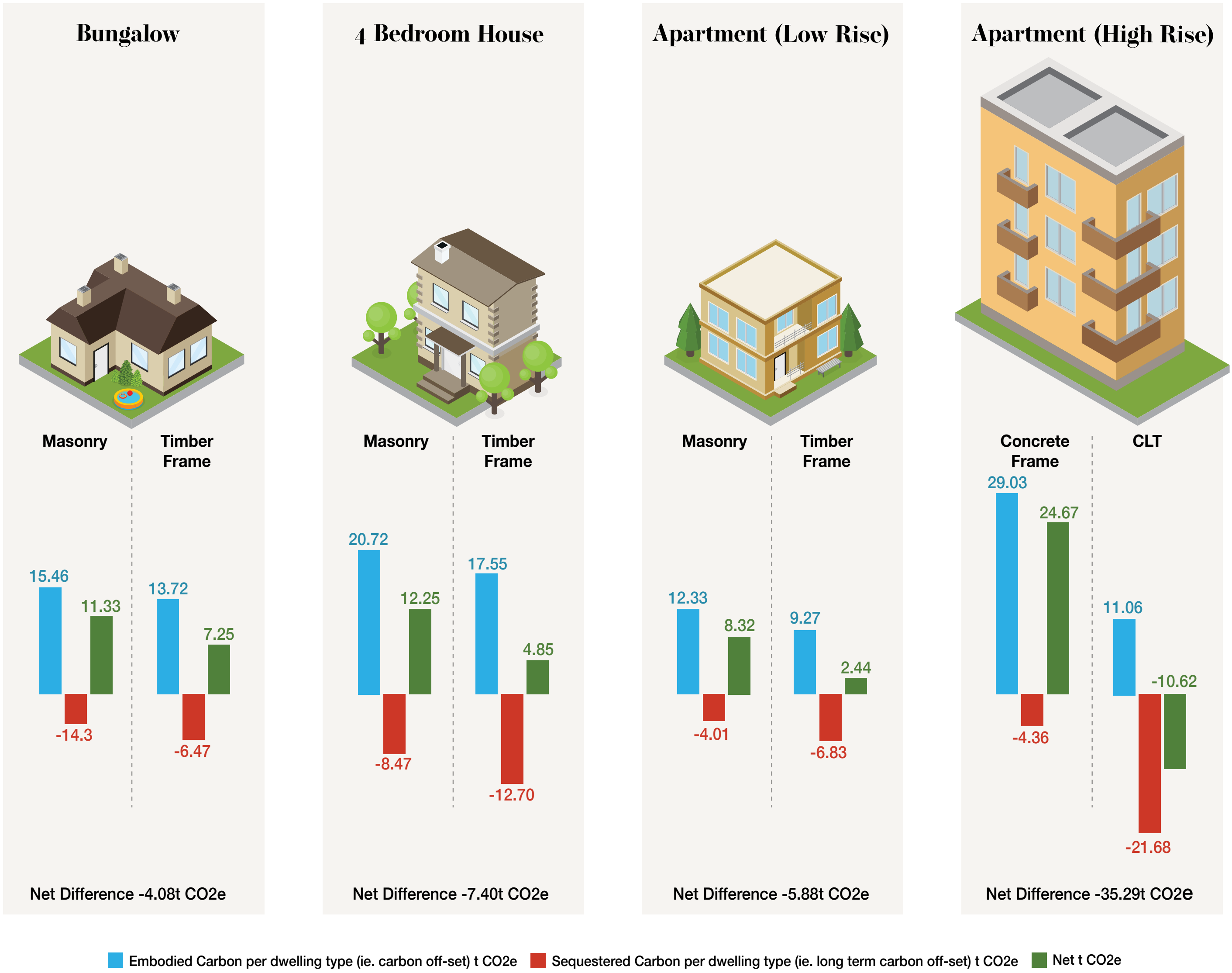


Figure 10: Wood in Construction in the UK: An Analysis of Carbon Abatement Potential [29]

scenarios for delivering the projected demand of 32,000 homes per annum in Ireland are presented here. Today, Ireland's new build dwelling units comprise a mix of single and scheme dwelling homes and apartments, with an estimated 24% built using timber frame construction (Table 1).
The calculations draw on different scenarios regarding the proportion of new build dwelling types in the coming years, and how many will be built with timber. The analysis is based on the fact that a timber framed structure has lower embodied carbon compared with a functionally-equivalent masonry structure. In addition, a timber frame house stores more sequestered carbon in the structural elements than a masonry house. The same applies when comparing CLT with concrete frame (Figure 10).

