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THE ECONOMICS OF AFFORESTATION AND MANAGEMENT IN IRELAND: FUTURE PROSPECTS AND PLANS

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Foreword

This project, funded by industry, forms an important part of the research programme of the BiOrbic SFI Research Centre. BiOrbic is Ireland's national bioeconomy research centre, established to promote and develop Ireland's bioeconomy through excellent research and innovation. The Centre brings together over one hundred researchers from across Ireland's leading academic and research organisations. Our expertise is multi-disciplinary and focused on supporting Ireland in a just transition to a sustainable society. We collaborate with industry, policy makers, producers, communities and citizens to support to advance this objective. Our research is both informed and informs bioeconomy and climate policy and we work to support national efforts to meet and exceed policy targets. We are working to create a bioeconomy system that is optimised for circularity, incorporating technological, ecosystem and social innovations that reduce the overall pressure on limited land resources and increase resilience of the bioeconomy.

One of the unique features of the Centre is that it provides both scientific and social scientific knowledge to help address major societal challenges. The challenge of achieving a Sustainable Forestry sector in Ireland is part of the BiOrbic research programme. How to deliver added value using innovative materials, conversion technologies, using planted timber but also natural capital and the resultant ecosystem services arising are key questions BiOrbic is addressing. We also consider strategies to slow down emissions from the sector through product variation that either stores or substitutes more emissions through mechanisms such as carbon storage and greater timber use in construction to substitute concrete and steel.

The recent fall off in planting creates a significant risk of missing national Carbon Net Zero 2050 goals. Failure to deliver will have consequences in the rest of the bio-economy as emissions savings will have to be found later. BiOrbic will research policy, organisational and behavioural solutions to support the planting programme.

This report comprises an important plank in BiOrbic's enabling research to facilitate the delivery of Ireland's forestry sector goals.

Prof. Kevin O'Connor

Director, SFI BiOrbic Research Centre

Key Points

Key Points

The national afforestation policy has been a great success, with 690,000 hectares planted in 100 years 1922-2022, reaching 11% of the total land area, the largest land-use change since the foundation of the State. However, the area planted has declined substantially in recent years with 2021 planting 8% of peak in 1995.

The external environment is particularly challenging in 2022. Supply chain issues and fuel and food price inflation has seen inflation return to levels unseen since the 1980's, with price growth between June 2022 and 2021 of 9.1% equivalent to the price growth over the 14 year period 2007-2020. Given this price inflation which is likely to remain for a significant period of the next forestry programme, price assumptions and associated establishment grants be reviewed regularly

Although afforestation is very important for the timber industry, given the climate action objectives associated with global warming, the carbon sequestration potential for forestry related land use is becoming increasingly important. The national Climate Action Plan sets a roadmap for halving carbon emissions by 2030 and reaching net zero emissions no later than 2050 and identifies that afforestation as the single largest land-based climate change mitigation measure available to Ireland.

Modelling scenarios that can reach carbon neutrality by 2050, the mean area of forestry required is about 18% of the land area; consistent with the Department of Agriculture, Food and the Marine's goal. Without a major afforestation strategy, it would be impossible to achieve carbon neutrality objectives using rewetting or agriculture alone unless there was a major reduction in animal numbers with consequential economic impacts. These goals are supported by the Department of Public Expenditure and Reforms carbon shadow price, which has to be used in economic appraisals of public policy which rises from €46 per tCO2e in 2022 to €100 in 2030 and to €208 in 2045.

Many farms can benefit from planting forestry financially. About 50% of all farms would have a higher income from forestry than agriculture for Sitka Spruce and about 30% have a higher return for broadleaf. The relationship however differs by farm system. Only 11% of specialist dairy farms would have a higher return from forestry. On the other hand, nearly 80% of cattle rearing farms and 70% of cattle finishing farms would have a higher return from forestry.

There is a mismatch between system and size. While cattle and sheep farms have a higher return from planting, in general they have a smaller farm size, yet dairy farms have a lower return but have a higher farm size. The challenge therefore for cattle and sheep farms is that although most have higher returns, that their land base is lower, so they have less "spare land" for forestry. The replanting obligation is a particular issue for small farms as it rules out a proportionally higher area from potential planting in the future. Similarly the extra burden in recent years associated with administration and licensing, reducing planting rates.

It is important to link afforestation plans with agricultural plans. Two thirds of farms undertake other on-farm decisions while planting. Some treat afforestation as a retirement income source, reducing stocking rate and reducing labour, while others, "diversifiers" increase stocking rate and generate other income from off farm activity at the same time as planting. It emphasises the importance of linking farm incentive programmes in the Common Agricultural Policy (CAP) with forestry incentive programmes. It also highlights the need for different advisory programmes for different types of farmers.

The Climate Action Plan reduced the target to 8,000, but that Minister McConalogue, has indicated that the target will be challenging to hit over the next decade This target however, outlined above is far below the need to achieve 18% land cover in forestry by 2050. While in 2014, this meant 14,500 Ha per year, given the current low planting rates, the target planting rates in fact need to by 18,000 hectares per year to achieve this goal by 2050. The further this target is missed the greater will be the need to deliver reductions from other sources including agriculture.

The last time we saw such a large decline in afforestation was after Ireland's entry to the EEC, where planting rates nearly halved in the period to 1985. Recognising this trend a major report by the National Economic and Social Council undertook a root and branch review of the forest sector. It made a series of recommendations, implemented over the following decade that saw a huge recovery, with a fourfold increase in forest planting between 1985 and 1995, significantly exceeding the long-term target.

At a carbon price of €32 per hectare, the share of farms with a positive social return (private return plus carbon benefit) from planting is 46.6% respectively. Using a carbon value of €100 per hectare, the share rises to 96.5%, while at a carbon value of €163 per hectare, nearly all farms (99.9%) have positive social returns. It emphasises the benefit to the country of planting forestry relative to other agricultural land uses.

As it takes about 40 years for a forest to reach maturity, giving the existing fall off in afforestation levels over the past two decades, regardless of current strategies, there will be a reduction in carbon sequestration or carbon cliff as the forest estate moves from being a carbon sink to carbon source as harvesting exceeds planting. Carbon stored in harvested wood products however diminish the impact. However the more we can plant the less deep the cliff will be and more carbon sequestration there will be after replanting. Delaying planting decisions has a major impact on 2050 totals.

For yield class 22, the discounted output per hectare is lower for forestry than beef or dairy. However, when we include processing which has a higher multiplier than food processing, the gap closes, with the return similar between beef and forestry. The return to planting on dairy land is higher. Incorporating the carbon value of emissions and sequestration, the gap widens with beef at a carbon price of €32 per tCO2. However, at €100 per tCO2, forestry has a higher return than dairy. Quantifying the cost of missing a target over a rotation, we find that missing a target by 6,000 hectares (distance relative to Climate Action Target) costs more than €400m at a €100 carbon price over a 40 year forest rotation, while the cost is over €1bn over a full rotation if the target is missed by 16,000 hectare as is currently the case.

Reflecting on the Food Harvest 2020 strategy that combined ambitious targets for the food sector and was accompanied by a forestry planting target of 14,700, the targets for milk and beef were met early. The afforestation target only once reached 50% of target and worsened over the period. If the afforestation target had been met, then it would have been possible to sequester over time all the emissions from the increase in animal numbers over this period, in effect allowing for carbon neutral dairy expansion.

Current legislation imposes a replanting obligation on those who harvest trees. While it may seem like a sensible approach in maintaining the current estate after harvest, it has the implication of increasing the restrictions on land use and acts as a significant disincentive for land owners who are contemplating afforestation. Alternative behavioural strategies in relation to afforestation might also be impactful in relation to planting decisions.

Given the net increase in carbon of each forest rotation, there is an opportunity to provide a carbon sequestration benefit each rotation. Pending ways to finance the scheme, the carbon value provides an opportunity both to provide a significant incentive to plant in the first place and also a way to factor in the economic cost of deforestation should a forest owner choose not to replant.

We propose a Carbon Sequestration scheme to take net carbon sequestration over a forest life-cycle to pay an upfront payment of (say one third of the value), followed

by an annual premium for a period. Using the carbon price of the public spending code, the total value of the net carbon sequestered in a Sitka Spruce plantation of one hectare discounted at 4% varies from €21,700 to €29,100 depending upon the yield class. These carbon prices can support a grant of up to €7,200-€9,700 depending upon the yield class and an annual premium of between €1,300 and €1,700. The results illustrate the substantial value that carbon has. Avoided animal emissions from agricultural land use change, varying from on average €14,084 to €20,184 per hectare, about two thirds of the net carbon sequestration in the trees are also assumed to accrue to the state. There is thus a win-win for the forest owner and the state.

Policy coordination, development and implementation therefore provides particular challenges. Effective governance or coordination is essential to deliver the complex set of goals in the complex operating environment. The present governance structure of the forest industry eco-system is itself fragmented with different state agencies having responsibility. There is also an overlap between policy and regulatory and development functions. Given the unique circumstances faced by the sector and the large societal benefits that the sector can deliver, there is a merit in exploring new governance structures such as establishing Forestry Development Agency to undertake a leadership role in developing the sector and to coordinate and deliver actions within the sector. Lessons drawn by the Mackinnon Report in relation to the Scottish context should be applied in Ireland.

As the focus and structure of the forestry sector has changed over the past century, so has the Government Department in which forestry has been located. The Mackinnon report identified a “lack of political commitment and priority from the Irish Government to woodland creation”. As the relative importance of the carbon sequestration goal of the sector increases, it is timely that a review of the best department location for forestry in achieving national carbon neutrality goals to give the sector an added political impetus.

Another organizational issue relates to scale economies. The business model since the 1990’s has been farm afforestation, with relative small parcels within farms being planted. Compared with Scotland the Mackinnon report found that economies of scale are less in Ireland. The organizational challenge of dealing with so many small holder forest owners is very significant. It is a credit to the Forest Service in managing such a large challenge and to Teagasc for the training and education support provided. However the country seems to be reaching the limits of what this business model can achieve both in terms of the amount of agricultural land that can be converted and in relation the organizational complexity of managing so many individual units. It seems inevitable that the scale economies of the sector need to be considered. It may not require a move back to the large scale land purchase for planting undertaken by the state, but at a minimum multiple approaches need to be taken. The artificial divide between public and private elements of the sector should be reconsidered in taking a more flexible approach.

Executive Summary

Executive Summary

As a major national strategic objective, the afforestation policy has been a great success, with 690,000 hectares planted in 100 years 1922-2022, reaching 11% of the total land area. It is thus the largest land-use change since the foundation of the state, driven and delivered largely by public policy both in terms of public planting by Coillte and its forerunners and more recently by publicly subsidised planting by the private sector. By comparison, from a marginal land use in 1922, the forestry estate is now twice the area of crops, fruit and horticulture, which is a relatively important agricultural sub-sector.

However, the area planted has declined substantially in recent years with 2021 planting 8% of peak in 1995. In 1995, 23,710 hectares were planted, with over 17,000 hectares in the private sector and nearly 6,500 hectares in the public sector. Between 1997 and 2005, planting rates (almost entirely in the privates sector) have been between 10,000 and 15,000 hectares. After 2005, planting rates fell to a relatively consistent 6-7,000 hectares per year, while there has been a steady decline.

The policy context for forestry is changing. While the primary aim of Irish forest policy has remained the achievement of self-sufficiency in timber supplies, broader policy objectives were also pursued. The social dimension around rural employment particularly in the western half of the country was an important policy objective. More recently, carbon sequestration from forestry has become an important pillar in national plans to achieve carbon neutrality.

External Environment and Inflation

The external environment is particularly challenging in 2022. Supply chain issues that resulted from BREXIT and COVID related disruptions, the economic recovery post COVID lock-down and the fuel and food price inflation that has resulted from the Ukraine conflict has seen inflation return to levels unseen since the 1980's. The price growth between June 2021 and June 2022 of 9.1% is higher than any average inflation rate since the 1980's and equivalent to the price growth over the 14 year period 2007-2020. Post-COVID exceptional economic growth in 2021 and into 2022 has seen a large increase in employment levels. Of particularly relevant to the forest contracting sector is the increase of construction employment to over 159,000, higher than at any point since 2008 and an increase of 30,000 in 12 months, which has resulted in labour cost inflation for workers that the sector seeks to attract of 48% in 2022 compared with 2021.

Road diesel prices increased by 12% in 2021 and 50.7% in 2022, reflecting both the bounce back from low fuel prices during the COVID lockdown and the price inflation resulting from the Ukraine conflict. green diesel is cheaper than road diesel due to lower excise duties. However as a result the price is more volatile relative to market price changes. As a result Green Diesel increased by 50% in 2021 and a further 80% in 2022.

Applying inflation factors to the cost base of afforestation, we estimate the total cost per hectare for forest establishment in 2023 to be €7,004 for Conifers, €10,551 for Broadleaf (Hard) and €9,631 for Broadleaf (Soft).

Reflecting the price inflation in recent years, these rates are higher than the establishment grant rates from the previous Forestry Programme. It should also be noted that given the price inflation visible at present and is likely to remain for a significant period of the next programme that prices and associated establishment grants should be reviewed regularly to avoid delays in the afforestation programme due to an inability to plant new forests if the cost is higher than the grant.

Carbon Sequestration

Although afforestation is very important for the timber industry, given the climate action objectives associated with global warming, the carbon sequestration potential for forestry related land use is becoming increasingly important and is second to the Oceans as a carbon sink storing carbon in their biomass, soils and products (Climate Action Plan, 2021).

Within the Land Use, Land Use Change and Forestry (LULUCF) sector, EPA carbon accounting data indicates that forestry has been an important carbon sink, with forest land accounting typically for about 2 million tons of CO2 (mtCO2) removals between 2008 and 2020. As planting rates have fallen, we have seen carbon sequestered by forests fall in 2021. However carbon stored in harvested wood products continues to rise with increases of 1.6 mtCO2 in 2021.

The national Climate Action Plan 2021 sets ambitious targets for different sectors in relation to carbon reductions. It sets a roadmap for halving carbon emissions by 2030 and reaching net zero emissions no later than 2050. It identifies that afforestation is the single largest land-based climate change mitigation measure available to Ireland and suggests a number of key actions with the aim of realising the 2030 ambition, and contribute to achieving carbon neutrality no later than 2050.

Supported by a new Forest Strategy, the new Forestry Programme launched in 2023 will be one of the key drivers, with a particular focus on climate smart forestry. There are other actions that encourage multiple objectives (commercial, climate, water and biodiversity) and encourage the introduction of small scale afforestation within agri-environment schemes and via activities such as agroforestry. From a harvesting and timber mobilization point of view there will be investments in harvesting infrastructure, and research in timber and processing industries and develop decision support tools to enable forest owners to make decisions on timing of harvesting (such as extended rotations) to optimise carbon storage. From a climate adaptation point of view, genetic diversity will be supported to improve the resilience of forests to climate change.

The Climate Action Plan sets a target of planting 8,000 hectares per annum Although current and future forest planting will have a limited impact upon carbon emissions in 2030, they are essential for the objective of carbon neutrality by 2050.

As part of the strategy of delivering carbon neutrality by 2050, the Irish government has agreed a set of carbon budgets. The first carbon budget programme proposed by the Climate Change Advisory Council and approved by Government comprises three successive 5-year carbon budgets. Ireland's total GHG emissions in 2018 were 68.3 Mt CO2eq. requiring via two carbon budgets to reduce total emissions to 33.5 Mt CO2eq by 2030. Worryingly, emissions increased by 4.7% in the first year of the carbon budget, with emissions increasing across all sectors.

In July 2022, the government agreed sectoral carbon budgets with ceilings or maximum limits on greenhouse gas emissions for each sector of the Irish economy to 2030. A reduction in emissions of 25% is required from the Agriculture sector, reducing emissions from 23 mtCO2e to 17.25%, albeit engagement by individual farmers is voluntary. It should be noted that the sectoral emissions reductions announced amount to a reduction of 43% rather than 51%. Finalising the Sectoral Emissions Ceiling for the Land-Use, Land-Use Change and Forestry (LULUCF) sector has been deferred for 18 months to allow for the completion of the Land-Use Strategy.

In research undertaken by the author with other colleagues in Galway in relation to land use scenarios that can reach carbon neutrality by 2050, the mean area of forestry required is about 18% of the land area; very similar to the Department of Agriculture, Food and the Marine's target of planting 18% of the land area by 2046. The higher the area forested the lower the reduction in animal numbers required to meet national carbon neutrality targets. Carbon sequestration from rewetting is limited by the amount of organic soil under grassland that is possible to rewet. Therefore, without a major afforestation strategy, it would be impossible to achieve carbon neutrality objectives using rewetting or agriculture alone unless there was a major reduction in animal numbers with consequential economic impacts. Given how long it takes for afforestation to realise carbon sequestration, it is essential to frontload the planting of forestry now to achieve Carbon Neutrality by 2050. Compared with all other land based scenarios, trees are essential for Ireland's climate goals, far exceeding livestock reductions or rewetting alone. An increase in afforestation is necessary to develop high-value, bio-based industries over the next 10 to 40 years, which will require additional harvested wood. To avoid and/or offset GHG emissions, the policy should be to pay farmers now to increase planting.

The Public Spending Code are the set of rules and procedures defined by the Department of Public Expenditure and Reform (DPER) to be used in undertaking planning in relation to plans for the spending or investment of public expenditures. Of specific relevance to decisions in relation to afforestation are the code's recommendations in relation to valuing greenhouse gas emissions. The carbon shadow price to be used in economic appraisals of public policy rises from €46 per tCO2e in 2022 to €100 in 2030 and to €265 in 2050.

The Economics of Agriculture and Land Use Change to Forestry

As the largest single land use in Ireland, agriculture is the most common source of land for afforestation. The economics and policy of agricultural land use are therefore very important in relation to farm level afforestation decisions. Using data from the Teagasc National Farm Survey, we calculated the share of farms that have a higher return from forestry than from agriculture. In terms of family farm income, about 50% of all farms have a higher family farm income than forestry for Sitka Spruce and about 30% have a higher return for broadleaf. This proportion is higher for those that actually planted at nearly 60%, indicating that those who had a higher return from planting forestry were more likely to plant. The relationship however differs by farm system. Only 11% of specialist dairy farms would have a higher return from forestry. On the other hand, nearly 80% of cattle rearing farms and 70% of cattle finishing farms would have a higher return from forestry. 60% or higher of all other farms would have a higher return from forestry.

Generally farms that planted forestry, regardless of the return were on better land, were more likely to be Teagasc clients and had much larger area. In terms of labour, age and off farm labour the pattern varied depending whether they had a higher return from forestry or agriculture. For those that had a higher return from forestry, planters were older, applied less farm labour and were less likely to have an off-farm job than non-planters. The opposite applied where agriculture returns were higher than forestry.