New Builds 2019 - CSO Figures and Timber Frame Industry Data

Dwelling Type	Masonry Dwellings	Timber Frame Units	Total Units
Single House	4,817	250	5,067
Scheme house	7,863	4,650	12,513
Apartments	3,407	100	3,507
Total	16,087	5,000	21,087

Table 1 - New Builds 2019 [30, 31]

The following key assumptions apply to the scenarios modelled:

- All scenarios assume that in 2022 the proportion of dwelling types will be the same as in 2019: 24%, 59% and 17% for houses, scheme houses and apartments, respectively.
- All scenarios assume that housing output will gradually increase year-on-year from 22,000 dwelling units in 2022 to reach a cumulative 881,000 units completed by 2050. The calculations draw a common scenario from 2022 adding an additional 1,500 units a year until reaching 33,000 units per year (2030). This is maintained until 2040, falling to 30,000 per year from 2040-2050. For the period 2022-2040 this is 581,000 units (The National Development Plan states that 500,000 new homes will be required by 2040 [32].)
- Ireland has the lowest rate of apartment construction of any of the EU member states, at just 12%. For scenarios 2, 3 and 4, the calculations assume an increase of 1% a year for apartment units, going from 17% in 2022 to 30% in 2035 and maintaining that percentage thereafter. This increment of new build apartments reduces the percentage of scheme houses, assuming Ireland will transition to a more apartment-style residential model.
- The scenarios only examine the sequestered and embodied carbon associated with the 'capital' phase of a new build project when comparing building types. The analysis does not include operational carbon or substitution effects and benefits.

Scenario	Description	Cumulative Embodied Carbon Mt CO2 eq 2022-2050	Cumulative Sequestered Carbon Mt CO2 eq 2022-2050	Cumulative Net Carbon Mt CO2 eq 2022-2050	Cumulative Net Carbon Difference from Base Scenario Mt CO2 eq 2022-2050
1	Base Scenario - Dwelling types and % mix (24%, 59% and 17%) remain as 2019 for entire period. Timber frame remains 24% per annum for entire period.	14.6	-5.8	8.8	8.8
2	Small annual increase in timber buildings across all dwelling types averaging 35% over the entire period. Gradual increase in low and medium rise apartments to reach 30%.	14.7	-6.1	8.6	-0.2 (-3%)
3	Medium annual increase in timber buildings across all dwelling types averaging 49% over the entire period. Gradual increase in apartments to reach 30%. Small % of medium rise CLT from year 2025.	15.1	-7.6	7.5	(-15%)
4	Strong annual increase in timber buildings across all dwelling types averaging 55% over the entire period. Gradual increase in apartments to reach 30% of which 70% medium rise built with CLT by 2032.	14	-8.6	5.4	-3.4 (-38%)

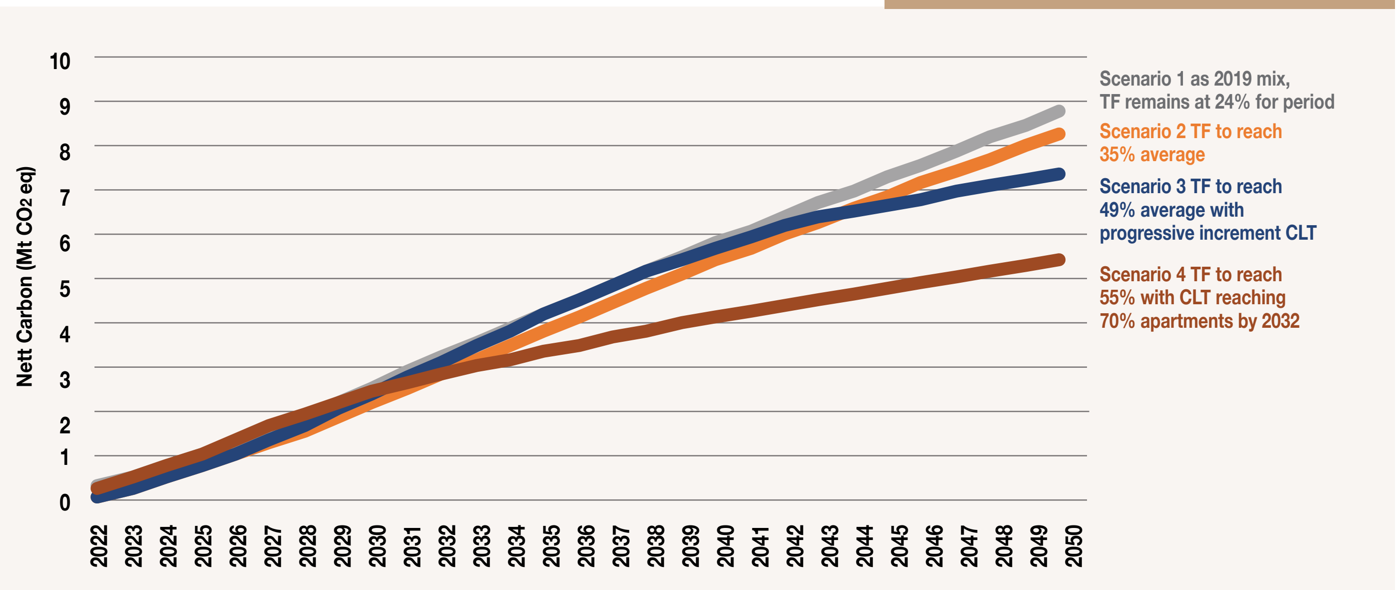
Table 2 - Modelled Scenarios – Carbon Footprint of New Build Construction

Analysis of results

The scenarios modelled show the net carbon emission savings between a base case where we continue to build with current forms of construction and the timber frame market share remains at 24% per annum for the entire period, to alternatives where we gradually increase timber use. As timber frame market share increases to displace masonry construction, it can be shown that nett carbon savings increase. As higher apartments are permitted, and CLT is introduced to the market, carbon savings become even more pronounced (Table 2 and Figure 11).

Potential carbon savings of 3.4 million tonnes CO2eq are achieved over the period to mid-century when comparing the base case against a market where timber frame penetration achieves an average of 55% over the period and the regulatory environment permits the use of CLT for buildings over 10 m, accounting for 70% of all new apartment developments in the future. The 3.4 million tonnes of CO2eq avoided are equivalent to removing 2.4 million cars off the road in one year (Calculation based on average new vehicle emitting 120 grams of CO2 per kilometre and travelling 12,000 kms = 1.44 metric Tonnes CO2 per annum) or the equivalent of 5.6% reduction in Ireland's current annual emissions of ~ 60M tCO2eq [7, 33].

Figure 11: Net Carbon Dioxide Emissions by Scenario (TF: Timber Frame)



Benefits of Wood Product Substitution in Displacing Fossil Based Products

Analysis was undertaken to assess how the global climate is impacted by the domestic forest-based sector (Republic of Ireland and Northern Ireland). Scenarios were then examined to determine the relative magnitude of different climate actions on the daily operations of the sector based on the effects of changes in production levels and efficiency.

The methodology employed is based on two principal components:

- Assessment of the benefits of using wood-based products to displace more carbon intensive alternatives.
- Assessment of fossil emissions in the forest products value chain.

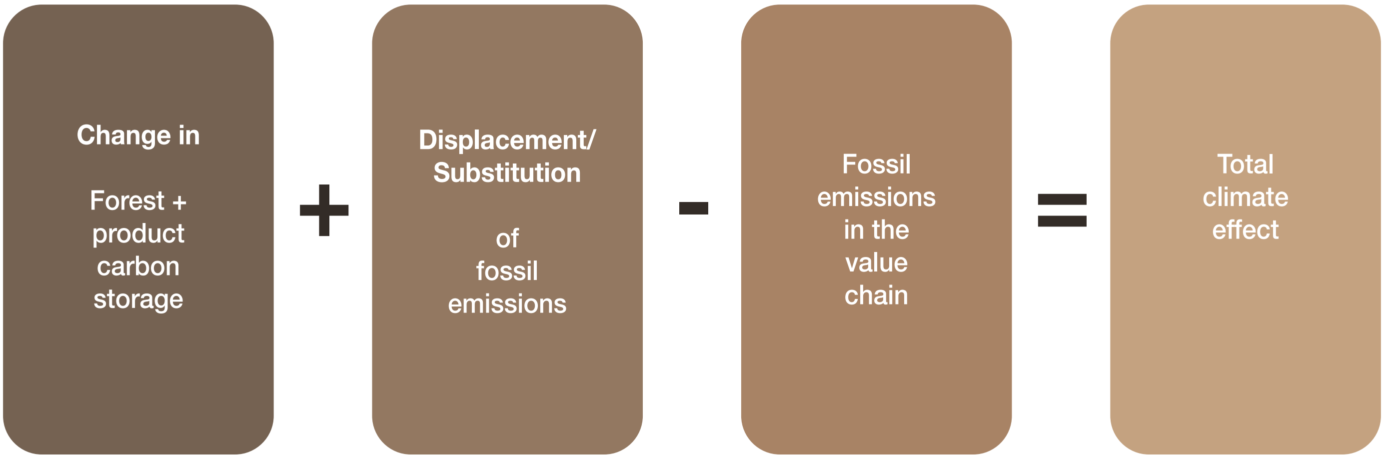
The overall climate effect equation is summarized below. The analysis undertaken covers the second and third component which looks to assess the displacement benefit of using wood products and also accounts for the fossil emissions in the wood value supply chain.

Analysis of Substitution/ Displacement Benefit

Displacement effects for the Irish forest products sector output were estimated based on a review of international studies of comparable end use product categories. Using estimated production data for the domestic forest products sector, the total displacement effect of domestic forest products is estimated at 3.8 Mt CO_2eq/yr. This is the level of avoided emissions from fossil-based products through the use of wood-based products and translates to an overall displacement factor of 0.86 tCO_2eq/tCO_2eq or 0.79 tCO_2eq/m^3 at the roundwood stage.

"This means that for every m3 of roundwood we use we save 0.79 tonnes of CO2 eq"

Figure 12: Total Climate Effect Equation



Primary Product Category	Estimated Production 2019 000 m³	Displacement Factor[1] tCO2eq/tCO2eq	Total Displacement Mt CO2eq
Construction and Timber frame	642	1.85	1.09
Pallet and Packaging	344	0.75	0.24
Fencing and other	436	1.57	0.63
Posts	207	1.57	0.30
Wood Based Panels (OSB and MDF)	919	1.35	1.14
Bioenergy (of which internal use)	986	0	-
Bioenergy[2]	619	0.35	0.20
Other uses	188	0	-
"Export" of residues	362	0.7	0.23
Total	4699	-	3.82
Waste / Unaccounted for	157		

Table 3 - Estimated Displacement Effect from Domestic Wood-Based Products

Note 1: The Displacement Factor is an estimate of avoided fossil emissions by quantity of wood-based product, expressed in tCO2eq/tCO2eq or tonnes of carbon emissions avoided by tonnes of carbon in the wood-based product.