A key message here is that there is a mismatch between system and size. Cattle and sheep farms have a higher return from planting, but in general have a smaller farm size, yet dairy farms have a lower return but have a higher farm size. Tillage and mixed farms are larger and have higher planting rates. The challenge therefore for cattle and sheep farms is that although most have higher returns, that their land base is lower. Given well research cultural barriers to planting forestry due to issues like a preference for agriculture, general inertia in decision making associated with preference for the status quo and hassle associated with changing land use and the long term nature of the return. The replanting obligation is a particular issue for small farms as it rules out a proportionally higher area from potential planting in the future. Similarly the extra burden in recent years associated with administration and licensing imposes what is known as a transaction cost, reducing planting rates.

When we consider what farmers did when they planted forestry, for only about one third of farms is afforestation a straight land use change. For two thirds of farms, afforestation is undertaken at the same time as other on farm changes. These farms have the lowest share that have a higher return from forestry. However they have the highest farm size and have the highest farm incomes and are least likely to have an off-farm job. They also have the highest stocking rate and are more likely to be dairy farms. They are more typical of full-time commercial farms, allocating a proportion of their larger farm to forestry, perhaps to provide future retirement income or to reduce risk. 43% of farms however decrease their stocking rate. These tend to be older with smaller farms , more likely to be in an agri-environmental scheme, have higher direct payments are least likely to have dairy cows and have higher potential forestry income than agriculture. These are in effect a group of farmers that see afforestation as part of a retirement planning process. 25% of farms actually increase their stocking rate. These are the youngest group and started with the lowest stocking rate and the lowest incomes. They increase their intensity on the remaining farm while benefitting from higher forestry income and are more likely to combine it with off-farm income. These are diversification farmers, increasing their income sources on land that has a lower farm income.

A key lesson from this table is that afforestation decisions for farmers is tied to the other decisions on the farm. Only for a minority is afforestation a straight land use change from agriculture to forestry as current incentive schemes assume. For most, afforestation is tied to wider farm decision making. It emphasises the importance of linking farm incentive programmes in the Common Agricultural Policy (CAP) with forestry incentive programmes. It also highlights the need for different advisory programmes for different types of farmers. The need for this type of strategy will only increase as the pressure to reduce greenhouse gas emissions grows.

Scaling Up Forest Targets

The current stated afforestation target is 8,000 hectares per year as part of the Climate Action Plan in 2021. However there have been a variety of targets set in the past. The Programme for Economic Expansion in 1959 set a target of approximately 10,000 hectares per annum which was more or less achieved until EEC entry in the mid 1970's, where planting rates nearly halved in the period to 1985. Recognising this trend a major report by the National Economic and Social Council, Irish Forestry Policy undertook a root and branch review of the forestry sector. It made a series of recommendations, implemented over the following decade that saw a huge recovery, with a fourfold increase in forest planting between 1985 and 1995, significantly exceeding the long-term target. The strategic plan, Growing for the Future in 1996 set a target of planting 20,000 hectares per year, equivalent to the planting rates of the first half of the 1990's. The closest to the target was the 15,500 hectares planted in 2001, but with planting in the 10,000-15,000 range until the next target was set as part of National Climate Change Strategy 2007-2012. The strategy acknowledged a target of reaching 17% land cover under forestry with a target of 13,000 hectares for forestry. However, the mechanisms for delivery were relatively weak. The Programme for Government in 2011, building upon the Agri-Food strategy Food Harvest 2020, set a target of 14,700 hectares in 2011. The strategy, "Forests, products and people - Ireland's forest policy – a renewed vision," published in 2014 set an afforestation target to be 10,000 hectares per annum up to 2015 and 15,000 ha per annum for the period 2016 to 2046, with an aim of reaching 18% by 2046. This strategy was reviewed by the COFORD report in 2014, who questioned the capacity, based on existing trends of meeting this target.

The Climate Action Plan reduced the target to 8,000, but Minister McConalogue, has indicated that the target will be challenging to hit over the next decade This target however, outlined above is far below the need to achieve 18% land cover in forestry by 2050. While in 2014, this meant 14,500 Ha per year, given the current low planting rates, the target planting rates in fact need to by 18,000 hectares per year to achieve this goal by 2050. The further this target is missed the greater will be the need to deliver reductions from other sources including agriculture.

Farm Level Carbon Sequestration

In the report section, we examine both the private and the social return in terms of carbon emissions and sequestration to farm afforestation. In order to model the social impact of land use change, it is necessary to include the alternative land use, namely agriculture, and to combine the private economic components with the social component. The private return to a landowner incorporates the life-cycle monetary impact of moving from agriculture to forestry. However this clearly ignores significant public good impacts in relation to carbon sequestration. To keep the analysis tractable but useful, we adopt a narrow definition of social return to a land use change, i.e. the combination of the private return to the landowner plus the value of the net carbon sequestration of the land use change.

In order to undertake an economic assessment of carbon sequestration at forest and farm level, we adapt a forest carbon sequestration model (C-FORBES) developed by the author with a colleague. On average 32.4% of farms have positive private returns to planting, including forest subsidies. Replacing the afforestation subsidy with low carbon (subsidies) values of €20 and €32 per hectare, and using the NIR (2015/18) assumptions for biomass expansion factors and also incorporating agricultural subsidies, the share of farms with a positive social return from planting is 30.4% and 46.6% respectively. Using a carbon value of €100 per hectare, the share rises to 96.5%, while at a carbon value of €163 per ha, nearly all farms (99.9%) have positive social returns.

National Targets and the Carbon Cliff

Scaling up from the single hectare to the national forest estate, we consider the impact of reaching or conversely missing targets on carbon emissions and the impact on the wider value chain. In this analysis we explore a number if scenarios:

- A current scenario where planting rates are kept at 2,000 hectares per annum
- The Food Harvest 2020 target of 14,700 hectares per annum
- The Climate Action Plan target of 8,000 hectares per annum
- The revised carbon neutrality target 2050 of 18,000 hectares per annum
- An adjusted carbon neutrality target 2050 of 18,000 hectares per annum, where there is a delay for a decade in implementing the target

We simulate these scenarios until 2050, with zero afforestation afterwards. The zero afforestation assumptions allow us to consider the long-term sustainable carbon sequestration within the sector.

As it takes about 40 years for a forest to reach maturity, giving the existing fall off in afforestation levels over the past two decades, regardless of current strategies, there will be a reduction in carbon sequestration or carbon cliff as the forest estate moves from being a carbon sink to carbon source as harvesting exceeds planting. Carbon stored in harvested wood products however diminish the impact.

With the lowest planting rate, the current scenario has the lowest carbon cliff and future peak carbon sequestration at lower levels than the present. Each of the remaining scenarios follow a pattern that relates to the number of hectares planted with the carbon neutral or 18% of land cover at 2050 target of 18,000 hectares per annum. If the Food Harvest target of 14,700 was achieved then the peak carbon sequestration would have been lower than the peak carbon neutral 2050 scenario (due to lower peak planting). However, the carbon cliff would have been less pronounced if planting targets had not fallen since 2010 the way they did. In 2050, the Food Harvest scenario delivers about 25% more carbon sequestration than the carbon neutral scenario as a result of the earlier start. Both the food harvest 2020 and the carbon sequestration totals result in similar planting totals. The climate action plan target sees a slightly higher profile than the status quo scenario, but realizes a peak that is only two thirds of the carbon neutral peak. The final scenario which delays a concerted effort to reach the targets, realizes a slightly lower peak and in 2050 realises only 33% of the carbon sequestration of the carbon neutral total. Delaying planting decisions as a result has a major impact on 2050 totals.

In order to gauge the impact of the target on the wider value chain, we consider a forest planted on yield class 22. On average the discounted output per hectare is lower for forestry than beef or dairy. However, when we include processing which has a higher multiplier than food processing, the gap closes, with the return similar between beef and forestry. The return to planting on dairy land is higher. Incorporating the carbon value of emissions and sequestration, the gap widens with beef at a carbon price of €32 per tCO2. However, at €100 per tCO2, forestry has a higher return than dairy.

Quantifying the cost of missing a target over a rotation, we find that missing target by 6,000 hectares (distance relative to Climate Action Target) costs more than €400m at a €100 carbon price over a 40 year forest rotation, while the cost is over €1bn over a full rotation if the target is missed by 16,000 hectare.

Food Harvest 2020

In order to illustrate the impact of missing targets we look back and assess the Food Harvest 2020 strategy developed by the industry in 2010 which focused on Smart Green Growth, that combined ambitious targets to increase milk volume output by 50%, expansion of beef output by 20%, and aquaculture by 78%. It was accompanied by a forestry planting target of 14,700. From an economic point of view, the ambitious milk target was met in 2017 and the less ambitious beef target was met almost immediately. The level of beef output achieved by the year 2020, was in fact a 43% increase in value. The afforestation target has only once reached 50% of target and has been worsening over the period 2010 to 2020 as outlined above.

In terms of overall economic output, a €164.7 million increase in output would have been produced by the forestry and beef sectors if the afforestation target had been met compared with the €123 million increase in actuality relative to the 2007 to 2009 average. Over the scenario period, €61.1 million extra is generated in terms of value added if the afforestation target was met compared with reality. Regarding GHG emissions, the actual outcome saw yearly average emissions staying almost completely flat relative to 2007-2009 while GHG emissions fall by 124.3 ktCO2e relative to the afforestation scenario. For carbon sequestration, we see 276.8ktCO2e extra being sequestered over what would take place in reality. When emissions and sequestration effects are combined, a greater reduction in net emissions takes place in the afforestation scenario with a fall of 2013 ktCO2E compared with 1612ktCO2e in reality across the value chains.

The results show that both beef and afforestation targets could have been reached while realising an overall decrease in GHG emissions and a larger overall decrease in net emissions. Hitting the afforestation target required the reallocation of 3.7% of land used for beef production also results in greater economic output and higher overall value added. These results suggest that agricultural intensification can exist in accordance with GHG emissions reduction goals.

In a related but simplified analysis, merely looking at the emissions associated with the change in animals and the lost carbon sequestration associated with missing the targets, we assess the net carbon account of the dairy expansion since 2010. Since 2010, the number of livestock units has increased by 386,000 (where live stock units are animal numbers adjusted for feed input). Give that on average each hectare of forest sequesters the emissions from 3.8 Livestock Units, 102,000 Hectares of Forest would have mitigated the emissions from Dairy Expansion. Summing up the difference between the target and actual hectares afforested during this, period, Ireland missed the target by 112,000 over the 12 years to 2022 (Figure 14). In other words if the earlier afforestation had been met, the entire additional emissions from dairy expansions could have been met from afforestation. So in effect the country could have achieved carbon neutral dairy expansion.

The Delivery of Other Public Goods

Given the important role forestry plays in carbon sequestration, this paper has mainly concentrated on carbon sequestration as a forestry related public good. However clearly forestry impacts other dimensions:

- The impact on wider environmental issues is an increasing issue. Combining economics with Farrelly & Gallagher's land availability study, we can identify a potential land pool of 1.3 m hectares of grassland which is marginal for agricultural production but suitable for forestry. It is clear that opportunities for further afforestation vary with location depending on environmental constraints and income potential for forestry versus agriculture.
- The species of tree is also important. There are opportunities to increase biodiversity as there is a high citizen willingness to pay for mixed forests, as there is a societal preference for mixed broadleaf and conifer. This is reflected in afforestation decisions with about 30% of the national estate containing broadleaves compared to a much higher historic share of Sitka Spruce.
- In relation to water quality, forest depending upon the life-cycle stage of the forest has different impacts. Disturbance events such as planting and in particular clearfell can have issues in relation to sedimentation. However, overall forest cover replacing agriculture can be positive as there is less disturbance and lower nutrient loads over a longer period of time relative to a pre-existing agricultural use.

Economic Impact of Carbon Sequestration Scheme

Thus far we have seen some key drivers and barriers related to afforestation decisions. At a high level they relate to

- Financial Incentives
- Culture and replanting decisions
- Licensing, administration and transaction costs

An increased emphasis on carbon and carbon sequestration provides a number of opportunities to deal with these drivers.

As the carbon price represents the opportunity cost of not reducing carbon or increasing carbon sequestration, the increase of the carbon price to €265 per tCO2 indicates the high value of the carbon stored in trees and wood products. While the carbon price is the target value of carbon taxation or the levy on the cost of emissions and likely to be similar to the cost of buying carbon credits. Future strategies will have to define the cost of released carbon from either wood energy or carbon emissions form waste wood and paper products.

Current legislation imposes a replanting obligation on those who harvest trees. While it may seem like a sensible approach in maintaining the current estate after harvest, it has the implication of increasing the restrictions on land use and acts as a significant disincentive for land owners who are contemplating afforestation. Behavioural economics is extensively used in long-term decision making as in the case of pensions. Alternative behavioural strategies in relation to afforestation might also be impactful in relation to planting decisions. Exploiting carbon sequestration and release across the forest life-cycle and later harvested wood products can enable this. Given the net increase in carbon for each forest rotation, there is an opportunity to provide a carbon sequestration benefit each rotation.

Pending ways to finance the scheme, the carbon value provides an opportunity both to provide a significant incentive to plant in the first place and also a way to factor in the economic cost of deforestation should a forest owner choose not to replant.

A particular challenge of a carbon sequestration scheme is that the carbon is sequestered later in the forest cycle, while from a land owner's decision making point of view, it would be preferable to make an upfront payment or payments as is the case in the current afforestation scheme where an establishment grant is paid and is followed by 15 years of forest premia.

We propose a Carbon Sequestration scheme is to take net carbon sequestration over a forest life-cycle to pay an upfront payment of (say one third of the value), followed by an annual premium for a period. For simplicity we mimic the current scheme with a one third up front payment followed by 15 annual equal payments. We use the public spending code discount rate of 4% to discount the value of future carbon sequestration to produce parameters for this scheme.

Using the carbon price of the public spending code (less the value of the current scheme), the total value of the net carbon sequestered in a Sitka Spruce plantation (as above only considering sequestration of above ground timber, net of harvest losses and excluding the energy use) of one hectare discounted at 4% varies from €21,700 to €29,100 depending upon the yield class. The carbon price of each year of growth from €52 per year in 2023 to €265 in 2050 is utilised, less the €32 to fund the existing programme. By comparison, at this carbon price, the discounted carbon value is higher than the discounted clearfell value as the environmental return becomes higher than the market return. Turning to the potential scheme parameters, with one third being paid as an establishment grant and the remainder paid as a flat premium for 15 years, we can support a grant of up to €7,200-€9,700 depending upon the yield class and an annual premium of between €1,300 and €1,700.

These numbers relate to the upper bound in relation to the value of net carbon sequestered by forests. As outlined above, the capacity to fund the programme depends upon choices in relation to charging for life-cycle emissions from burning wood energy and managing the release of carbon from wood products, avoiding the purchase of carbon credits and a contribution from direct taxation to support carbon sequestration efforts. Nevertheless, the results illustrate the substantial value that carbon has. The proposed scheme does not consider carbon sequestered in below ground livewood, branches and leaves, tree mortality or litter, assuming that either these will emit carbon after the harvesting of the tree or stored in soil carbon. To be conservative these gains are assumed to accrue to the state. Similarly avoided animal emissions from agricultural land use change, varying from on average €14,084 to €20,184 per hectare, about two thirds of the net carbon sequestration in the trees are also assumed to accrue to the state. Much of the large variation in farm tCO2 value NPV relates to differential harvest ages. There is thus a win-win for the forest owner and the state.

Regional Development

Improving the balance between the regions is a challenge in a very centralized country such as Ireland. The dominant trend of the regional economy as measured by gross value added per capita for a region relative to Dublin has been one of divergence, with the gap widening over the past two decades between Dublin and the rest of the economy. The Midlands in the most recent year of data availability, 2019 had a GVA per capita of 20.6% of Dublin's. Two regions with the highest share of Foreign Direct Investment outside of Dublin, the Mid West and the South East were closest, with respectively 67% and 55% of Dublin's.

While GVA measures the size of the economy in terms of what is produced, Household Disposable Income (HDI) is a better measure of local welfare as it captures the difference between where economic development occurs relative to where incomes are spent. Prior to the financial crash there was a convergence in incomes between regions, with regions catching up with Dublin in relation to relative incomes and purchasing power. In 2006, the Mid-East HDI per capita was 95% of Dublin, while in 2008, the South-East had disposable incomes per capita of 91% of Dublin's. However during both the economic recession after the financial crash and during the recovery period to 2019 the gap between this measure of living standards has widened between each region and Dublin.

One of the historic objectives of the sector has been as a source of economic growth and development in rural areas and in particular in remote rural areas. To this day in reports such as the Commission for the Economic Development of Rural Areas (CEDRA) or more recently Our Rural Future, Rural Development Policy 2021-2025 have recognized the importance of utilising resources including natural resources such as forestry to support the rural economy. Both in terms of economic development in timber value chains and in relation to the increasing importance and value of sequestered carbon, the forestry sector provides an opportunity to address some of these divergent trends through the provision of economic and environmental development in rural areas.

Organisational Structure

The recent national agri-food strategy emphasized the need for a systems approach in the planning and implementation of strategies to deliver complex policy objectives. Forest policy is an example of a highly complex policy environment:

- Afforestation involves a large, long-term land use change
- Returns are long-term with associated risks
- The costs and benefits affect many parts of society and not simply the land owner
- It involves land use competition and engagement with an already complex agri-food sector
- Forests serve many purposes, with a need for different types of forests for different goals
- As an export sector, the value chain is global and complex
- The sector is fragmented with large public and private domains

Policy coordination, development and implementation therefore provides particular challenges. Effective governance or coordination is essential to deliver the complex set of goals in the complex operating environment. The present governance structure of the forest industry eco-system is itself fragmented with different state agencies having responsibility. There is also an overlap between policy and regulatory and development functions. Given the unique circumstances faced by the sector and the large societal benefits that the sector can deliver, there is a merit in exploring new governance structures.

Other natural resource sectors have targeted development agencies such as Teagasc and An Bord Iascaigh Mhara (BIM). State development agencies tend to have a different outlook, perspective on risk and approach to their line departments. As a result, in other spheres development functions and the policy and regulatory functions have been separated. The Mackinnon Report identified a particular tension in these functions with "pre-application consultations is very much the exception because of perceived tensions between the Inspectorate's enabling and regulatory roles".

Given the scale of the challenge and opportunity, there is a merit in establishing a Forestry Development Agency to undertake a leadership role in developing the sector and to coordinate and deliver actions within the sector. Mackinnon questioned the commitment of other state bodies to afforestation noting that "State Bodies are not as engaged in helping deliver the afforestation programme as they could and should be". Engagement by a development agency with the external environment is therefore also critical to leverage their support and deliver goals.

Mackinnon identified some major organizational barriers in Ireland to the achievement of national forestry goals that are handled more effectively via an arm's length development agency in Scotland, Scottish Forestry (formerly the Forestry Commission). Lessons drawn by Mackinnon in relation to the Scottish context should be applied in Ireland.