Note 2: Bioenergy includes power, CHP, commercial and residential use of woodfuel. A weighted average displacement factor was applied.

Analysis of Fossil Emissions in Value Chain

Four components of the value chain were assessed and comparative data from international studies were applied.

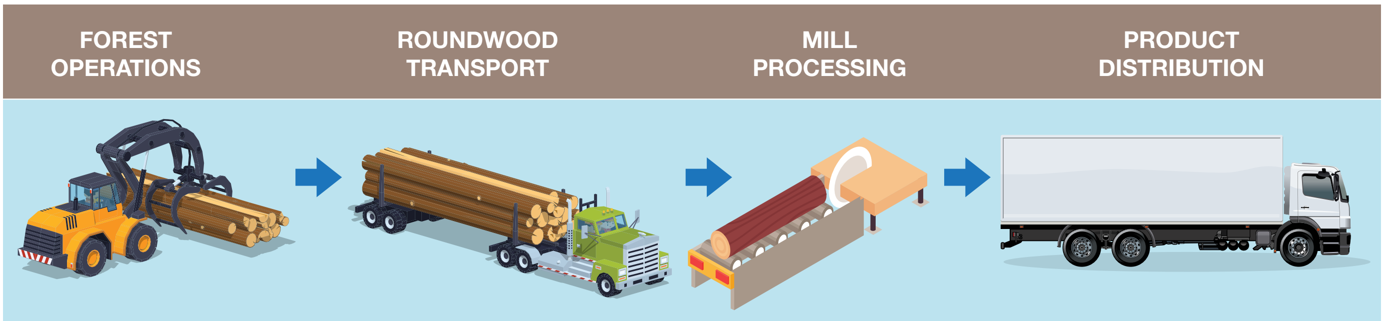
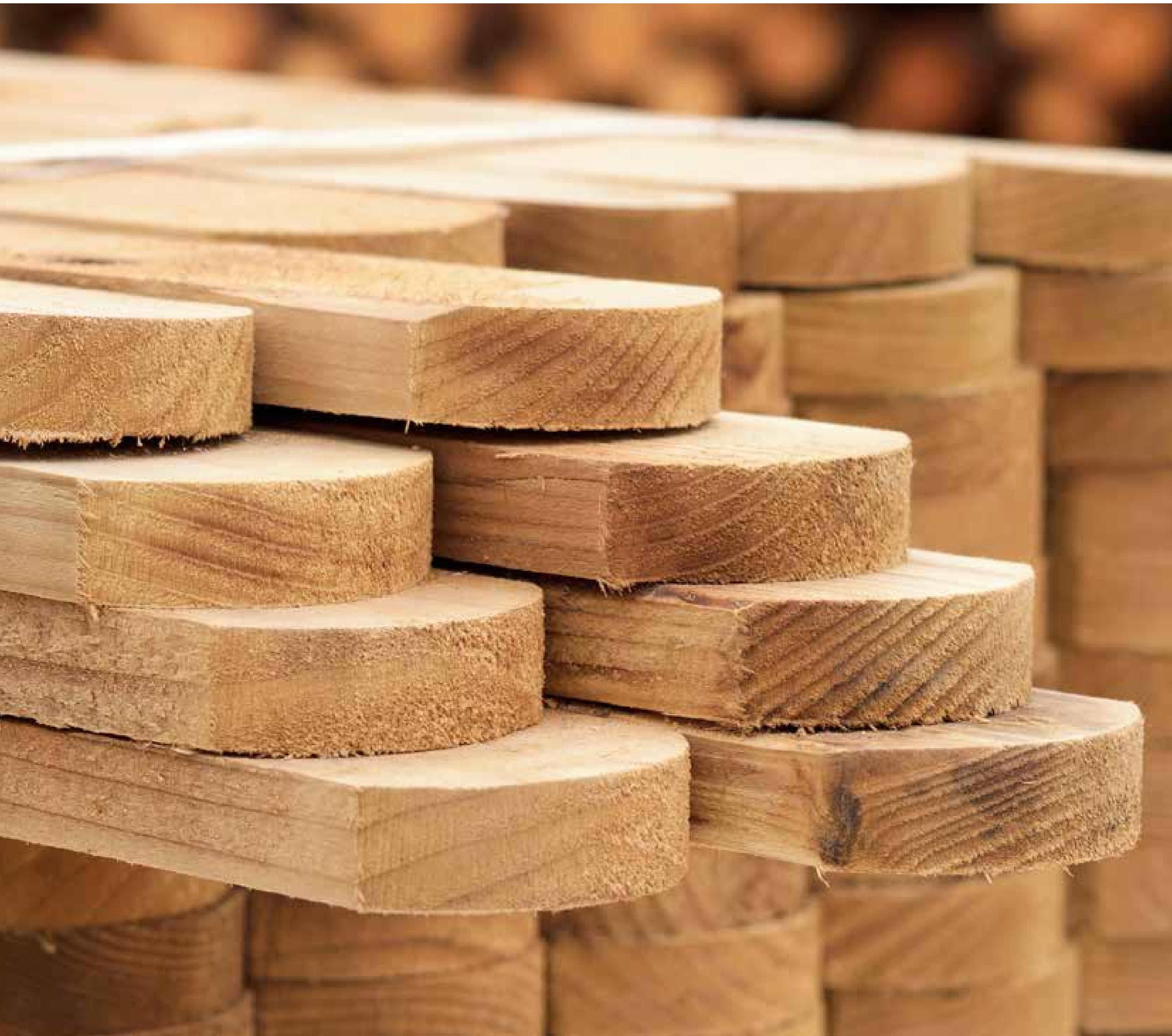