As the focus and structure of the forestry sector has changed over the past century, so has the Government Department in which forestry has been located. It has variously moved between Land, Natural Resource and Agriculture departments as the sector evolved from a large state owned land and natural resource sector to one where the recruitment of farmers for afforestation became important. The Mackinnon report identified a "lack of political commitment and priority from the Irish Government to woodland creation". As the relative importance of the carbon sequestration goal of the sector increases, it is timely that a review of the best department location for forestry in achieving national carbon neutrality goals to give the sector an added political impetus.

Another organisational issue relates to scale economies. The business model since the 1990's has been farm afforestation, with relative small parcels within farms being planted. Compared with Scotland the Mackinnon report found that economies of scale are less in Ireland, with the average size of application in Ireland is 8 hectares, compared with 40 hectares per afforestation application in Scotland. The organizational challenge of dealing with so many small holder forest owners is very significant. It is a credit to the Forest Service in managing such a large challenge and to Teagasc for the training and education support provided.[1]

However the country seems to be reaching the limits of what this business model can achieve both in terms of the amount of agricultural land that can be converted and in relation the organizational complexity of managing so many individual units. In relation to the former there is a conflict between larger farms being more likely to plant but with cattle rearing farms having a higher relative return to forestry. Thus, many of the larger farms that wished to plant have planted. For smaller farms the inflexibility of the replanting obligation places a disproportionate burden.

Organisationally the Mackinnon report presented a very illustrative example. In order to achieve an 8,000 hectare target with the 60% success rate in Ireland, over 1,650 application processes would be required, where the average size is 8 hectares. In Scotland where the average application is 40 hectares and nearly 100% of applications are successful, only 250 application processes are required. It seems inevitable that the scale economies of the sector need to be considered. It may not require a move back to the large scale land purchase for planting undertaken by the state, but at a minimum multiple approaches need to be taken. The artificial divide between public and private elements of the sector should be reconsidered in taking a more flexible approach.

Policy Recommendations

Recommendation 1

Retain the longstanding target of achieving the 18% forest cover target by mid-century. Given the time lag between planting and sequestration, there is need to deliver significantly higher planting earlier, well beyond current targets.

Recommendation 2

Improve the design of forest payments to improve their compatibility with behavioural incentives including going beyond basic compensation

Recommendation 3

Link afforestation public good payments to carbon prices. Develop alternative financial instruments to continue to deliver up front payments in a carbon sequestration scheme and over multiple rotations

Recommendation 4

Develop mechanisms to deal with current inflationary environment to reduce risk by stakeholders and increase confidence

Recommendation 5

Full implementation of the Mackinnon report is necessary in a defined timeframe to deal with uncertainty due to licensing delays.

Recommendation 6

Develop a national land use strategy to provide a formal framework to make land use planning decisions

Recommendation 7

Review the legislation on forestry and consider the introduction of a single consent covering planting, road construction, management and felling.

Recommendation 8

Afforestation incentives and forestry guidelines should be aligned to CAP rules and regulations to reflect the joint forestry and agriculture decision making that happens on farms

Recommendation 9

Develop a Carbon Neutral Certification with the diary farm Co-Operatives

1 Recognising scale economies higher grants may be required for areas less than 5 hectares. For example, they could use the same model as the ecology grant i.e. weighted in favour of smaller area 1ha 450, 2ha 400 etc, added on cumulatively, or for areas less than 5ha, with an additional grant.

Recommendation 10

Improve Afforestation Incentives by Increasing Flexibility in relation to the replanting obligation.

Recommendation 11

Establish a new Forestry Development Agency.

Recommendation 12

Undertake a review of the optimal department location for forestry in achieving national carbon neutrality goals.

Recommendation 13

Review the current afforestation business model to improve scale economies and deliver wider scale .

Recommendation 14

Eliminate disincentives and anomalies that arise from the interaction of afforestation and tax and social welfare policy for all stakeholders

Conclusions

Reflecting back on Frank Convery's 1979 NESC report, the good news is that solutions were identified to the crisis faced by the sector at the time and radical operational and organizational changes were implemented and were implemented during a period of greater economic challenges during the 1980's. The challenge now is to show the same ambition as 40 years ago and renew the potential the forestry sector can achieve for national economic, social and environmental objectives over the next 40 years.

- Achieve a viable afforestation programme that will provide the critical mass for an international-scale wood processing and manufacturing industry.
- Contribute to reducing levels of greenhouse gases with benefits for the environment and agriculture.
- Support a quality export driven forest products sector including maximising wood mobilisation.
- Support research, development and training.
- Revitalise many rural communities by increasing sustainable employment.
- Promote non-wood aspects of forestry including biodiversity, water quality and flood control, leisure and rural tourism.

1. Introduction

1. Introduction

The United Nation's report State of Europe's Forests 2020 highlights the annual rate of growth of forestry area in Ireland as the second highest in Europe (second to Iceland with a very small forestry estate) over the period 1990-2020.

Figure 1.

Annual Change in forest area by country 1990-2020

Source: State of Europe's Forests 2020

As a major national strategic objective, the afforestation policy has been a great success, with 690,000 hectares planted in 100 years, 1922-2022. At independence, only 1% of land area was covered by forestry, compared to over 11% of the land area in 2022. It is thus the largest land-use change since the foundation of the state, driven and delivered largely by public policy both in terms of public planting by Coillte and its forerunners and more recently by publicly subsidised planting by the private sector (Figure 2). By comparison, from a marginal land use in 1922, the forestry estate is now twice the area of crops, fruit and horticulture, which is a relatively important agricultural sub-sector.

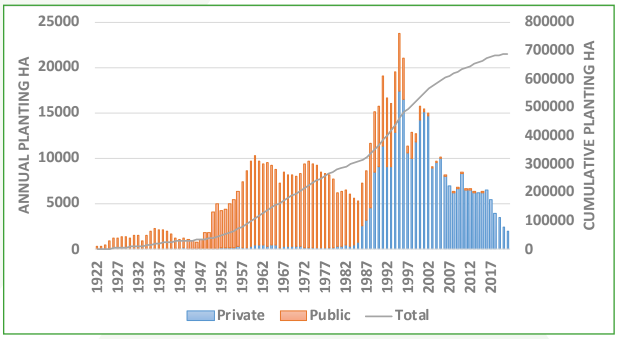
However, the area planted has declined substantially in recent years with 2021 planting 8% of peak in 1995 (Figure 2). In 1995, 23,710 hectares were planted, with over 17,000 hectares in the private sector and nearly 6,500 hectares in the public sector. Between 1997 and 2005, planting rates (almost entirely in the private sector) have been between 10,000 and 15,000 hectares. After 2005, planting rates fell to a relatively consistent 6-7,000 hectares per year, while there has been a steady decline. By 2021, planting rates were down to about 2,000 hectares.

The policy environment over the past 30 years has changed significantly with a movement from state planting on land purchased or leased by the state to grant and subsidy aided planting of forestry on mainly former agricultural land, by both farmers and more recently at a growing rate non-farmers.

The afforestation (or establishment of a forest on previously un-forested land) of agricultural land involves a complex decision-making process and the influencing factors can be difficult to isolate. Moving to an agricultural land use change has both presented opportunities in terms of access to sometimes under utilised land, but also has increased the complexity of the policy environment as forest planting decisions are influenced both by forest planting incentives and by the complex agricultural policy environment. It is unsurprising that the two negative step changes over the past 2 decades in afforestation levels occurred during major changes in agricultural policy, the decoupling of agricultural payments or linking agricultural payments to land rather than mainly animals[2] and to the abolition of milk quotas in 2015, spurring an increase in demand for land for agricultural purposes. For the less intensive farmer, there also have been alternative shorter term environmental related land uses via the participation in agri-environmental policies, leading to the perception of competition between forestry policy and agri-environmental payments, which was an unintended consequence.

Figure 2.

Annual afforestation in Ireland (hectares) from 1922 to 2021



Source: DAFM (2021)

Afforestation is an important policy objective across many EU countries as outlined in the EU Forest Strategy, covering over 40% of the EU land area (EU Commission 2021), Yet in recent years, the rate of afforestation in many European countries has been declining. The 2030 strategy re-affirms the Commission goal on sustainable re- and afforestation, with a roadmap for planting at least 3 billion additional trees in the EU by 2030. Despite having soils and climatic

2 Stacking of entitlements did not fully compensate.

conditions which are particularly suited to timber and fibre production and despite the large increase in afforestation, Ireland has one of the lowest forest covers in Europe at 11% (Eurostat 2013). In addition, despite the availability of strong financial incentives, afforestation has fallen well short of policy targets over the last 20 years.

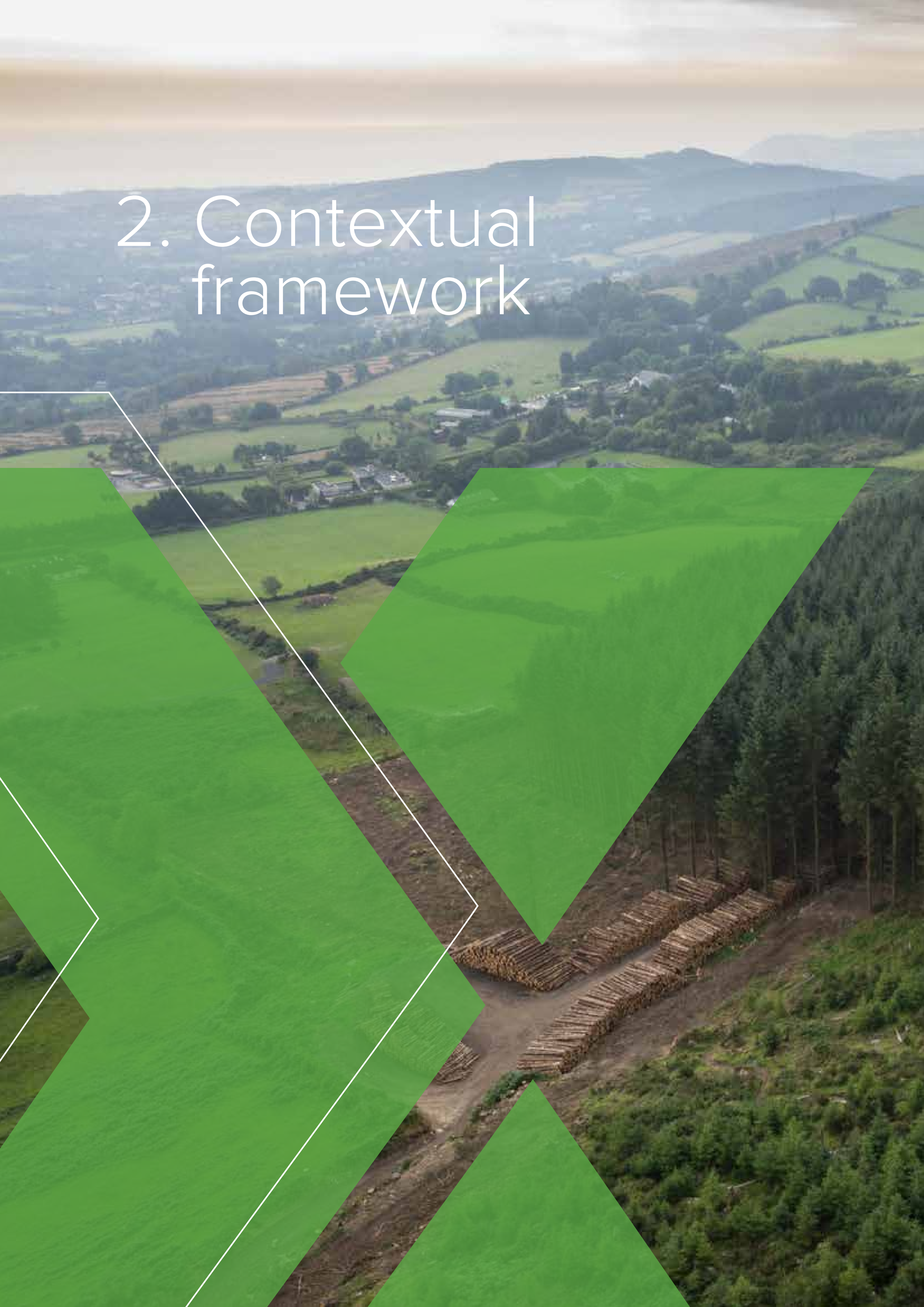
The decline in afforestation comes at a time when the importance of the ecosystem services provided by forests is increasingly recognised and valued (EU Commission 2021). In Ireland, forest policy reaffirms the benefits of afforestation and sets targets for future afforestation in order to optimise benefits from forest ecosystems such as the provision of timber for processing, fibre for renewable energy production, carbon sequestration and biodiversity conservation. This decline in afforestation has consequences in the future for downstream timber processing; for the increasing demand for wood fibre; and for the potential of forests to sequester carbon and mitigate greenhouse gases generated by other sectors such as agriculture.

This report builds upon a decade long research programme undertaken by the author with his research term, working closely with former colleague and PhD student Prof Mary Ryan of Teagasc. While this report has been co-funded by industry, the research builds upon a programme of peer reviewed published work cited throughout this document, funded by a variety of public research bodies including Teagasc, the Department of Agriculture, Food and the Marine, the Environmental Protection Agency, the Sustainable Energy Authority of Ireland, Science Foundation Ireland and the European Commission. In this document, we have updated existing models, but while employing the same rigor and assumption philosophy as in the articles published in peer reviewed journals.

The report is broken into a number of sections. Section 2 provides a national and international context to forestry decisions such as planting. Section 3 reports a stakeholder assessment of forest policy. Section 4 reviews the cost economics of forest management. Section 4 introduces carbon sequestration. In section 6, we consider the economics of the conversion of agricultural land to forestry. Section 7 reflects on historic and current afforestation targets. In section 8, we describe an analysis of carbon sequestration in relation to farm afforestation, looking in section 9 at the implications of various planting scenarios on a future carbon cliff. Section 10 evaluates the impact of missing forestry targets in Food Harvest 2020. In section 11, we discuss issues in relation to licensing. Section 12 discusses issues associated with delivery of other public goods. Section 13 evaluates the impact of a potential carbon sequestration scheme while section 14 makes some policy recommendations.

The decline in afforestation comes at a time when the importance of the ecosystem services provided by forests is increasingly recognised and valued.

2. Contextual framework



2. Contextual framework

International forest policy context[3]

Afforestation is increasingly valued for its potential to enhance ecosystem services and is being actively promoted in many countries through state policy and support (Kanowski, 2010). For example, the Scottish Government's rationale for woodland expansion includes the tackling of greenhouse gas emissions, restoring lost habitats and adapting to climate change (Forestry Commission 2009). Forest cover expansion is included as a source of carbon dioxide emission reduction under the Kyoto Protocol, which is a significant factor in the promotion of forest expansion policies (Nijnk and Bizikova 2008). Similar to many countries, Ireland has sought to increase forest cover for some time with rural employment and economic diversification benefits being important drivers in the 20th Century, while ecosystem services are increasingly recognised in modern forest policy (DAFF 1996; OCarroll 2004; DAFM 2014a).

In the context of overall forest cover, the conversion of land from agriculture to forest is unusual in the European and even in the global context. Many countries with high levels of forest cover either have a long tradition in the management of plantation forests or have large areas of natural forest. Countries with well-developed forest cultures are generally more interested in management and reforestation decisions, rather than the afforestation of additional land. However, a number of countries with low levels of forest cover have been actively promoting afforestation of agricultural land in order to increase forest cover (Eurostat FAO). Globally, this includes Australia, New Zealand and Chile. In Europe, the United Kingdom, the Netherlands, Belgium, Greece and Ireland all have incentive programmes to increase afforestation (in most cases of agricultural land) with varied success.

In the EU 28, forests and other wooded land cover a slightly higher proportion of total area (42.4%) than agricultural land. The drivers of incentive schemes in western European countries which have had extensive policy supports to incentivise farmers to afforest agricultural land, are based generally on the multifunctional timber and ecosystem benefits provided by forests, with increasing prominence on the potential for afforestation to mitigate agricultural greenhouse gases. In the UK, a target of 23,000 hectares (ha) of additional forest annually for 40 years is needed to contribute to climate change mitigation (Read et al. 2009). However, UK forest expansion has dropped back from a high of 40,000 per year in the early 1970s to an average of about 10,000 (Forestry Commission 2013).

The Flemish region of Belgium which is characterised by low forest cover has a target to expand forest area by 10,000 hectares to 12%. However, afforestation in Flanders has actually declined and expectations are that it will be difficult to realize an increase in the forest area (Van Gossum et al. 2012). It is likely that the Dutch policy goal to increase forest cover by 66,000 hectares by 2020 will also not be realised (Van Gossum et al. 2010).

Despite having soils and climatic conditions which are particularly suited to timber and fibre production, Ireland has one of the lowest forest covers in Europe at 11% (Eurostat 2013). Successive policy interventions have implemented incentives to increase forest cover. Despite consistently ambitious targets and despite the strong financial incentives, annual afforestation are currently well short of target afforestation rates.

Irish afforestation policy context

The expansion of non-industrial private forests (NIPF) in Ireland is unique in the European context in that the almost doubling of forest cover within the last thirty years has taken place largely on farmland. Until the mid-1980s, virtually all afforestation in Ireland was undertaken by the State as only limited financial incentives were available to the private sector. However by 1989, as a result of the introduction of EU funded afforestation subsidies, the level of afforestation carried out by the rapidly expanding private sector exceeded public sector (State) planting for the first time. By 1993, an early government target of one million acres (404,700 hectares) of new forest cover was reached. From 5,242 hectares in 1985, annual afforestation reached a high of 23,710 hectares in 1995 (Forest Service 2014).

However, as financial incentives for private afforestation increased, public afforestation declined rapidly due to the unavailability of EU forest subsidies for public afforestation. From 2006 onwards, public planting virtually ceased and all afforestation was carried out by the private sector; the vast majority of which was undertaken by farmers (Forest Service 2014).

From a bio-physical perspective, the increase in farm afforestation is not surprising as Ireland has some of the highest growth rates for conifers in Europe and also has a large proportion of land which is marginal for agriculture but highly productive under forests (Farrelly et al. 2011). From an economic perspective, the expansion was facilitated by a series of Irish and EU subsidies which increased in magnitude over time and which were largely focused on incentivising the afforestation of agricultural land. However,

3 I draw upon the research of Mary Ryan in this section.

from a behavioural or attitudinal perspective, the rate of expansion is surprising, given the dis-incentive presented by the permanency of the land use change decision from agriculture to forestry. Under the 2014 Forestry Act (and previously under the 1946 Forestry Act), a felling licence is necessary to thin forests and to fell or remove trees. The Act also allows the Minister to set conditions which include re-planting of harvested forests (re-forestation) (Irish Statute Book 2014). Thus the decision to plant is not taken lightly by farmers. The rapid increase in forest cover is also surprising given the lack of forestry tradition among Irish farmers and the consequent low level of knowledge of the economic returns from forestry (Ní Dhubháin and Greene 2009).

Ireland's forest policy has undergone a number of significant changes in emphasis since the founding of the State when forest cover represented just 1% of the land area, to the current forest cover of 11%. While the primary aim of Irish forest policy has remained the achievement of self-sufficiency in timber supplies, broader policy objectives were also pursued. The social dimension around rural employment particularly in the western half of the country was an important policy objective. Successive forest policy strategies have set policy objectives and annual targets for private sector afforestation and have made recommendations as to the achievement of these targets, largely through financial incentives. In the 1996 Strategic Plan for the Development of the Forestry Sector in Ireland, ambitious targets of 20,000 and 25,0000 hectares were outlined (DAFF 1996). These targets were set in order to achieve a critical mass of timber production which would allow the developing timber processing sector to grow. Achieving this target would deliver an annual timber output of 10 million and a total forest cover of 17% by 2030.

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3. Review of Forestry Sector Policy

3. Review of Forestry Sector Policy

As part of the project, we conducted a stakeholder review in relation to contractor views in relation to strengths and weaknesses of the Forestry Programme and the 2014-2021 CAP.

Strengths and Weaknesses of Forestry Programme

Overall Weaknesses:

- Mismanagement of forestry budget, many opportunities to allocate money to schemes which was not done
- Across all measures – breakdown in relationship and trust between industry and Department
- Lack of commitment and leadership within DAFM and Government to the Forestry Programme

Table 1. Strengths and Weaknesses Forestry Programme

	Strengths	Weaknesses
Afforestation and Creation of Woodlands	• Government backed • Principle of 100% funding a strength • Income tax free status • Full ownership retained • Land remains eligible for CAP Basic Payments • Full suite of support measures • Ecosystem service – biodiversity enhancement & protection, water quality, soil protection, air quality and carbon sequestration	• Competing with CAP (GLAS in particular) – see SEEFA submission on CAP • Premium and grants not sufficient in term nor value • Timelines for approval unworkable • Licencing process deterrent for participation • Expand eligibility of land for afforestation, currently too restrictive • Lack of coherent marketing plan • Existing owners not being catered for i.e. Ash Dieback owners • Replanting obligation • Lack of clarity on carbon • Lack of timelines on payments • Lack of awareness of forestry amongst agricultural advisors, farmers and general public • 20% rule on unenclosed land – AA process should be adequate in these situations • Lack of leadership and can do attitude in DAFM • Lack of Government support • Ownership qualification criteria too restrictive • Tax clearance certificate requirements a deterrent • FIR & Remedial works letters are standard practice on most files • Basic payment should not be held up based on forest premium • Payment area at Form 2 stage must remain for the duration of the forest premium payments
Investments improving the Resilience and Environmental value of Forestry: NeighbourWood Scheme	• Social and stakeholder engagement • Creation of recreational amenities • Knowledge and education for public • Appreciation of woodlands by the public • Access to woodlands for the public	• Application process too complicated • 100% grant needed • Grants need to be increased • Premium required for establishment and enhancement works (i.e. affor and NWCS), at moment have to do it under two different schemes to maximise benefit to owner, needs to be under the one scheme • Increased grant needed for stakeholder consultation and involvement
Investments in Infrastructure: Forest Road Scheme	• Good support measure for existing forest owners • Aids mobilisation of timber • Forest owners need to build roads for access and like having access to their forest • Reengages forest owner's interest in forest due to access • Positive marketing benefit for forest owners and sector • Protects biodiversity in roadside margins	• Road grant not available at establishment stage • Single consent process not working • Grant rates insufficient • Tax clearance certification requirement unnecessary • Application process too cumbersome • Mandated grants on forest roads too high risk due to differing interpretation of specification by DAFM inspectorate • Forest road and felling licence application should be same process or joined up, this also applies to Woodland Improvement, native woodland conservation, continuous cover forestry scheme etc • Allowing public access on private road can be a deterrent

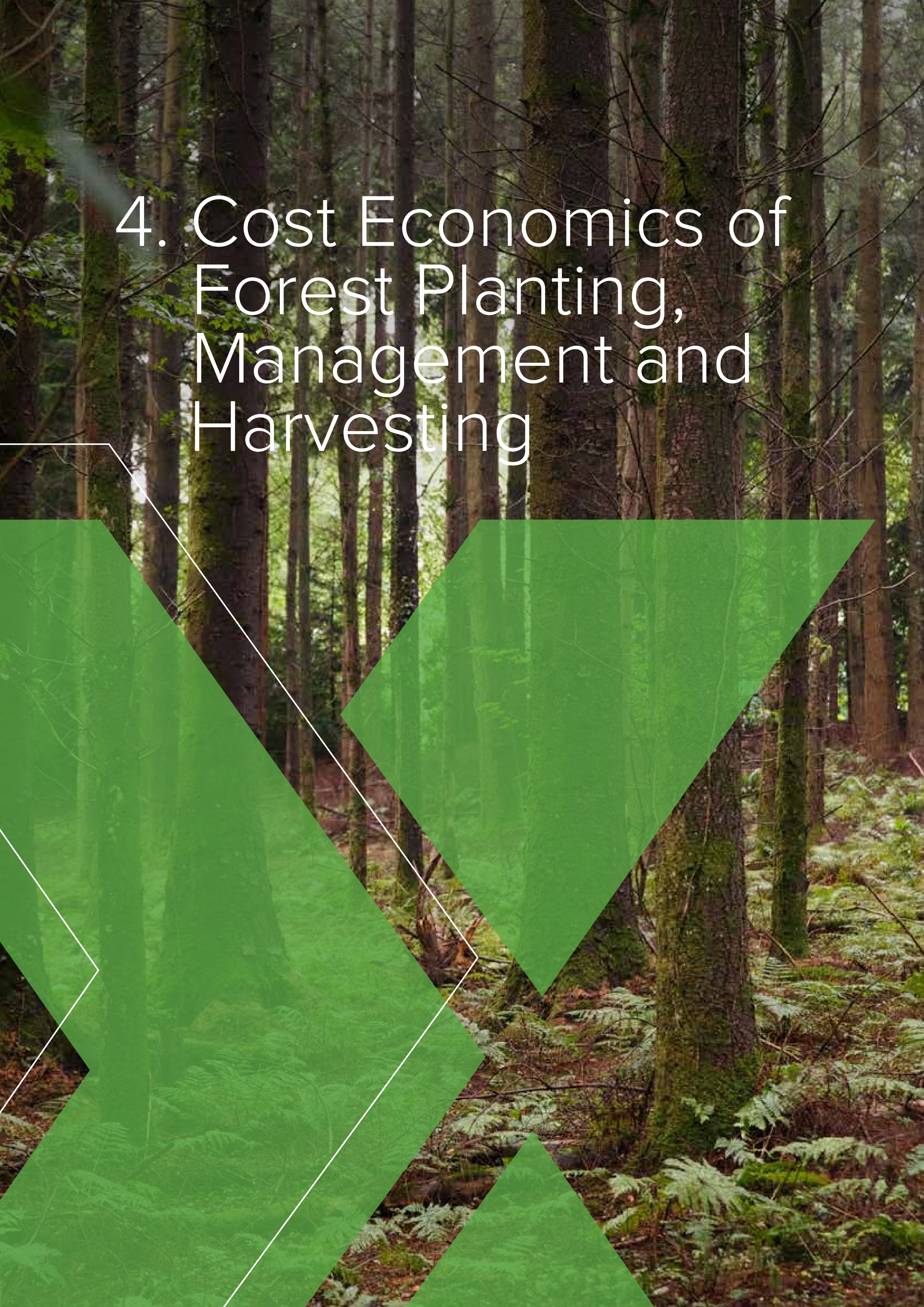
Prevention and Restoration of Damage to Forests: - Reconstitution Scheme	• Support measure for forest owners • Confidence measure for forest owners, reaffirming the Government's commitment to forest owners	• Current scheme is Ad hoc • No planning • Insufficient • Poorly thought out and administered • Not resourced • For example – Ash Dieback, thereby resulting in lack of confidence for forest owners
Investments improving the Resilience and Environmental value of Forestry:- Woodland Improvement	• Good to have support for pioneers who planted broadleaves • Second payment positive move • Grant aid is assisting the management of these woodlands • Woodland Improvement operations create biomass that contributes to reduction of fossil fuel use in home heating • If managed correctly increase the value of the woodland • When undertaken successfully it is a positive marketing benefit for forest sector	• Woodland Improvement grant has not been increased since it was launched many years ago • Restriction on second payment doesn't make sense, needs to be based on silviculture rather than administration • Grant needs to be weighted in favour of smaller sites as currently application process and admin does not cover costs on sites <5 hectares, nothing left to undertake silviculture works after site visits, admin and paperwork • Simplify application process • Woodland Improvement grant is for silvicultural improvement operations and should not be used to reconstitution activities • Due to longevity of rotation, further support should be considered • Tax clearance requirement unnecessary and deterrent
Investments improving the Resilience and environmental value of Forests:- Native Woodland Conservation Scheme	• Extremely important to protect our old and ancient woodlands so support is welcome • Commitment by Government to sector • Important to compensate owners for protecting these woodlands for many years • Forest Premiums will aid the protection of these fragmented and vulnerable woodlands	• Forest premium amount too low and duration far too low, the original forest premium payment was for the lifetime, this needs to be reintroduced in order to protect these extremely rare and hugely valuable woodlands • No recognition of the ecosystem services these woodlands provide and habitat they protect • Forest grant not sufficient • Application process to complicated, needs to be simplified • Perceived 12 hectares cap, not necessary • No training in management of these woodlands • No marketing of this scheme • A dedicated team within DAFM is required to only deal with applications and ensure consistency in the management of these forests • Tax clearance cert should not be required
Knowledge Transfer and Information Actions	• Good support for forest owners • Is assisting in the management of forests • Assisting in mobilising timber • Providing skills and knowledge to forest owners to help them manage their forests • Getting forest owners engaged in the management of their forests • Increases the value of the woodland due to better management • A positive marketing benefit for forest owners	• Must have the same terms and conditions as other agricultural KTG schemes • Not available to owners who haven't afforested • The principle of mandatory Teagasc involvement is wrong, it should be optional • Should be marketed to the farming community in the same way as all other KTG schemes are • Should be available to forest owners every year, 3 year barrier must be removed, forest owners are only getting started after first KTG programme • Process needs to be simplified • Facilitators should not be penalised if participant's to not show up, deduct the payment of the participant only
Innovative Forest Technology	We are unsure that any measures under this were introduced?	We are unsure that any measures under this were introduced?
Forest Management Plans	• Very necessary measure • COFORD study has detailed the necessity of this measure	• Commitment in principle but no action • Was never introduced • Forest owners and industry will pay the price for this inaction into the future • Lack of vision, leadership and commitment to this measure

Ireland CAP strategic plan 2014 to 2020

Table 2. Strengths and Weaknesses by Scheme

Scheme	Srengths	Weaknesses
Pillar I		
Basic Payment	Success as was compatible with afforestation	
Sheep Grassland Payment	None	Forestry was not compatible
Young Farmers	None	Forestry was not compatible
RDP	None	
Beef Data and Genomics Programme	None	
Investments in physical assets (TAMS)	None	
Agri-environment-climate (GLAS)	None	Forestry was not compatible
Organic Farming	None	Forestry was not compatible
Natura 2000 payments	None	Forestry was not compatible
Payments to areas facing natural or other specific constraints	None	Forestry was not compatible
Support for LEADER local development	Some measures available to support fire wood production	Needs to be expanded

4. Cost Economics of Forest Planting, Management and Harvesting



4. Cost Economics of Forest Planting, Management and Harvesting

In understanding the cost structure of various forest activities such as afforestation and reforestation, forest roads, fencing, thinning and harvesting, we draw upon the recent report (Bruton and Phillips, 2021)[4] who did a survey of forest contractors in a report for the Council for Forest Research and Development (COFORD) Working Group, established to formulate the socioeconomic contribution of the Irish forestry sector. The purpose of the study was to

- Determine the extent (e.g. full-time equivalents) and nature (e.g. direct or contract) of employment generated for a range of forestry activities,
- Determine the labour and material inputs (costs) associated these activities,
- Develop coefficients showing the labour and material inputs associated with each forest activity and
- Using the coefficients national information available on the extent of forest operations produce estimates of the national employment and economic activity generated by the forestry sector.

This study has amended the model developed by Bruton and Phillips in two ways:

- Firstly, to be able to incorporate new price estimates, which is important given the substantial inflation that has occurred
- Secondly to incorporate a broader income measure than direct costs, adding overhead expenditures and operating surplus to be able to assess a full cost per forest management activity.

Inflationary Pressures

Supply chain issues that resulted from BREXIT and COVID relation disruptions, the economic recovery post COVID lock-down and the fuel and food price inflation that has resulted from the Ukraine conflict has seen inflation return to levels unseen since the 1980's. The price growth between June 2021 and June 2022 of 9.1% is higher than any average inflation rate since the 1980's and equivalent to the price growth over the 14 year period 2007-2020 (Table 3).

Post-COVID exceptional economic growth in 2021 and into 2022 has seen a large increase in employment levels. At the end of quarter 1, 2022, employment levels at 2.5m were at the highest levels since the foundation of the State. Of particular relevance to the forest contracting sector is the increase of construction employment to over 159,000, higher than at any point since 2008 and an increase of 30,000 in 12 months.

Table 3. Price Growth

Price Growth		
2022-2023 (forecast)	0.040	
2021-2022 (June)	0.091	
2020-2021 (June)	0.016	
Price Growth	**Average**	**Total**
2010-2019	0.006	0.066
2000-2009	0.032	0.288
1990-1999	0.023	0.216
1980-1989	0.093	1.031
1970-1979	0.128	2.046

Of relevance to the forest contracting sector in particular are increases in

- Wage Costs
- Fuel Costs
- Material Costs

Table 4 details the main price inflation factors used in this study. Wage inflation is based upon the CSO and Eurostat Labour cost index by NACE Rev. 2 activity. Given the interoperability with the construction sector and the direct competition for labour with this sector, manual wage rates are assumed to follow construction labour, while other occupations are assumed to follow the average wage index.

As the forestry costs survey was collected in 2020, we require at least two wage inflators, 2020-2021 and 2021-2022. For future years, we utilise assumptions within the ESRI Quarterly Economic Commentary (QEC). Between 2020 and 2021, construction wages fell 8.6%, while other occupations fell 3.5%. However in 2022, given the tightening construction labour market, construction wages increased by 48% in 2022 compared with 2021. This puts the Irish construction sector as a significant outlier in Europe, where the average construction sector wage growth was 3.5% over that period. If these labour costs were maintained, it would likely attract migrant construction labour. In aggregate, the ESRI in their Summer 2022 QEC assume a wage growth rate of 4.5% in 2023. It should be noted that each of the ESRI QEC's this year have revised upwards the expected price inflation, reflecting the turbulent price volatility at present.

4 Bruton P., H. Phillips (2021). Final Report: The estimated employment and economic activity associated with the forestry sector. Forestry Services Ltd.

Fuel costs utilise the CPI data from the CSO. Road diesel prices increased by 12% in 2021 and 50.7% in 2022, reflecting both the bounce back from low fuel prices during the COVID lockdown and the price inflation resulting from the Ukraine conflict. Green diesel is cheaper than road diesel due to lower excise duties. However the price is more volatile relative to market price changes. As a result Green Diesel increased by 50% in 2021 and a further 80% in 2022.

Table 4 details a variety of other price inflation factors taken from the producer price index of the CSO with price inflation 2020-2022 varying from the fossil fuel intensive fertilizer of 92% to road materials of 37.5% and other materials closer to the underlying inflation rate of 10%.

Table 4. Price Inflation Factors

	Price Growth (1:NoChange)		
	2020-2021	2021-2022	2020-2022
Manual labour cost per hour	0.914	1.480	1.352
Chainsaw Operator	0.914	1.480	1.352
Excavator Operator	0.914	1.480	1.352
Forwarder Driver	0.914	1.480	1.352
Harvester Driver	0.914	1.480	1.352
Haulier	0.914	1.480	1.352
Forester	0.965	1.168	1.127
Engineer	0.965	1.168	1.127
Ecologist	0.965	1.168	1.127
Contract Admin	0.965	1.168	1.127
Contract Admin2	0.965	1.168	1.127
Fencing Labour	0.914	1.480	1.352
Diesel Afor Refor €/hour	1.122	1.507	1.691
Metres fencing per ha Afor	1.152	1.402	1.616
Metres fencing per ha Refor	1.152	1.402	1.616
Road diesel €/l	1.122	1.507	1.691
Green Diesel	1.500	1.800	2.700
Petrol/Oil Chainsaw/l	1.115	1.438	1.603
Travel/hour	1.115	1.438	1.603
Fertiliser Bag 25kg	1.000	1.923	1.923
Deer gate (cost per unit)	1.025	1.074	1.101
Stock gate (cost per unit)	1.025	1.074	1.101
Oak (cost per 1000 plants)	1.000	1.100	1.100
Alder (cost per 1000 plants)	1.000	1.100	1.100
Birch (cost per 1000 plants)	1.000	1.100	1.100
Sitka Spruce (cost per 1000 plants	1.000	1.100	1.100
Chemicals 20l	0.997	1.023	1.020
Shelter (cost per unit)	1.152	1.402	1.616
Stake for shelter (cost per unit)	1.152	1.402	1.616
Barbed wire/m	1.025	1.074	1.101
Sheep Netting/m	1.025	1.074	1.101
Fertilizer NPK (350kg)	1.000	1.923	1.923
Fertilizer GRP (350kg)	1.000	1.923	1.923
Machinery Hire and Depreciation	1.013	1.079	1.093
Road Materials	1.122	1.225	1.375

Cost Structure of Forest Planting, Management and Harvesting

Applying these inflation factors to the Bruton and Phillips Cost model, we produced in table 5 revised cost assumptions for various forest contracting activities.

The Forestry management cost analysis focuses primarily on direct material and labour costs and management labour costs associated with the main forestry planting and management activities, calculated separately for different broad species types. These costs are outlined in fine detail and as a result of access to experienced operators provides in granular detail the types of costs associated with each activity. These include:

- Afforestation
- Reforestation
- Thinning and Harvesting
- Fencing
- Road Building and
- Maintenance

It should be noted that fencing cost vary significantly depending upon the purpose of the fence i.e. what type of animal one wants to protect the forest from (sheep, deer, rabbit). It is important that in cost planning that this expense, which is identified by the land owner in the afforestation application is incorporated in the cost planning and consequentially in the fencing grant made to support establishment.

These costs adjusted for the price inflation factors in table 4 are reported in table 5.