Figure 13: Value Chain Emissions in Forest Products Sector Supply Chain

Each product produced from our forests was examined and supply chain emissions determined from local data and international forestry supply chain emissions studies. Supply chain emissions include harvesting and transport of logs to sawmill, processing and delivery of wood products to main distribution points within the merchant network both in Ireland and the UK. Emissions from the construction of forest roads are excluded. Emissions from any further haulage of the finished product from the merchant network to the point of end use is also excluded. Based on the above system boundaries, total domestic value chain emissions were estimated at 0.38 Mt CO2eq/yr.

Component of Value-chain	Estimated fossil Emissions per unit tCO2eq/m3	Total value chain emissions Mt CO2eq/yr
Forest operations (including harvesting)	0.0059 tCO2eq/m3 roundwood	0.028
Roundwood transport (to processing mill)	0.0131 tCO2eq/m3 roundwood	0.063
Processing at mill(s)	0.02 tCO2eq/m3 roundwood input	0.097
Transport of finished products (to customer)	0.0832 tCO2eq/m3 product volume	0.194
Total		0.38

Table 4 - Estimated Value Chain Emissions from Irish Wood Based Products



Summary of Review

On average each m3 of wood led to a downstream fossil/process emission displacement of 0.79 tCO_2 eq for a total displacement effect of 3.8 million tCO_2 eq, corresponding to about 6% of reported emissions for the Republic of Ireland.

Fossil emissions in the value chain were estimated at 0.38 million tCO_2 eq for 2019. This includes forest operations (7% of emissions), transport of wood to mill (17%), emissions in mill processing (25%) and transport of products to customers (51%).

A range of independent scenarios were examined, based on the above results and data to determine the relative magnitude of different climate actions on the daily operations of the sector based on the effects of changes in production levels and efficiency. All scenarios indicate positive climate effects (ie. a reduction of atmospheric CO_2).

Change in product volume/composition and value-chain efficiency	Potential Climate Impact – Change in atmospheric CO_2 per year $MtCO_2eq/yr$
Increase overall production (roundwood + products by 10%)	-0.4
Increase sawn-wood output (from 30% of roundwood volume to 40%)	-0.5
Increase displacement when using sawn wood products for construction (from 1.5 to 2 tCO_2eq/tCO_2eq)	-0.3
Increase end-use recovery of wood (from 50% to 80% and use as CHP energy)	-0.3
Maximise bioenergy CHP displacement (80% recovery, only CHP use, Unaccounted waste used)	-1
Maximise bioenergy heat displacement (80% to heat, 20% to CHP, Unaccounted waste used)	-0.7
Reduce transport emissions (by half)	-0.1
Reduce fossil emissions in processing mills (by half)	-0.05

Table 5 - Indicative climate effects of selected scenarios related to displacement and value chain emissions*

*Scenarios are not mutually exclusive, and they should not be added up and do not include the impact of the forest (carbon stocks, carbon sinks and the rate of uptake).

Summary and conclusions

- The wider construction and building sector accounts for 38% of energy-related CO2eq emissions annually, of which 28% represents the energy use for heating and cooling these buildings.
- Reducing the carbon footprint of the construction sector is essential to reach the climate goals set out in the Paris Agreement. The design professions deeply influence the selection and flows of the materials and energy within this sector and they will continue to play an important role, to be aware of, and design for, the impact of climate change
- As the energy efficiency of buildings improves through new construction technologies and a greater use of insulation, the embodied carbon impact increases in both absolute and relative terms.
- A whole life cycle approach and specific Environmental Product Declarations (EPDs) are needed to accurately assess the environmental impact.
- Reducing embodied impacts has an immediate effect. Embodied impacts occur upfront at the start of the building's life whereas operational emissions are zero at the start of the building's life and are spread uniformly over the operational lifespan.
- Wood products reduce the carbon emissions of buildings through (i) low embodied CO2eq, (ii) carbon sequestration and (iii) substitution of higher embodied materials. Timber frame structures use significantly more wood than their masonry counterparts and, when comparing the embodied and sequestered carbon storage between a typical timber frame and masonry home, it can be shown the net carbon emissions are reduced by 7.4t CO2eq for the structure which is a 2.5 times emission reduction.
- Residential building in Ireland is mostly low-rise of which 24% is timber frame with relatively small amounts of CLT used unlike our European or UK counterparts where these forms of construction are becoming more common and the regulatory environment permits taller buildings.
- Increasing the use of timber frame and CLT in Ireland over the period 2022 to 2050 has the potential to reduce CO2eq emissions by 3.4 million tonnes.
- At the project level more significant savings can be achieved in medium- and high-rise construction using CLT to replace reinforced concrete.