In order to quantify total output, we require in addition an estimate of other indirect costs such as:

- Overhead materials such as telecommunications, utilities, insurance and other office costs
- Operating Surplus or Profit Margin
- Company taxes
- Investment related costs such as depreciation

Table 5. Cost Assumptions in 2023

	Labour and Machines					Administration Technical Support			Totals/ha	
Afforestation	**Hours/ha**	**Cost/ha**	**% Contract**	**Materials + Fuels**	**Machine Cost**	**Hours/ha**	**Cost/ha**	**% Direct**	**Hours/ha**	**Cost/ha**
Conifer	67.46	€1,131	92%	€1,928	€235	43.52	€1,132	93%	111.0	€4,426
Broadleaf Hard	82.04	€1,443	91%	€3,821	€282	43.52	€1,132	93%	125.6	€6,678
Broadleaf Soft	82.04	€1,443	91%	€3,233	€282	43.52	€1,132	93%	125.6	€6,090

	Labour and Machines					Administration Technical Support			Totals/ha	
Reforestation	**Hours/ha**	**Cost/ha**	**% Contract**	**Materials + Fuels**	**Machine Cost**	**Hours/ha**	**Cost/ha**	**% Direct**	**Hours/ha**	**Cost/ha**
Conifer	63.36	€1,093	93%	€1,463	€261	25.79	€679	100%	89.2	€3,495
Broadleaf Hard	87.96	€1,527	95%	€3,003	€310	25.79	€679	100%	113.8	€5,519
Broadleaf Soft	87.96	€1,527	95%	€2,414	€310	25.79	€679	100%	113.8	€4,930

	Labour and Machines					Administration Technical Support			Totals/ha	
Conifers	**Hours/ ha**	**Cost/ ha**	**% Contract**	**Materials + Fuels**	**Machine Cost**	**Hours/ ha**	**Cost/ 100m3**	**% Direct**	**Hours/ ha**	**Cost/ ha**
First Thinning	14	€324.65	97%	€189.25	€762.83	7.7	€233.61	89%	21.9	€1,510
Second Thinning	14	€319.31	100%	€186.28	€745.82	6.3	€177.53	81%	20.2	€1,429
Third + Sub Thinning	16	€344.57	100%	€215.21	€816.90	8.2	€228.06	80%	23.9	€1,605
Clearfell	86	€1,949.06	99%	€1,257.80	€4,131.22	57.8	€1,956.46	90%	143.3	€9,295
Clearfell Windblow	54	€1,227.83	100%	€769.05	€2,689.60	39.3	€976.99	83%	93.0	€5,663

	Labour and Machines					Administration Technical Support			Totals/ha	
Broadleaves	**Hours/ ha**	**Cost/ ha**	**% Contract**	**Materials + Fuels**	**Machine Cost**	**Hours/ ha**	**Cost/ha**	**% Direct**	**Hours/ ha**	**Cost/ ha**
Tending	11.2	€246	100%	€118	€512	3.4	€102	89%	14.6	€977
First Thinning	13.0	€296	100%	€161	€690	4.8	€145	89%	17.8	€1,292
Second Thinning	12.2	€276	100%	€150	€626	3.9	€110	81%	16.1	€1,163
Third + Sub Thinning	14.2	€322	100%	€175	€715	4.8	€133	80%	19.0	€1,344
Clearfell	121.5	€1,708	100%	€1,041	€3,481	30.8	€1,043	90%	152.3	€7,274

	Sub-operation			Labour Type		Hours/ha	Cost/ha	Cost per Hour		
Fencing		**% of Sites**	**Metres**	**Direct**	**Contract**	**Mean**			**Materials**	**Cost/Ha**
Conifer	Erect fence at 150m/ha	€0	25000%	€0	€100	7.5	€129	1723%	Wire, stakes, stainers gates	€797
Blvds	Erect fence at 150m/ha	€0	25000%	€0	€100	10.7	€184	1723%	Wire, stakes, stainers gates	€1,443
Refor Con	Erect fence	€0	25000%	€0	€100	3.8	€65	1723%	Wire, stakes, stainers gates	€319
Refor Blvds	Erect fence at 150m/ha	€0	25000%	€0	€100	8.5	€146	1723%	Wire, stakes, stainers gates	€577

	Labour and Machines					Administration Technical Support			Totals/km	
Roading	Hours/ km	Cost/ km	% Contract	Materials + Fuels	Machine Cost	Hours/ km	Cost/km	% Direct	Hours/ km	Cost/ km
New Road Construction	401	€13,244	95%	€55,416	€11,384	360	€16,021	96%	761.1	€96,064
Road Upgrading	140	€4,430	100%	€30,680	€3,104	150	€6,420	99%	289.9	€44,635

	Labour and Machines					Administration Technical Support			Totals/km	
Maintenance	Hours/ha	Cost/ ha	% Contract	Materials + Fuels	Machine Cost	Hours/ km	Cost/km	% Direct	Hours/ ha	Cost/ ha
Inpsection Paths	2.2	€95	98%	€28	€0				2.2	€124
Drainage Repairs	2.0	€63	100%	€65	€19				2.0	€147
Fence Repairs	2.5	€54	95%	€75	€0				2.5	€129
Road Repairs	1.2	€38	0%	€56	€11				1.2	€105

Table 6. Comparing Margins and Overhead Rates between Sectors

	Construction	Forest Contracting	Retail	Architect and Engineering	Professional and Scientific	Food and Beverage
Intermediate Inputs (Other)	0.472	0.461	0.164	0.305	0.297	0.230
Intermediate Inputs (Overhead Services)	0.031	0.042	0.058	0.054	0.061	0.064
Compensation of Employees	0.265	0.265	0.449	0.416	0.223	0.515
Taxes	0.025	0.025	0.012	-0.005	0.037	0.047
Operating surplus, net	0.186	0.186	0.276	0.152	0.328	0.085
Consumption of fixed capital	0.020	0.020	0.041	0.077	0.054	0.060
Output						
Output less Manufactured Inputs	1.000	1.000	1.000	1.000	1.000	1.000

Source: CSO Input Output Table

In order to develop an estimate of these indirect cost components, we draw upon the CSO's Input Output tables which divide total output into intermediate consumption, imports and value added (which comprises, taxes, labour operation surplus and investment).

Making the assumption that forest contracting businesses are similar to construction businesses, except for the degree of material inputs, we approximate these extra costs in table 6. Excluding material inputs and assuming the same overhead service rate, we find that construction and forest companies have the same intermediate consumption rate of 50.3%. As a share of the overlapping inputs (other intermediate consumption, excluding imports and other construction materials), the construction has a labour share of almost exactly the same. Finally we assume the same rate of operating surplus, company tax and investment as the construction sector, resulting in an operating surplus rate of 18.6%.

Comparing in table 6 with other similar sectors, we find that the resulting operating surplus rate is slightly higher than architects and engineers (but with lower labour costs), lower than retail and professional and scientific sectors, but with higher material input and significantly higher than food service businesses, which has double the employee share and half the material inputs.

Combining the direct establishment costs in table 7 for Afforestation with the additional overhead costs, the other dimensions of value added outlined above and VAT, we estimate the total cost per hectare for forest establishment in 2023 to be €7,004 for Conifers, €10,551 for Broadleaf (Hard) and €9,631 for Broadleaf (Soft).

Reflecting the price inflation in recent years, these rates are higher than the establishment grant rates from the previous Forestry Programme. It should also be noted that given the price inflation visible at present and likely to remain for a significant period of the next programme that prices and associated establishment grants be reviewed regularly to avoid delays in the afforestation programme due to an inability to plant new forests if the cost is higher than the grant.

Table7. Estimating Total Establishment Costs by Species in 2023

	Direct Costs	Overhead	Other Value Added	Sub Total	VAT @ 13.5%	Total inc VAT
Conifer	4478	261	1432	6171	833	7004
Broadleaf Hard	6746	393	2157	9296	1255	10551
Broadleaf Soft	6158	359	1969	8485	1146	9631

5. Carbon Sequestration

5. Carbon Sequestration

Although afforestation is very important for the timber industry, given the climate action objectives associated with global warming, the carbon sequestration potential for forestry related land use is becoming increasingly important and is second to the Oceans as a carbon sink storing carbon in their biomass, soils and products (Climate Action Plan, 2021).

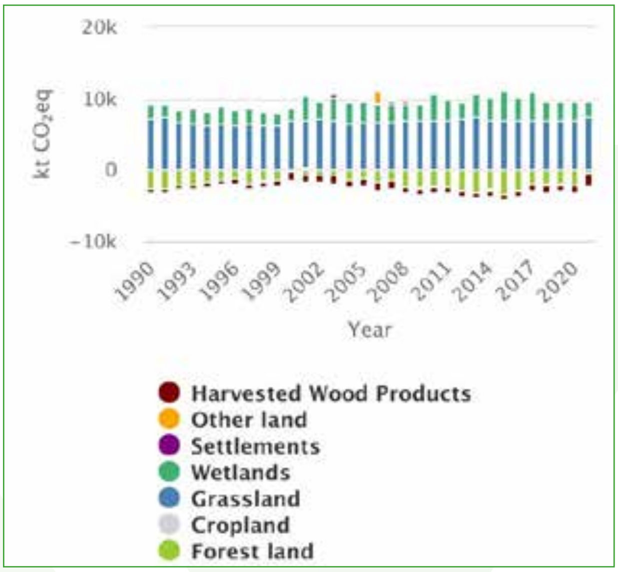
Within the Land Use, Land Use Change and Forestry (LULUCF) sector, EPA carbon accounting data indicates that forestry has been an important carbon sink, with forest land accounting typically for about 2 million tons of CO2 (mtCO2) removals between 2008 and 2020 (Figure 3). As planting rates have fallen, we have seen carbon sequestered by forests fall in 2021. However carbon stored in Harvested Wood Products continues to rise with increases of 1.6 mtCO2 in 2021.

The national Climate Action Plan 2021 sets ambitious targets for different sectors in relation to carbon reductions. It sets a roadmap for halving carbon emissions by 2030 and reaching net zero emissions no later than 2050. It identifies that afforestation is the single largest land-based climate change mitigation measure available to Ireland and suggests a number of key actions with the aim of realising the 2030 ambition, and contribute to achieving carbon neutrality no later than 2050.

Supported by a new Forest Strategy, the new Forestry Programme launched in 2023 will be one of the key drivers, with a particular focus on climate smart forestry. There are other actions that encourage multiple objectives (commercial, climate, water and biodiversity) and encourage the introduction of small scale afforestation within agri-environment schemes and via activities such as agroforestry. From a harvesting and timber mobilization point of view there will be investments in harvesting infrastructure, and research in timber and processing industries and develop decision support tools to enable forest owners to make decisions on timing of harvesting (such as extended rotations) to optimise carbon storage. From a climate adaptation point of view, genetic diversity will be supported to improve the resilience of forests to climate change.

Figure 3.

LULUCF Emissions and Removals, 1990-2021



Source: (EPA)

The Climate Action Plan sets a target of planting 8,000 hectares per annum[5]. Although current and future forest planting will have a limited impact upon carbon emissions in 2030, they are essential for the objective of carbon neutrality by 2050.

Carbon Budgeting

As part of the strategy of delivering carbon neutrality by 2050, the Irish government has agreed a set of carbon budgets. The first carbon budget programme proposed by the Climate Change Advisory Council and approved by Government comprises three successive 5-year carbon budgets.[6] The total emissions allowed under each budget is as follows:

- 2021-2025: 295 Mt CO2 eq1. This represents an average reduction in emissions of 4.8% per annum for the first budget period.
- 2026-2030: 200 Mt CO2 eq. The represents an average reduction in emissions of 8.3% per annum for the second budget period.
- 2031-2035: 151 Mt CO2 eq. The represents an average reduction in emissions of 3.5% per annum for the third provisional budget.

Ireland's total GHG emissions in 2018 were 68.3 Mt CO2eq. requiring two carbon budgets to reduce total emissions

5 https://www.oireachtas.ie/en/debates/question/2021-12-09/6/
6 https://www.gov.ie/en/publication/9af1b-carbon-budgets/

being reduced to 33.5 Mt CO2eq by 2030. Worryingly, emissions increased by 4.7% in the first year of the carbon budget[7], with emissions increasing across all sectors.

In July 2022, the government agreed sectoral carbon budgets[8] with ceilings or maximum limits on greenhouse gas emissions for each sector of the Irish economy to 2030. A reduction in emissions of 25% is required from the Agriculture sector, reducing emissions to 17.25%, albeit engagement by individual farmers is voluntary. It should be noted that the sectoral emissions reductions announced amount to a reduction of 43% rather than 51%. Finalising the sectoral emissions ceiling for the Land-Use, Land-Use Change and Forestry (LULUCF) sector has been deferred for 18 months to allow for the completion of the Land-Use Strategy.

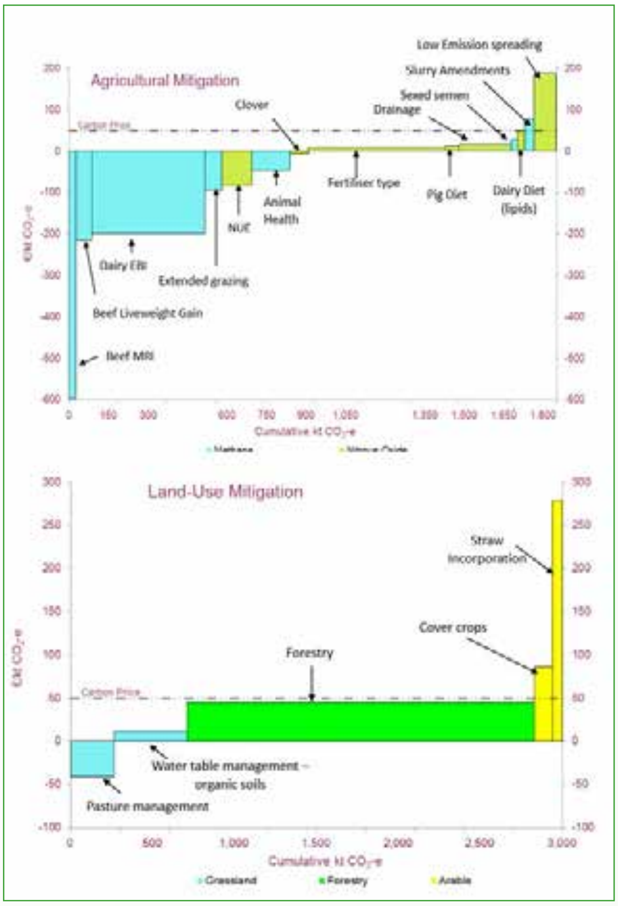
Marginal Abatement Cost Curve

Emphasising the close link between carbon sequestration in forestry and the substitution of agricultural emissions via the land use change, Teagasc have developed a Marginal Abatement Cost Curve to consider the net impact and associated costs of various carbon mitigation strategies including afforestation.[9] The Teagasc document categorises measures in three dimensions:

- Agricultural Mitigation
- Land-use and Land Management mitigation
- Energy mitigation

Figure 4.

The Teagasc Marginal Abatement Cost Curve



Source: Teagasc

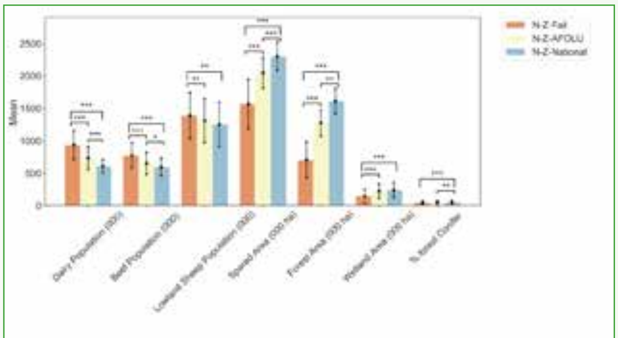
The report developed a Marginal Abatement Cost Curve that identifies the cost per measure of delivering emissions reductions (Figure 4). The report identifies 6.19 mtCO2e per annum potential saving for the periods 2021-2030 at a net cost (including efficiency savings) of circa €34 million per annum. By 2030, they identify 7.7 mtCO2 of savings, which are divided between agricultural mitigation (2.89), land-use mitigation (3.5) and energy mitigation (1.31m). Assuming a continuation of the afforestation levels of 7,000 hectares per annum, the Teagasc study assumes a net sink of 2.1 mtCO2 per annum and about 2.5 mtCO2 in 2030, approximately one third of all emissions (Figure 4). Forestry accounts for by far the largest amount for any measure. The Teagasc report notes the need to accelerate the afforestation programme, requiring the planting of 490,000 hectares of new forests by 2046. It notes that the achievement of further abatement from the sector could be achieved via greater sequestration in forests (through higher planting rates).

7 https://www.epa.ie/news-releases/news-releases-2022/epa-data-shows-irelands-2021-greenhouse-gas-emissions-above-pre-covid-levels.php
8 https://www.gov.ie/en/press-release/dab6d-government-announces-sectoral-emissions-ceilings-setting-ireland-on-a-pathway-to-turn-the-tide-on-climate-change/
9 https://www.teagasc.ie/media/website/publications/2018/An-Analysis-of-Abatement-Potential-of-Greenhouse-Gas-Emissions-in-Irish-Agriculture-2021-2030.pdf

SeQUEsTER (Scenarios Quantifying land Use & Emissions Transitions towards Equilibrium with Removals) is funded by the Irish Environmental Protection Agency and Department of Agriculture, Food and the Marine, led by David Styles in NUI Galway, explores scenarios towards "carbon neutrality" in the agriculture, forestry and other land use (AFOLU) sector in Ireland. In a paper forthcoming in Nature Sustainability[10], the project reports the results of scenario analyses to achieve carbon neutrality by 2050. 850 scenarios[11] were considered, based upon random mitigation choices were classified as:

- (i) failed to meet neutrality (N-Z-Fail), net flux > 2.5 Tg CO_2e;
- (ii) achieved AFOLU neutrality (NZ-AFOLU), net flux ≤ 2.5 Tg CO_2e, ≥ –2.5 Tg CO_2e;
- (iii) achieved national neutrality (N-Z-National), net flux ≤ –2.5 Tg CO2e.

Figure 5.
Changes in Agriculture, Forestry and Land Use



Note: Variation and spread of animal population input parameters, total spared, forest and wetland area outputs and proportional input parameters related to livestock productivity, forestry, rewetting and grassland utilisation. Significant differences between specific groups from a Dunn's post-hoc analysis. *** denotes statistically significant at 1%, ** denotes statistically significant at 5% and * denotes statistically significant at 10%. The standard deviation is represented by black arrows.

Source Duffy et al. (2022) and Prudhomme et al., (2022).

National neutrality scenarios are those that significantly exceed AFOLU neutrality, and therefore contribute surplus removals (equivalent to approximately 5% non-AFOLU national emissions in 2020) to support national level carbon neutrality. A total of 666, 146 and 38 scenarios were classified as N-Z-Fail, N-Z-AFOLU and N-Z-National, respectively. Figure 5 taken from this paper highlights the mean change of activity across scenarios necessary to achieve these three outcomes. For forestry, of the 166 scenarios that achieved neutrality within the AFOLU sector, the mean hectares of forestry required is about 1.25 million hectares, equivalent to about 18% of the land area. 95% of the scenarios range from 1.1 million hectares to 1.45 million hectares, respectively 15.7% to 20.7% of the land area. It is interesting to note that these results are very similar to the Department of Agriculture, Food and the Marine's target of planting 18% of the land area by 2046.[12]

The higher the area forested, the lower the reduction in animal numbers required to meet national carbon neutrality targets. Carbon sequestration from rewetting is limited by the amount of organic soil under grassland that is possible to rewet. Therefore, without a major afforestation strategy, it would be impossible to achieve carbon neutrality objectives using rewetting or agriculture alone unless there was a major reduction in animal numbers with consequential economic impacts. Given how long it takes for afforestation to realise carbon sequestration, it is essential to frontload the planting of forestry now to achieve Carbon Neutrality by 2050. Compared with all other land based scenarios, trees are essential for Ireland's climate goals, far exceeding livestock reductions or rewetting alone. An increase in afforestation is necessary to develop high-value, bio-based industries over the next 10 to 40 years, which will require additional harvested wood. To avoid and/or offset GHG emissions, the policy should be to pay farmers now to increase planting.

Carbon Pricing

The Public Spending Code are the set of rules and procedures defined by the Department of Public Expenditure and Reform (DPER) to be used in undertaking planning in relation to plans for the spending or investment of public expenditures. The code's goal is to assure that the best possible value for money is obtained whenever public money is being spent or invested.[13] The code applies to all economic appraisals conducted in the public sector.

Of specific relevance to decisions in relation to afforestation are the code's recommendations in relation to valuing greenhouse gas emissions published by DPER in 2019

10 Duffy et al. (2022), Randomised scenario modelling to identify national land management compatible with net-zero GHG emissions. *Nature Sustainability*, forthcoming.

11 Prudhomme, R., Duffy, B., Gibbons, J., O'Donoghue, C., Ryan, M., & Styles, D. (2022). GOBLIN version 1.0: a land balance model to identify national agriculture and land use pathways to climate neutrality via backcasting. Geoscientific Model Development, 15(5), 2239-2264.

12 Department of Agriculture, Food and the Marine. 2014. Forests, products and people. Ireland's forest policy – a renewed vision. Department of Agriculture Food and the Marine, Dublin

13 https://www.gov.ie/en/publication/public-spending-code/

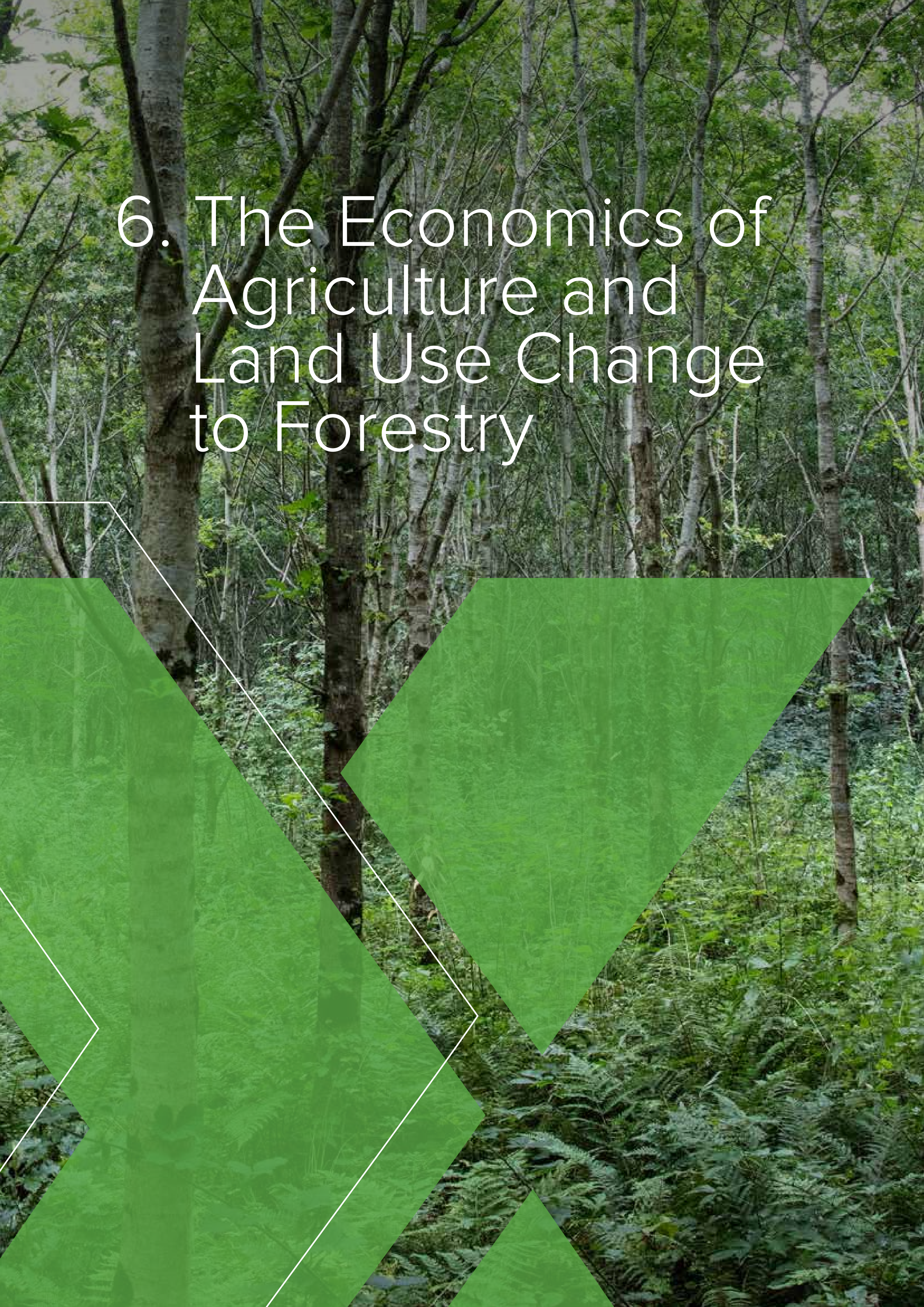
following a public consultation.[14] The value of greenhouse gas emissions included in the Public Spending Code are based on the estimated marginal abatement cost that Ireland will face to reduce greenhouse gas emissions to reach binding EU climate targets. The Public Spending Code applies to all public economic appraisals and hence takes into account emissions from all sectors of the economy. The shadow price of carbon for non-ETS (Emissions Trading Scheme) emissions is based on the estimated cost to Ireland of removing emissions from the atmosphere i.e. the abatement cost. The carbon shadow price to be used in economic appraisals of public policy is defined in Figure 6, rising from €46 per tCO2e in 2022 to €100 in 2030 and to €265 in 2045.

Figure 6.
Carbon Price for Non-ETS Sectors

The national Climate Action Plan 2021 sets ambitious targets for different sectors in relation to carbon reductions.

14 https://assets.gov.ie/19749/77936e6f1cb144d68c1553c3f9ddb197.pdf

6. The Economics of Agriculture and Land Use Change to Forestry



6. The Economics of Agriculture and Land Use Change to Forestry

As the largest single land use in Ireland, agriculture is the most common source of land for afforestation. The economics and policy of agricultural land use are therefore very important in relation to farm level afforestation decisions.

Agricultural Incomes

The Teagasc National Farm Survey collects very high quality information in relation to incomes and costs by farmers with different systems on an annual basis.[15] It is representative of most of the agricultural production in Ireland, but excludes the farms with the lowest output. Table 8 describes the structure of agriculture in terms of economic return and stocking rate for the most recent year data is available, 2020. The stocking rate rises as soil quality improves.[16] Specialist dairy farms have the highest stocking rate when the table is decomposed by stocking rate. This reflects both the greater intensity of dairy farms than other systems and in part because they tend to be on better land. Of the animal systems, cattle rearing and other finishing systems have the lowest stocking rates, reflecting their situation on poorer soils, the older age of farmers and the fact that many have off-farm employment. Sheep system stocking rates, with mixed farms have a stocking rate between beef and dairy.

The economic return per hectare can be classified in a number of different ways.

- Market gross output consists of market sales and changes in stock values for commodities such as animals, milk and crops produced on farms
- Gross margins comprise market gross output plus direct payments (subsidies) less direct costs (such as feed and fertilizer etc).
- Market gross margins are gross margins excluding direct payments
- Market net margins are market gross margins less overhead costs and reflect the return to the market
- Family Farm Income is the market net margin plus direct payments. It does however exclude the cost of labour on farms and excludes a contribution for the price of land

Table8. Average Stocking Rate and Economic Returns on Farms 2020

		Return per Ha					
Soil Type	**Stocking Rate**	**Market Gross Output**	**Gross Margin**	**Market Gross Margin**	**Market Net Margin**	**Direct Payments**	**Family Farm Income**
Best	1.79	2314	1639	1261	494	378	873
2	1.73	1767	1385	948	259	436	695
3	1.50	1651	1301	893	268	407	676
4	1.45	1514	1179	756	145	422	568
5	1.22	930	807	448	48	359	407
Worst	1.58	965	991	455	129	537	665
All	1.60	1803	1361	959	298	403	700
System							
Specialist Dairy	2.10	3378	2218	1888	903	331	1234
Cattle Rearing	1.24	731	779	316	-165	463	298
Cattle Finishing	1.37	944	892	450	-33	442	408
Sheep	1.42	801	835	378	-23	457	433
Tillage	1.15	1284	1101	697	139	404	543
Mixed Farming	1.59	1848	1160	850	186	309	496

Source: Teagasc National Farm Survey

15 https://www.teagasc.ie/rural-economy/rural-economy/national-farm-survey/

16 It should be noted that the stocking rate is higher for the poorest soils. This is a statistical artefact as only farms with a standard gross output of €8,000 or higher are reported in the NFS. For farms on the poorest soils to be included, only those with a higher stocking rate make the threshold.

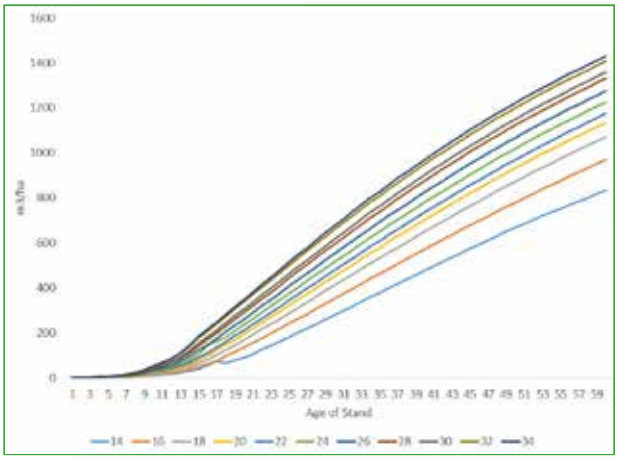
The average family farm income per hectare of the top soil classification is 25% higher than the next, with returns on second very similar to the third, with the third 20% higher than the fourth and the fourth 40% higher than the fifth category. Subsidies account for 43% of income of the top soil category, about 60% for the second and third and over 75% for the remaining soil types. Categorising by farm system, the difference is greater, with specialist dairy farms having family farm incomes more than double tillage and mixed farms, triple sheep and cattle finishing farms and 4 times the per hectare family farm income of cattle rearing farms. The difference is largely due to market returns as the share of subsidies on dairy farms is about 25%, compared to over 100% on cattle and sheep farms, with subsidies being 150% of cattle rearing farms. In the latter 50% of the subsidy funds costs.

Forestry Incomes

The potential forestry incomes in this report are based upon a bio-economic model that utilises forest yield curves (Edwards and Christie, 1981) based upon species, yield class and whether the forest is thinned or not (See Figure 7 and 8).[17]

Figure 7.

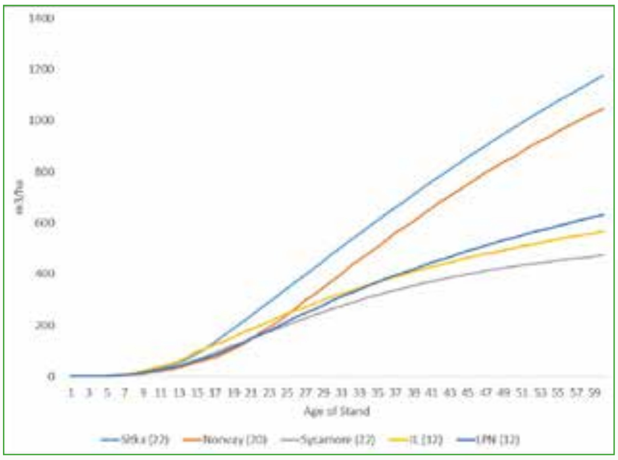
Yield Curves for Sitka Spruce



Source: Edwards and Christie (1981)

Figure 8.

Yield Curves for Different Species



Source: Edwards and Christie (1981)

A separate paper describes the bio-economic model, FORBES developed to model forest incomes building upon these yield curves.[18]The FORBES model applies a price size curve to evaluate the potential value of thinnings and clearfell income. The harvest time is determined by the financial optimal rotation length (Table 9). Forest owner costs are modelled as well as establishment grants and costs and forest premia. In this report, we update prices and premia to correspond to the year of the NFS, 2020.

In terms of economic assessment, one of the key differences between agriculture and forestry is the different time horizon of the crop. Most agricultural crops have an annual growth cycle. As a result farm accounts are undertaken annually. For forestry optimal rotation lengths are typically at least 40 years in length and so it will take a number of decades for the return on planting to be visible. A multi-annual production cycle such as this requires a methodology known as net present value (NPV) to be used, where income and costs streams are discounted to account for the different value of income over time. We use the discount rate of 4% recommended by the public spending code. Furthermore because different species and yield classes have different rotation lengths or time periods over which to judge a return, we use a method known as annual equivalised (AE) values of the NPV to create an annual equivalent of the income stream.

17 EDWARDS, P. N. and CHRISTIE, J. M., (1981). Yield Tables for Forest Management. For. Comm. Booklet 48, Forestry Commission, Edinburgh.

18 Ryan, M., O'Donoghue, C., & Phillips, H. (2016). Modelling financially optimal afforestation and forest management scenarios using a bio-economic model. Open Journal of Forestry, 6(01), 19.

Table 9. Financial Optimal Rotation Length by Species and Yield Class

	Thinned Crops					Unthinned Crops				
Yield Class	Sitka Spruce	Norway Spruce	Japanese Larch	Lodgepole Pine	Ash Sycamore	Sitka Spruce	Norway Spruce	Japanese Larch	Lodgepole Pine	Ash Sycamore
4					55					55
6			47	54	50			42	49	50
8			44	49	45			39	45	45
10	56	59	42	47	45	59	60	37	43	45
12	51	53	40	42	40	53	56	35	40	40
14	47	49	39	40		51	52	34	38	
16	48	48				47	48			
18	48	48				43	44			
20	44	45				41	44			
22	40	44				39	42			
24	37					38				
26	36					37				
28	35					35				
30	34					35				
32	34					34				
34	33					34				

Table 10. Annual Equivalised Net Present Value of Forest Return (Sitka Spruce and Broadleaf) 2022

Sitka Spruce			Broadleaf		
Yield Class	No Thin	Thin	Yield Class	No Thin	Thin
12	206.7	205.5	4	266.8	269.1
14	395.2	387.9	6	273.9	293.3
16	443.8	429.8	8	299.8	325.4
18	489.4	474.5	10	359.3	379.3
20	519.8	504.3	12	397.5	412.2
22	542.7	533.5			
24	568.3	541.3			
26	595.0	572.1			
28	630.7	601.7			
30	644.7	615.2			
32	677.7	642.9			
34	688.6	651.3			

Source: Teagasc National Farm Survey and FORBES Model

Table 10 reports the annual equivalised return on planting a hectare of Sitka Spruce or a broadleaf such as Sycamore or Birch. In general, reflecting the faster growth rate, the returns on Sitka Spruce are higher than broadleaves, with the return increasing at a declining rate as yield classes increase. The return for thinned versus unthinned trees are quite similar with the return on thinned broadleaf trees being slightly higher than unthinned, with the opposite for Sitka Spruce.

Table 11 reports a measure known as the net farm afforestation income (NFAI), subtracting the farm income variable from the forestry equivalent. Focusing on the measure relative to family farm income, we find that on average the return to agriculture is higher for both Sitka Spruce and Broadleaves for each soil type, except for the soil category 5.[19] When we consider farm system, we find that cattle rearing farms have a lower return than forestry for both Sitka Spruce and Broadleaves. Cattle

19 Soil code 6 is excluded given the statistical issue highlighted above, with less intensive farms being excluded due to the sample structure.

rearing and Mixed Farming on average have a lower return than for Sitka Spruce. While on average tillage farms had a lower return, most of the larger tillage farms on better land had a higher return from tillage. Therefore it is the much higher incomes on dairy farms that drive the average higher return from agriculture. Across most other systems and on poorer soils, over the long term, forestry represents a higher return than agriculture.

Table 11.
Average Net Farm Afforestation Income (NFAI) (€/ha) calculated using four agricultural income measures (Sitka Spruce & Broadleaves)

	Gross Margin	Market Gross Margin	Market Net Margin	Family Farm Income	Gross Margin	Market Gross Margin	Market Net Margin	Family Farm Income
	Sitka Spruce				**Broadleaves**			
Best	-1084.4	-705.9	60.5	-318.0	-1234.3	-855.9	-89.5	-467.9
2	-829.9	-393.5	296.2	-140.2	-979.9	-543.4	146.3	-290.2
3	-788.6	-381.1	243.9	-163.5	-988.0	-580.6	44.4	-363.0
4	-666.7	-244.2	366.6	-55.9	-866.1	-443.7	167.1	-255.3
5	-324.9	33.6	433.8	75.2	-523.3	-164.8	235.4	-123.2
All	-830.7	-428.2	233.0	-169.5	-1006.1	-604.1	58.3	-343.7
Specialist Dairy	-1683.5	-1352.7	-367.9	-698.7	-1854.8	-1524.0	-539.1	-870.0
Cattle Rearing	-255.6	207.3	688.3	225.5	-434.7	27.0	508.5	46.7
Cattle Other	-358.7	82.9	566.3	124.6	-533.3	-91.0	393.7	-48.5
Sheep	-976.1	-319.8	33.0	-623.4	-494.5	-39.6	362.2	-92.7
Tillage	-554.3	-150.4	407.9	4.1	-713.3	-309.5	248.9	-155.0
Mixed Farming	-634.5	-325.0	339.0	29.5	-814.0	-504.5	159.5	-150.0

Source: Teagasc National Farm Survey and FORBES Model

Table 12.
Share of Farms where Farms have a higher return from Family Farm Income than Forestry by whether they planted Forestry (2020)

	Family Farm Income	Family Farm Income
	Sitka Spruce	Broadleaf
Has Forestry		
0	0.480	0.296
1	0.582	0.347
All	0.492	0.302

Source: Teagasc National Farm Survey and FORBES Model

As the Teagasc National Farm Survey contains a representative sample, it is possible to look below the averages to consider the share of farms that have a higher return from forestry. In terms of family farm income, about 50% of all farms have a higher family farm income than forestry for Sitka Spruce and about 30% have a higher return for broadleaf (Table 12). This proportion is higher for those that actually planted at nearly 60%, indicating that those who had a higher return from planting forestry were more likely to plant.