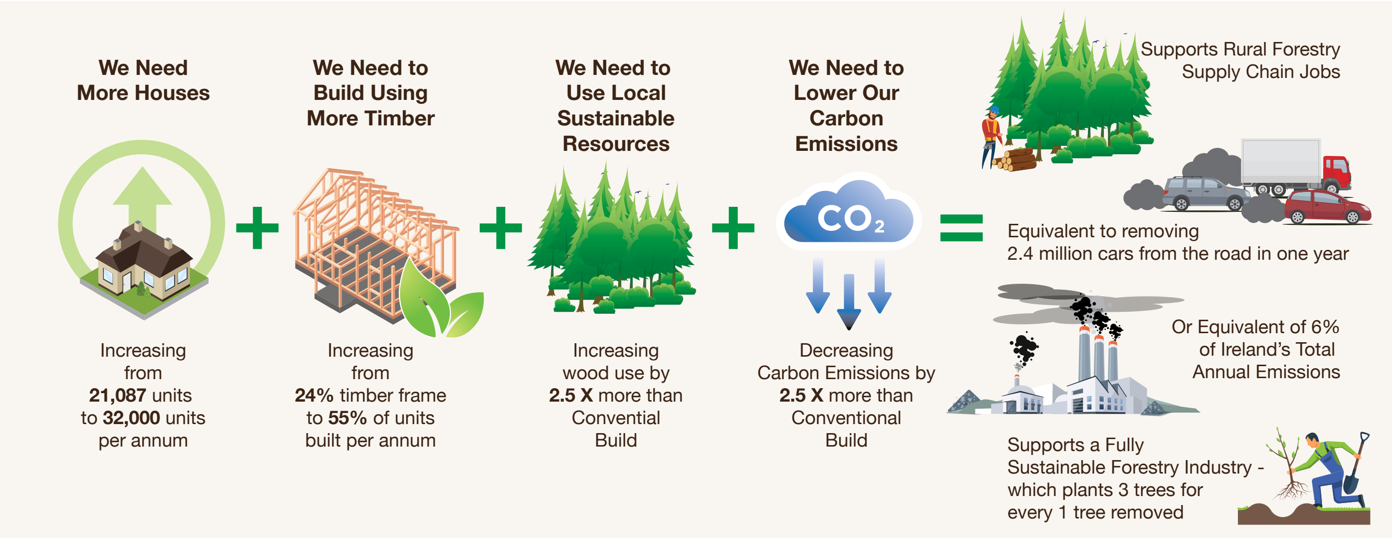


Figure 14: Summary of Potential Benefits of Increased Utilisation of Timber for Housing

Recommended Actions

1. Policy

Wood First policies

To promote the use of wood in construction, many national and local authorities have introduced 'Wood First' policies. In British Columbia, the Wood First Act [34], as part of its commitment to job creation and environmental sustainability, requires provincially funded projects to use wood as the primary construction material. The Swiss Wood Resource Policy [35] established targets for use of wood to reduced embodied energy and carbon in buildings. In Paris, all buildings higher than eight stories being built for the 2024 Paris Olympics must be timber construction, and all public buildings in France will be required to be made of at least 50% timber or other sustainable materials from 2022 [36]. The Borough of Hackney in London introduced a 'Timber First' policy in 2012 [37] and now has at least 18 multi-storey timber buildings. Similar policies have been put in place by regional authorities in Australia, New Zealand, and Sweden. All of these have resulted in a significant increase in the use of timber in construction.

In Ireland, South Dublin County Council (SDCC) has recently adopted a 'Wood First' Policy, requiring the use of wood as the primary building material where practical in all new and modified SDCC funded buildings. This is a first of its kind in Ireland and it will allow SDCC to lead the way in sustainable procurement practices. Implementation of targets for wood use in public buildings is an important part of a national strategy to enhance the sustainability of the built environment.

1.1 Recommendation: For all publicly funded projects, a wood first policy should be introduced and implemented. **Central government and local authorities should promote the use of a wood first policy throughout the construction sector.**

Integration of whole life carbon reporting in strategic planning

Several European countries are developing strategies to limit GHG emissions in the construction sector. These include the issuing of carbon budgets for buildings based on whole life carbon evaluation, which has been implemented in Finland, France, Germany, and Sweden [38]. Others are moving in that direction.

As part of the New London Plan to make London net-zero carbon and zero waste by 2030, Whole Life Cycle Carbon

Assessments will become part of the planning process [39]. This will require the submission of carbon assessment templates for proposed projects at different stages of the planning process and post completion. These will be compared to benchmarks for different building types. Developers will be required to demonstrate the measures taken to reduce emissions. Initially, these assessments will be required for strategic developments, but local boroughs can apply the policy to smaller developments. The assessment is aligned with the RICS embodied carbon database. As more data becomes available through the implementation of these assessments, it is expected that target values or carbon budgets will then be defined.

1.2 Recommendation: Government should introduce whole life carbon reporting to apply in the first instance to strategic developments and then rolled out to all construction projects through policy directives and building regulation. This should form part of the tender process for public projects by 2025 and be extended on a mandatory basis to all large scale residential and commercial building from 2028.

2. Tools & data

LCA assessment tools

LCA reporting often suffers from a lack of consistency in the analysis approach making it difficult to compare the reported carbon footprint of different buildings. A standardised approach is necessary to enable the implementation of carbon reporting. To facilitate this, a number of tools have been developed in the UK, such as the guidance document on Whole life carbon assessment for the built environment [40], How to calculate embodied carbon [41] and the New London Plan [39] assessment templates mentioned above, which is aligned with the RICS approach. Similar guidance documents and standardised approaches should be developed for Ireland.

2.1 Recommendation: An Irish-specific building carbon foot printing tool should be developed by the Department of Housing, Local Government and Heritage by the end of 2023 to enable the evaluation of the relative environmental performance of different building systems in a consistent manner.

Development of life cycle inventory data for Irish wood products

The availability of life cycle (LC) data for wood products is an essential requirement for undertaking carbon assessment. EPDs for specific products are a widely recognised source of LC data. Without specific product data, default values from generic databases can be used but they can be very conservative and result in overestimation of the emissions. The Irish Green Building Council (IGBC) is building an EPD database for construction products used in Ireland, but currently contains very few EPDs for wood products [21]. In particular, there is very limited data available relating to 'substitution' factors which describe how much GHG emissions would be avoided if a wood-based product is used instead of another product to provide the same function. To fill this gap, life cycle inventory data for Irish construction products should be gathered and EPDs for Irish wood products developed.

2.2 Recommendation: Producers of timber construction products should undertake Life Cycle Analysis (LCA) and produce EPDs for their products, with guidance being provided by the Department of Agriculture, Food and Marine and associated funded bodies.

3. Regulation

The Technical Guidance Documents (TGDs) to the Irish Building Regulations provide guidance to the regulations; works carried out in accordance with the TGDs will prima facie, indicate compliance with the regulations. However, the regulations and the TGDs allow alternative solutions to those given in the TGDs. The TGDs covering fire safety have a major influence on the use of timber in buildings and are in the process of becoming two separate volumes.

TGD B Fire Safety Dwelling Houses Volume 2 was published in 2017 and covers dwelling houses but not apartments. TGD B Fire Safety: 2006 [42] covers all buildings not covered by Volume 2 and after revision will become Volume 1. It is the 2006 TGD B (separate to Volume 2), which is relevant to high rise and medium rise buildings, and which is mainly discussed here.

Where the height of the top floor is over 10 m TGD B: 2006 specifically limits the use of combustible or limited combustible materials, such as timber. Effectively this limits the use of timber to buildings with a maximum of 4 storeys.

TGD B assumes that the main method of demonstrating fire resistance will be through fire testing; however, it allows alternative solutions to the requirements of the TGD as do the Building Regulations themselves. Fire resistance by calculation has been widely accepted by Building Control but, in September 2020, the DHLGH (Department of Housing, Local Government and Heritage) published supplementary guidance to Volume 2 of TGD B. The supplementary guidance applies only to timber elements and has effectively made fire testing the only means of demonstrating fire resistance, and implies that demonstration of fire resistance by calculation for timber is not acceptable under Volume 2. Further, the supplementary guidance gives prescriptive construction details which if not followed would require fire testing to demonstrate compliance. Both of these requirements have a negative effect on the use of timber and also on new building systems and new materials that use timber.

The restriction to **fire testing** for compliance in TGD B Volume 2 is therefore a significant barrier to expanding the use of wood and wood-based composites in domestic dwellings. TGD B: 2006 is being updated and there is a risk that it (i.e. Volume 1) will follow the supplementary guidance and for timber elements restrict the demonstration of fire resistance to fire testing only, and possibly have prescriptive construction details. Therefore, in the new Volume 1, it is essential to allow fire design by calculation to I.S.EN 1995-1-2 [43] and also to maintain the concept of alternative solutions.

During the revision of the standard on timber frame construction (I.S. 440 [44]) it was proposed that the standard would support the supplementary guidance, but when published, the standard is likely to continue to support the building regulations (rather than the supplementary guidance) and allow for the calculation of fire resistance as commonly used in Europe and the UK.

It is essential during the period of public comment on TGD B: 2006, that there is wide stakeholder consultation and support be made for the use of fire design by calculation for timber elements and for alternative solutions to be continued to be included in the TGD. If Volume 1 includes prescriptive construction details then these should be assessed for their effect on the use of timber and especially Irish timber.

3.1 Recommendation:
Demonstration of fire resistance of timber buildings by fire design to European standards and alternative solutions should continue to be allowed in the TGDs to the Irish Building Regulations and relevant Irish standards, such as I.S. 440. Any prescriptive details proposed for the new TGD B Volume 1 should be assessed for any negative impact on the use of timber and submissions made to the DHLGH during the period of public comment.