The relationship however differs by farm system (Table 13). Only 11% of Specialist Dairy farms would have a higher return from Forestry. On the other hand, nearly 80% of Cattle Rearing Farms and 70% of Cattle Finishing farms would have a higher return from forestry. 60% or higher of all other farms would have a higher return from forestry. In general also, a higher share of farms that actually planted have a higher return from forestry.

Table 13.

Share of Farms where Farms have a higher return from Family Farm Income than Forestry by whether they planted Forestry and System (Sitka Spruce, 2020)

	Specialist Dairy	Cattle Rearing	Cattle Finishing	Sheep	Tillage	Mixed Farming	All
Has Forestry							
0	0.105	0.795	0.704	0.643	0.600	0.643	0.480
1	0.154	0.810	0.692	0.714	0.800	0.000	0.582
All	0.110	0.797	0.703	0.652	0.633	0.600	0.492

Source: Teagasc National Farm Survey and FORBES Model

In table 14, we classify farms by whether forestry returns are higher than agriculture and by whether they planted. Generally farms that planted forestry, regardless of the return were on better land, were more likely to be Teagasc clients and had much larger area. In terms of labour, age and off-farm labour the pattern varied depending on whether they had a higher return from forestry or agriculture. For those that had a higher return from forestry, planters were older, applied less farm labour and were less likely to have an off-farm job than non-planters. The opposite applied where agriculture returns were higher than forestry.

A key message here is that there is a mismatch between system and size. Cattle and sheep farms have a higher return from planting, but in general have a smaller farm size, yet dairy farms have a lower return but have a higher farm size. Tillage and mixed farms are larger and have higher planting rates. The challenge therefore for cattle and sheep farms is that although most have higher returns, their land base is lower. Given well researched cultural barriers to planting forestry due to issues like a preference for agriculture, general inertia in decision making associated with preference for the status quo and hassle associated with changing land use and the long term nature of the return. [20] The replanting obligation is a particular issue for small farms as it rules out a proportionally higher area from potential planting in the future. Similarly the extra burden in recent years associated with administration and licensing, imposes what is known as a transaction cost, reducing planting rates.

Table 14.

Summary Statistics relative to Has Forest/No Forest (Sitka Spruce, 2020)

	Land Value per ha	Farm FFI_ha	Dairy Cows per Ha	Labour	Age	Farm Size	Teagasc	Has Off Farm Job	Soil Code 1	Soil Code 2	Soil Code 3	Soil Code 4	Soil Code 5
Ag>For / No For	18456	625.5717	0.310	1.072	58.606	41.121	0.558	0.322	0.297	0.203	0.217	0.222	0.057
Ag>For / Has For	19330	590.5309	0.200	1.082	56.284	58.588	0.580	0.422	0.304	0.140	0.136	0.346	0.074
For>Ag / No For	14333	43.01297	0.014	1.004	61.236	41.090	0.508	0.361	0.206	0.069	0.311	0.249	0.158
For>Ag / Has For	16179	151.9622	0.000	0.971	65.431	56.121	0.843	0.295	0.251	0.129	0.237	0.212	0.171

Source: Teagasc National Farm Survey and FORBES Model

20 Ryan, M., O'Donoghue, C., Hynes, S., & Jin, Y. (2022). Understanding planting preferences–A case-study of the afforestation choices of farmers in Ireland. Land Use Policy, 115, 105982.

Table 15.

Average characteristics of farms with new forests by category of stocking rate change (Sitka Spruce 1984-2015)[21]

Stocking rate change	Percentage	For >Ag	Farm income per ha	Dairy LU per ha	Labour Units	Age	Farm Size (ha)	Teagasc Clients	AE Scheme	Off Farm Job	Subsidies	Previous LU/HA	Medium soil	Good soil	Poor Soil
No change	32	0.32	398	0.87	1.3	49	68	0.53	0.18	0.12	11682	1.6	0.44	0.44	0.12
Increase SR by 5%	25.1	0.47	298	0.62	1.2	48	62	0.49	0.14	0.23	12796	1.2	0.48	0.31	0.2
Decrease SR by 5%	42.9	0.52	383	0.52	1.2	52	55	0.42	0.33	0.17	16585	1.5	0.4	0.46	0.14

Table 15 considers what farmers do when they plant, drawing upon previously published work looking at a time series of the NFS in Ryan et al., (2018). A straight land use change would see the stocking rate remain the same as land is converted to forestry. However this is only the case for about one third of farms. These farms have the lowest share and have a higher return from forestry. However they have the highest farm size and have the highest farm incomes and are least likely to have an off-farm job. They also have the highest stocking rate and are more likely to be dairy farms. They are more typical of full-time commercial farms, allocating a proportion of their larger farm to forestry, perhaps to provide future retirement income or to reduce risk.

43% of farms however decrease their stocking rate. These tend to be older with smaller farms , more likely to be in an agri-environmental scheme, have higher direct payments are least likely to have dairy cows and have a higher probability of having higher forestry income than agriculture. These are in effect a group of farmers that see afforestation as part of a retirement planning process.

25% of farms actually increase their stocking rate. These are the youngest group and started with the lowest stocking rate and the lowest incomes. They increase their intensity on the remaining farm while benefitting from higher forestry income and are more likely to combine it with off-farm income. These are diversification farmers, increasing their income sources on land that has a lower farm income.

A key lesson from this table is that afforestation decisions for farmers is tied to the other decisions on the farm. Only for a minority is afforestation a straight land use change from agriculture to forestry as current incentive schemes assume. For most, afforestation is tied to wider farm decision making. It emphasises the importance of linking farm incentive programmes in the Common Agricultural Policy (CAP) with forestry incentive programmes. It also highlights the need for different advisory programmes for different types of farmers. The need for this type of strategy will only increase as the pressure to reduce greenhouse gas emissions grows.

In terms of economic assessment, one of the key differences between agriculture and forestry is the different time horizon of the crop.

21 Ryan, M., O'Donoghue, C., & Hynes, S. (2018). Heterogeneous economic and behavioural drivers of the farm afforestation decision. Journal of forest economics, 33, 63-74.

7. Scaling Up Forest Targets

7. Scaling Up Forest Targets

The current stated target is 8,000 hectares per year as part of the Climate Action Plan in 2021. However there have been a variety of targets set in the past. Figure 9 details these targets and compares them with the actual planting levels.

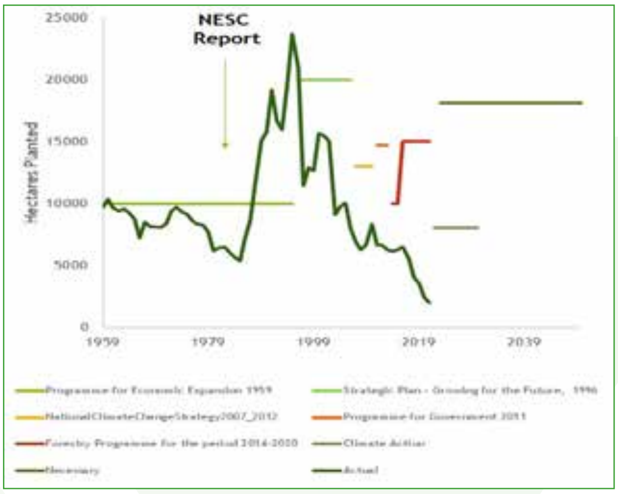
The Programme for Economic Expansion in 1959[22] set an objective to develop a large domestic timber processing industry, to export surplus timber exports and to substitute for imported timber and timber products. The programme set a target of approximately 10,000 hectares per annum. This strategy, led by public planting by the Department of Lands was successful, achieving or close to achieving these targets until EEC entry in the mid 1970's, where planting rates nearly halved in the period to 1985.

Recognising this trend a major report by the National Economic and Social Council, Irish Forestry Policy[23] undertook a root and branch review of the forest sector. It made a series of recommendations, implemented over the following decade that saw a huge recovery, with a fourfold increase in forest planting between 1985 and 1995, significantly exceeding the long term target.

The strategic plan, Growing for the Future published by the Department of Agriculture in 1996 was part of a strategy to increase employment and to "develop forestry to a scale and in a manner which maximizes its contribution to the national economic and social well being on a sustainable basis and which is compatible with the protection of the environment". The plan set a target of planting 20,000 hectares per year, equivalent to the planting rates of the first half of the 1990's. However this target was never met. The closest to the target was the 15,500 hectares planted in 2001, but with planting in the 10,000-15,000 range until the next target was set as part of National Climate Change Strategy 2007-2012.[24] The strategy acknowledged a target of reaching 17% land cover under forestry with a target of 13,000 hectares for forestry. However, the mechanisms for delivery were relatively weak.

Figure 9.

Planting Targets and Actual Planting 1959-2022



The Programme for Government in 2011[25], building upon the Agri-Food strategy Food Harvest 2020, set a target of 14,700 hectares in 2011. The strategy, "Forests, products and people - Ireland's forest policy – a renewed vision," published in 2014 set an afforestation target to be 10,000 ha per annum up to 2015 and 15,000 ha per annum for the period 2016 to 2046, with an aim of reaching 18% by 2046. This strategy was reviewed by the COFORD report in 2014, who questioned the capacity, based on existing trends of meeting this target.[26] The Climate Action Plan reduced the target to 8,000, but that Minister McConalogue, has indicated that the target will be challenging to hit over the next decade.[27]

This target however, outlined above is far below the need to achieve 18% land cover in forestry by 2050. While in 2014, this meant 14,700 Ha per year, given the current low planting rates, the target planting rates in fact need to increase by 18,000 hectares per year to achieve this goal by 2050. The further this target is missed the greater will be the need to deliver reductions from other sources including agriculture.

Given the economic returns highlighted above, the land availability study prepared by Farrelly & Gallagher (2015) suggested that in meeting these targets and consistent with the economic returns identified above that it may be prudent to focus on opportunities for afforestation on the 1.3 M ha of marginal agricultural grassland.[28]

22 https://opac.oireachtas.ie/AWData/Library3/Library2/DL006590.pdf
23 http://edepositireland.ie/bitstream/handle/2262/72031/NESC46.pdf?sequence=1&isAllowed=y
24 https://www.teagasc.ie/media/website/crops/crops/NationalClimateChangeStrategy2007_2012.pdf
25 https://www.socialjustice.ie/system/files/file-uploads/2021-09/2011-03-06-programmeforgovernment2011-2016.pdf
26 COFORD Policy Review Group. http://www.coford.ie/media/coford/content/publications/2018/1COFORDForestPolicyReviewGroupReport121218.pdf
27 https://www.farmersjournal.ie/mcconalogue-admits-8-000ha-forestry-planting-target-will-be-challenging-685011
28 Farrelly, N., & Gallagher, G. (2015). The potential availability of land for afforestation in the Republic of Ireland. Irish Forestry.

8. Farm Level Carbon Sequestration

8. Farm Level Carbon Sequestration

In order to undertake an economic assessment of carbon sequestration at forest and farm level, we adapt a forest carbon sequestration model (C-FORBES) developed by the author with a colleague.[29] The process is quite complex involving a number of different carbon pools and sources of carbon sequestration or storage including

- Above ground livewood
- Below ground livewood
- Soil Carbon
- Litter fall and tree mortality
- Harvested Wood Products

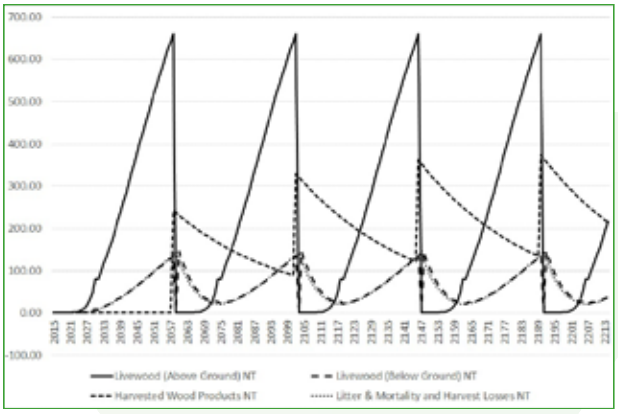
The model uses the assumptions contained in the 2018 National Inventory Report and does an assessment of the implications of the variety of different forest carbon model assessments over time. The validation exercise highlights the robust nature of the model assumptions compared to other models used for Ireland and the UK.[30]

The model builds upon the forest yield curves and economic modelling of the bio-economic model described above. In to illustrate the functioning, we report in figure 10 the accumulation and loss of carbon over a 200 year period for Sitka spruce yield class 18 (no thin). The largest increase in carbon is evident in the above ground livewood, particularly in the early years, with an acute loss of carbon at the point of harvesting, when timber is removed from the forest. The lower rate of sequestration in the below ground livewood reflects the 80/20 above/below ground ratio.

At clearfell (final harvest), the above ground biomass declines to zero, while the below ground biomass transfers slowly to the DOM pool. There is an immediate decline in carbon in HWP at harvest, relative to above ground livewood, as just over a third of the livewood is used for energy (Knaggs & O'Driscoll, 2017) and is immediately oxidised. Harvesting (roundwood) losses are also incurred during the harvesting process.

Figure 10.

Carbon Sequestration/Loss for No Thin (NT) Yield Class 18 over 200 years



In contrast to the no thin scenario presented in figure 10, on thinning (periodic removal of trees), there is an initial drop in above ground biomass, followed by a subsequent increase in growth (and carbon sequestration) due to the greater availability of light, moisture and nutrients for the remaining trees. As each thinning occurs, livewood carbon declines and the cumulative carbon in HWP increases, albeit declining if the biomass is combusted (oxidised). An important difference between thinned and unthinned forests is that harvest losses at thinning can be substantial, particularly in the case of first thinning.

Private and Social Returns to Land use Change from Agriculture to Forestry

In this section, we examine both the private and the social return to farm afforestation. In order to model the social impact of land use change, it is necessary to include the alternative land use, namely agriculture, and to combine the private economic components with the social component. The definition of social return can be quite broad incorporating all monetary and non-monetary aspects. The private return to a landowner incorporates the life-cycle monetary impact of moving from agriculture to forestry. However this clearly ignores significant public good impacts in relation to carbon sequestration. There are of course other aspects of the return, including the private return to other value chain actors such as timber

29 Ryan, M., & O'Donoghue, C. (2021). The Complexity of Incorporating Carbon Social Returns in Farm Afforestation: A Microsimulation Approach. International Journal of Microsimulation, 14(1), 102-134.

30 C-ForBES livewood (above ground) carbon estimation (based on Edwards & Christie (1981) yield models and NIR (2018) accounting rules, against those produced in the Teagasc Forest Carbon Tool (Teagasc, 2021), using the Carbon Budget Model (CBM) (Kurz et al., 2009) and National Forest Inventory activity data (DAFM, 2018). The resulting carbon estimations for accumulated carbon dioxide over one rotation is quite similar in both models, albeit differing in relation to the estimation of early growth. Growth prior to age of first thinning is not recorded in Edwards & Christie (1981), thus differences arise between carbon models in relation to imputation of early growth and are sensitive to the data or assumptions employed.

mills and other ecosystem services such as biodiversity or water quality. To keep the analysis traceable but useful, we adopt a narrower definition of social return to a land use change, i.e. the combination of the private return to the landowner plus the value of the net carbon sequestration of the land use change.

Table 16 describes the economic dimension of planting one hectare of forestry. Columns A, B, C and D respectively report market gross margin (MGM) and direct payments/subsidies for agriculture, forest MGM and forest subsidies. MGM for agriculture and forestry is correlated with soil type. Agricultural subsidies have a redistributive focus and are uncorrelated with soil type. Forest subsidies are paid as compensation for loss of agricultural income and as an implicit incentive for the provision of forest ecosystem services and are also uncorrelated with soil type.

Table 16. Economic Components of Agriculture and Forestry (2015) (Annual Equivalised NPV per ha (€)

Soil Code	Agriculture		Forestry	
	Mkt Gross Margin / ha (A)	Subsidies /ha (B)	Mkt Gross Margin /ha (©)	Subsidies /ha (D)
	€	€	€	€
SC1/YC24	1200	366	224	306
SC2/YC22	792	388	224	306
SC3/YC20	803	342	154	302
SC4/YC18	731	351	154	302
SC5/YC16	356	314	124	300
SC6/YC14	258	326	52	298
Average	878	359	155	296

The carbon sequestration/emissions resulting from planting one hectare of SS forest replacing agricultural enterprises, are calculated by applying the carbon dioxide equivalent coefficients per hectare from table 1 to farm-level activity data (both direct and indirect emissions) and forest life-cycle (200 years) data. In facilitating comparisons between agriculture and forestry, life-cycle sequestration from forestry and emissions from agriculture are annualised using a 5% discount factor to produce the average discounted tonnes of carbon dioxide equivalent per hectare for the farm systems and soil types. These are reported as average annual equivalised values in table 17 (columns E and F). The components that result in these returns are also reported, showing that for higher quality soil types, the quantity of carbon sequestered per hectare is almost twice that of the animal emissions displaced. For SC5, the ratio is closer to a factor of three. The implication here is that replacing agriculture with forestry on the best land would result in a reduction of net carbon dioxide emissions of 24.1 tCO_2-e on average over the life-cycle. In terms of the corollary (replacing agriculture on poorer soils with forestry), the net reduction or sequestration is lower, because of (a) the lower carbon sequestration from forests and (b) because the substituted enterprise had lower emissions.

However, we would also like to examine the impact of taking carbon into account in the returns to planting. In generating the social return to planting, as the afforestation subsidy (D) is not a direct measure, it is replaced with a carbon subsidy (carbon emissions (agriculture E and forestry F) x Cost per t for a range of carbon values. There is not currently a carbon instrument in place, as the inclusion of carbon in incentives could act as a negative driver if farm forest owners were fined for carbon losses to the atmosphere on harvesting, thus the more pragmatic solution is to provide an indirect subsidy at planting and tax-free incentives for timber sales. Thus as we are not modelling a behavioural response, static carbon values are included.

Table 17 reports the average private and social returns from the afforestation of one hectare of agricultural land and shows that on average, the private return to forestry is lower than the return from agriculture in the current policy environment, but becomes increasingly positive when increasing carbon values are substituted for afforestation premium. At low values of €20 and €32, (similar to the lower bound carbon price in the national agricultural GHG Marginal Abatement Cost (MAC) curve (Lanigan et al., 2018) of €25 per tonne of, the social return for planting a hectare of forest exceeds that of agriculture on the poorest soils. Once the carbon value is increased to €100 and €163 (reflecting the Irish government shadow price of carbon for 2030 and 2040 respectively) all soil codes have a higher social return from forestry than from agriculture, with the highest returns on the most productive soils.