4. Education, training, and public awareness

While the environmental benefits of building with wood are clear, there is a lack of knowledge and experience across the construction sector generally in the use of wood and modern engineered wood products in construction. This can lead to a reluctance to use wood instead of other more familiar materials. Eliminating the barriers that inhibit the use of timber is key to increasing its specification in key target markets. By focusing on Continuing Professional Development (CPD) training and skills development, the forest sector can increase market share and develop new markets for Irish grown timber products. This investment in training will position Ireland to have a competitive edge internationally and be a platform to drive growth in the sector in the medium term.

Stakeholder engagement has identified training needs among architects, engineers and within the builder's merchant network and trade. Understanding and specifying timber should be easy but a '**knowledge gap**' has been identified where few professionals or members in the trade have the confidence, knowledge or understanding of how to specify or design with timber correctly. The lack of understanding of the properties of timber and the lack of a central repository to source this information locally is seen as a challenge for specifiers. In addition, the sustainability of timber and concepts such as embodied carbon and whole life carbon assessments are only now starting to become recognised and adopted by specifiers. Educational guides and tools are now required to increase awareness on these related topics. Providing appropriate design guidance and support in the form of dedicated CPD modules has the maximum potential to influence timber specification and use thereby contributing to the sustainability and carbon objectives within the Green Deal.

In a recent survey [45] aimed at stakeholders in the construction sector and carried out as part of the DAFM-funded WoodProps Programme at NUI Galway, key factors identified as barriers to the wider use of mass timber products in Ireland were 'Poor knowledge of timber among designers' and 'Lack of a wood culture among designers and clients'. Over 97% of respondents expressed an interest in learning more about the use of timber in construction with some respondents highlighting the environmental credentials of timber in construction as one of the topics of interest.
The general public are not well informed in relation to the positive benefits of building with wood, including low carbon emissions and positive health benefits of timber buildings. The Wood Awards Ireland programme merits further support and continuance, given its track record in engaging with architects, engineers and the general public in promoting excellence in the use of wood across a range of applications, including the built environment.

4.1 Recommendation: DAFM working with industry, third level and other state institutions to continue to improve knowledge of timber as a construction material, design of timber buildings and whole life cycle assessment of buildings among construction professionals. Examples of good practice in fire design of multi-storey buildings in Europe and North America are available and should be consulted and documented (see some examples in this statement); not just in the regulatory setting but also in what solutions were used to overcome fire requirements and performance. WoodSpec and the STEP programme should be updated and expanded to include design and detailing of timber buildings and moved to an eLearning platform.

Materials should be developed to inform the general public about developments in timber construction and the associated benefits of using more timber in buildings. The underlying message from key industry stakeholders was that our forest products industry needs to create the link between Forests, Climate and Wood.
Ensure that the Climate Action Plan and associated annual annex of actions encourages policies, steps, and measures to increase the use of wood and wood products in climate change mitigation and adaptation.

5. Remove Barriers to Use of Home-grown Timber

The domestic **timber frame** market is dominated by imported grade C24 and TR26 timber which is used for the main structural components of all wall, floor, and roof elements. There is limited use of home-grown timber in timber frame construction with manufacturers reluctant to switch. This is markedly different from other jurisdictions such as Scotland where the timber frame sector has embraced the use of locally sourced timber.
The Irish forest products sector has invested heavily in recent years in both production and kiln drying technology and is satisfied that any historic technical, quality, or economic concerns can now be addressed. Further work is required by our industry to identify, understand, and address the issues surrounding the lack of use of home-grown timber.

5.1 Recommendation: DAFM working with industry, third level and other state institutions to engage with the timber frame and roof truss manufacturers sector to identify innovation opportunities to utilises more home-grown timber in off-site prefabricated solutions.

6. Supporting Research, Development and Innovation (RD&I)

Increased demand for timber presents an opportunity for the Irish forest products sector to innovate, enter new added value markets, diversify their product portfolio and to exploit the forecast increase in supply of round wood; this supply is predicted to double in the next 15 years. Increased economic value from the forest sector through the expansion of existing markets and development of new ones will contribute to further export potential and job creation in the sector. Furthermore, a manufacturing industry based around the use of Irish timber, with increased utilisation of Irish-grown Sitka spruce in added-value applications, should also lead to increase in the financial returns to forest owners. This in turn supports further afforestation and the drive to reduce carbon in construction.

The sector currently exhibits low investment in RD&I and lacks an industry led **Centre of Technology and Marketing Excellence** to underpin market led product and systems development. From an export perspective, the industry has a strong reliance on standard commodity products and a new industry led focus is required on innovation to achieve product diversification and expand into new markets.

6.1 Recommendation: The Forestry and Forest Products sector, working with Enterprise Ireland, Third Level and other State Institutions, to scope the potential for an industry-led Centre of Excellence which would contribute to the entrepreneurial discovery process, play an important role in connecting stakeholders, including national and international stakeholders, build research and technology capacities and contribute to knowledge transfer.

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