Table 17.
Average Annual Equivalised Social Return to Planting one hectare of Unthinned Forest (2015) Displacing Agriculture

Soil Code	Private Return[31]	Agriculture	Forestry	Social Return			
	(C+D) – (A+B)	E[32]	F[33]	C – (A+B) + (E+F)*P[34]			
t Value (P)	0	t	t	20	32	100	163
SC1	-1036	-9.2	14.9	-556	-268	1365	2878
SC2	-651	-8.4	14.9	-185	95	1680	3148
SC3	-690	-7.5	11.8	-304	-72	1239	2455
SC4	-627	-7.4	11.8	-242	-11	1298	2511
SC5	-246	-4.5	10.8	59	242	1281	2243
SC6	-234	-4.9	7.8	19	171	1031	1828
Total		-8.0	13.4	-359	-103	1347	2691

Note: No-thinning assumed; BEF Factors from the 2015/18 National Inventory Reports are used.

Distribution of Private and Social Returns

This report thus far describes average carbon figures for different soils and sectors. However, these averages mask a wide distribution. Table 18 presents distributional assumptions in relation to private returns and social returns. On average 32.4% of farms have positive private returns to planting, including forest subsidies. Replacing the afforestation subsidy with low carbon (subsidies) values of €20 and €32 per hectare, and using the NIR (2015/18) assumptions for biomass expansion factors and also incorporating agricultural subsidies, the share of farms with a positive social return is 30.4% and 46.6% respectively. Using a carbon value of €100 per tCO2, the share rises to 96.5%, while at a carbon value of €163 per tCO2, nearly all farms (99.9%) have positive social returns.

Table 18. Share of Farms with a positive Private and Social return to Forestry

	Private Return	Social Return			
Carbon value (€)	0	20	32	100	163
BEF (NIR, 2015/18)					
Incl Farm Subsidy	0.324	0.304	0.466	0.965	0.999
Excl Farm Subsidy	0.551	0.594	0.697	0.991	0.999

31 Note: A, B, C, D from Table 4
32 E is annual emissions reduction from displacing agriculture
33 F is average annual sequestration from conversion to forestry
34 P is the carbon price (cost per t)

9. National Targets and the Carbon Cliff

9. National Targets and the Carbon Cliff

Thus far, we have focused on the return to forestry on individual hectares. As part of a national strategy to increase timber supply and for now and in the future, the need is to achieve this goal at scale. In order to scale the analysis up to national level, we develop a simple national forest planting model. Utilising historical planting data and current data in relation to the forest estate from National Forest Data, combined with the yield curves utilised in the forest bio-economic model above, we estimate the current and future pattern of forest by species, yield class and time of planting.

In Figure 11, we reweight the individual yield curves by yield class, species (sitka and conifer) weighted for the number of hectares planted in individual years. Using the yield curves we generate the entire carbon sequestration profile described above incorporating livewood and harvested wood products.

On the basis of using financial optimal rotation lengths, we produced an area of new planting (including reforestation) in 2015 within 2% of actual totals. While the trajectory of harvest volumes is slightly different to the trajectory of Henry Phillips's Timber Forecast, due to Phillip's work incorporating actual rotation lengths (which are lower than financial optima), the overall volume of harvested timber over a 10 year period is relatively similar. It is debatable what future rotation lengths would be like if the strategy to focus on carbon sequestration were applied as carbon optimisation rotation lengths are longer than financial optima which are longer than personal preferences. As the analysis ignores specific carbon accounting rules in relation to historic forestry, and given uncertainty about appropriate rotation lengths, Figure 11 should be viewed as a theoretical exercise.

The purpose of the figure is to explore the implications in relation to planting decisions on total carbon sequestration. What is more important than the height of the curve is the relative height of different scenarios. In this analysis we explore a number if scenarios:

- A current scenario where planting rates are kept at 2000 hectares per annum
- The Food Harvest 2020 target of 14,700 hectares per annum
- The Climate Action Plan target of 8,000 hectares per annum
- The revised carbon neutrality target 2050 of 18,000 hectares per annum
- An adjusted carbon neutrality target 2050 of 18,000 hectares per annum, where there is a delay for a decade in implementing the target

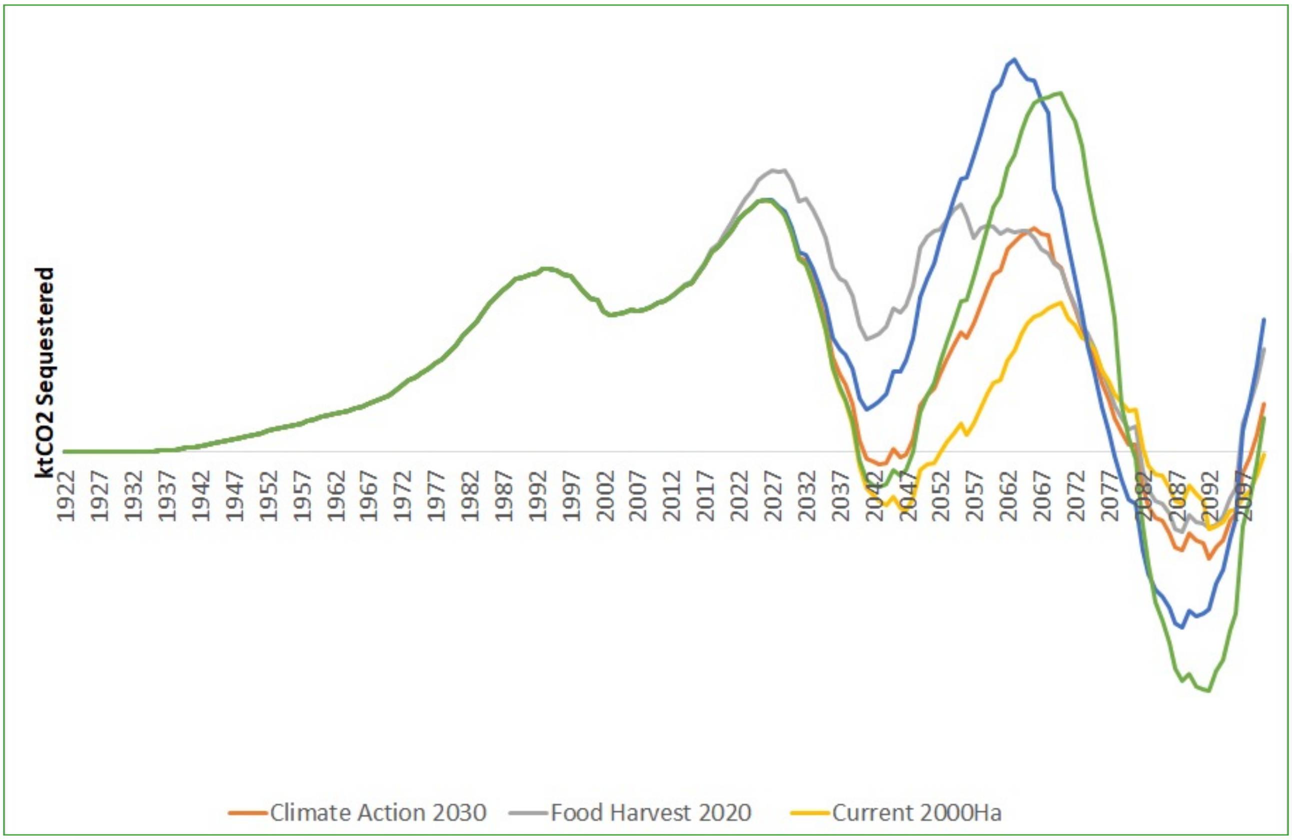
We simulate these scenarios until 2050, with zero afforestation afterwards. The zero afforestation assumptions allow us to consider the long-term sustainable carbon sequestration within the sector.

As it takes about 40 years for a forest to reach maturing, given the existing fall off in afforestation levels over the past two decades, regardless of current strategies, there will be a reduction in carbon sequestration or carbon cliff as the forest estate moves from being a carbon sink to carbon source as harvesting exceeds planting. Carbon stored in harvested wood products however diminish the impact. The timing of the turning points in relation to carbon sequestration depend also upon rotation length assumptions. Lower rotation lengths will lead to earlier turning points, while longer rotation lengths will lead to a later turning point. The aim of the current strategy is to limit the size of the carbon cliff. Increasing planting now will reduce the initial carbon cliff and improve the net carbon position in mid-century after the carbon cliff.

With the lowest planting rate, the current scenario has the lowest carbon cliff and future peak carbon sequestration at lower levels than the present. Each of the remaining scenarios follow a pattern that relates to the number of hectares planted with the carbon neutral or 18% of land cover at 2050 target of 18,000 hectares per annum. If the Food Harvest target of 14,700 was achieved then the peak carbon sequestration would have been lower than the peak carbon neutral 2050 scenario (due to lower peak planting). However, the carbon cliff would have been less pronounced if planting targets had not fallen since 2010 the way they did. In 2050, the Food Harvest scenario delivers about 25% more carbon sequestration than the carbon neutral scenario as a result of the earlier start. Both the food harvest 2020 and the carbon sequestration totals result in similar planting totals. The climate action plan target sees a slightly higher profile than the status quo scenario, but realizes a peak that is only two thirds of the carbon neutral peak. The final scenario which delays a concerted effort to reach the targets, realizes a slightly lower peak and in 2050 realises only 33% of the carbon sequestration of the carbon neutral total. Delaying planting decisions as a result has a major impact on 2050 totals.

Figure 11.

Net change in Forest, Agriculture and Harvested Wood Product Emissions under different Planting Profiles 1922-2100

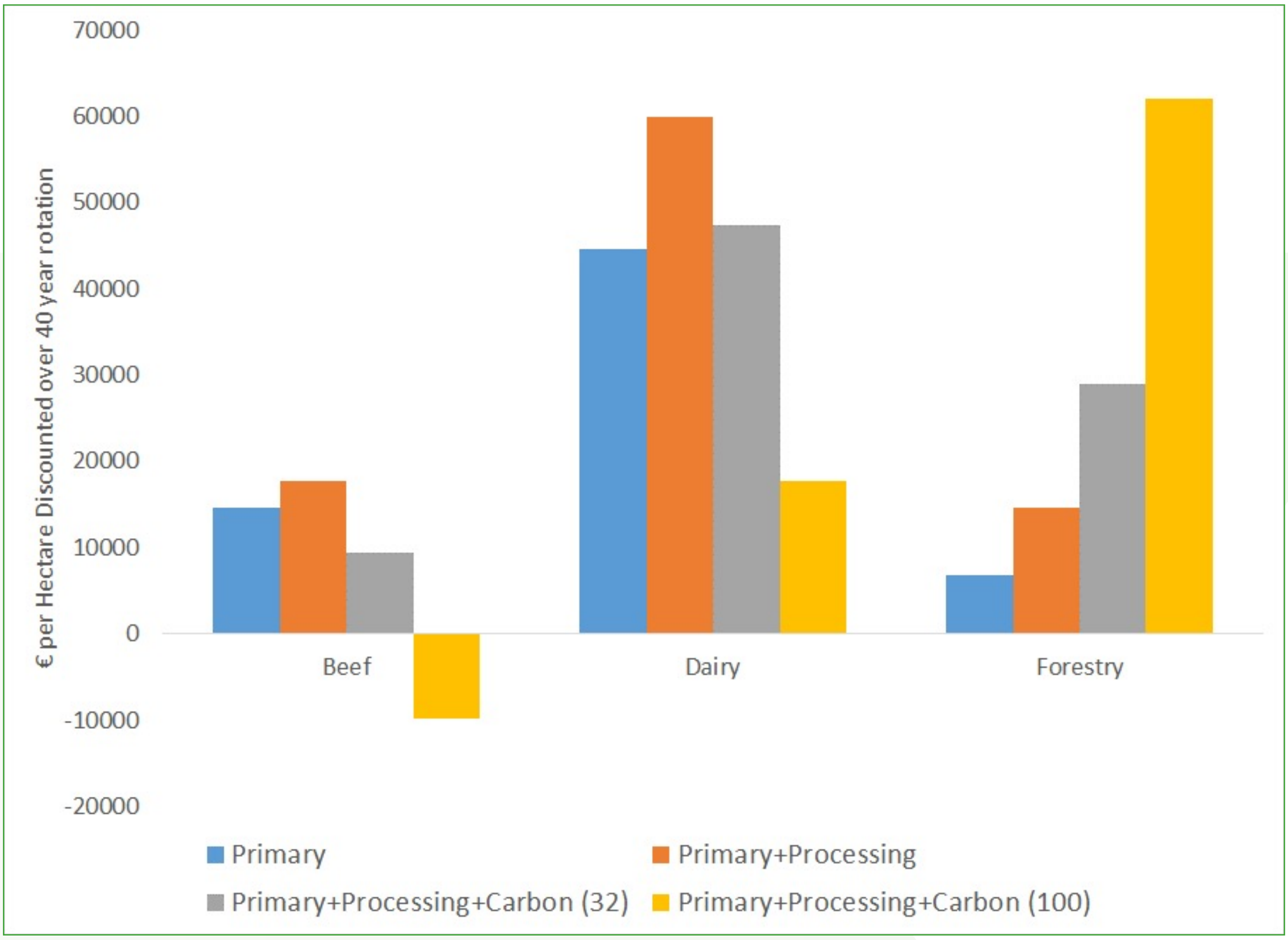


Value Chain Impact

In order to gauge the impact of the target on the wider value chain, we consider a forest planted on yield class 22 (Figure 12). On average the discounted output per ha (at a 4% discount rate) is lower for forestry than beef or dairy. However, when we include processing which has a higher multiplier than food processing, the gap closes, with the return similar between beef and forestry. The return to planting on dairy land is higher. Incorporating the carbon value of emissions and sequestration, the gap widens with beef at a carbon price of €32 per tCO2. However, at €100 per tCO2, forestry has a higher return than Dairy.

Quantifying the cost of missing a target over a rotation is produced by discounting the flow of incomes between the three scenarios (beef, dairy and forestry). Missing target by 6000 hectares (distance relative to Climate Action Target) costs more than €400m at a €100 carbon price over a 40 year forest rotation, while the cost is over €1bn over a full rotation if the target is missed by 16000 hectare.

Figure 12.
Discounted Return per Ha over 40 years at different Carbon Price



Note: Assuming a 4% Discount Rate and Sitka Spruce Yield Class 22 with thinning

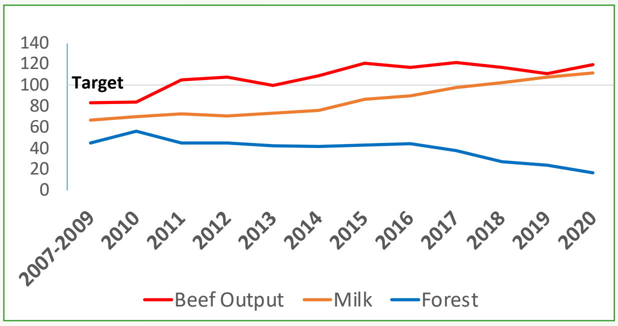
10. Food Harvest 2020

10. Food Harvest 2020

In order to illustrate the impact of missing targets we look back and assess the Food Harvest 2020 strategy35 developed by the industry in 2010 which focused on Smart Green Growth. that combined ambitious targets to increase milk volume output by 50%, expansion of beef output by 20%, and aquaculture by 78%. From an economic point of view, the ambitious milk target was met in 2017 and the less ambitious beef target was met almost immediately (Figure 13). The level of beef output achieved by the year 2020, was in fact a 43% increase in value. The afforestation target has only once reached 50% of target and has been worsening over the period 2010 to 2020 as outlined above.

The Timber, Wood products and Forestry value chain has the highest tier II multiplier incorporating direct, indirect and induced effects of any industry based value chain at a level of 2.7, indicating that an increase in output of €1 million leads to a €2.7 million increase across the value chain. It is the highest by virtue of the low share of imported inputs used in the value chain compared to other value chains. It is higher than the food processing sub sectors such as dairy at 2.3 and beef meat processing at 2.1

Figure 13. **Food Harvest 2020 targets**



In order to assess the economic impact of missing these targets, we utilise the Bio-Economy Input Output (BIO) model developed by the author.[36] This model builds upon the CSO's Input-Output table amended to incorporate a disaggregated agriculture, fisheries and forestry sector. The model is a national economy model containing all economic flows between individual sectors and can be used to track the generation of value across value chains. It is frequently used to calculate economic multipliers for specific sectors.

The sector is quite important as the output of the forest and timber products sector is over €1bn per annum. About €900m is purchased, mainly in the rural economy directly reflecting the higher multiplier. The remainder of the multiplier relates to the expenditure of employees within the local economy. If timber can be mobilised, the potential timber supply can increase by 60% to 2035 (Phillips et al.)

Table 19. **Beef Output and Forestry Planted from 2007 to 2020**

Year	2007-2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beef Output (€m)	582	587	736	753	700	763	847	819	849	816	777	835
Forest (ha)	6615	8314	6653	6652	6252	6156	6293	6500	5536	4025	3550	2434

35 https://www.gov.ie/en/publication/5a0f2-food-harvest-2020/
36 https://www.teagasc.ie/publications/2015/the-economic-impact-of-the-irish-bio-economy---the-bio-economy-input-output-model-development-and-uses.php

In order to illustrate the impact of the missed targets, we will use scenario analysis applied to the BIO model. We consider two scenarios, a baseline scenario comprising the actual activity in these sectors in the period 2010 to 2020 (Scenario A) and a second reflecting the targets outlined related to separate policy targets set out by the Irish government in recent years, namely, a yearly afforestation target and an output target for the beef sector.

Scenario A reflects what occurred in reality in the years 2010 to 2020 (see Table 19). Scenario B looks at what would have happened had the forestry target been met each year from 2010 to 2020 while also achieving the beef target.

We use the disaggregated IO tables to analyse Scenario A and Scenario B in terms of overall economic output, value added and net greenhouse gas (GHG) emissions. The disaggregated forestry sector allows us to account for the life-cycle nature of forestry in a way that is not possible with an aggregated forestry sector. In order to account for the full value of forestry versus other potential land uses, the scenarios run from 2010 to 2075 with all amounts generated discounted back to 2010 values and presented as net present values (NPVs). In Scenario B, the extra land used for afforestation is reallocated from land used for beef production. This decision is taken due to cattle farming having the largest land share amongst farm systems in Ireland, higher quality, more productive land being concentrated on dairy and tillage farms, and the difficult financial conditions currently affecting many beef farmers in Ireland currently (Geoghegan & O'Donoghue, 2018).

The results of our analysis are shown in Table 20. Results are presented as the NPV of the change in output, value added, and GHGs that would result from each scenario relative to the average of 2007 to 2009. In terms of overall economic output, a €164.7 million increase in output is produced by the forestry and beef sectors in Scenario B compared with the €123 million increase in Scenario A relative to the 2007 to 2009 average. Over the scenario period, €61.1 million extra is generated in terms of value added in Scenario B compared with Scenario A. Regarding GHG emissions, Scenario A sees yearly average emissions staying almost completely flat relative to 2007-2009 while GHG emissions fall by 124.3 ktCO2e relative to the baseline in Scenario B. For carbon sequestration, we see 276.8 ktCO2e extra being sequestered over what would take place in Scenario A. When emissions and sequestration effects are combined, a greater reduction in net emissions takes place in Scenario B with a fall of 2013 ktCO2E compared with 1612 ktCO2e in Scenario A across the value chains.

Table 20.

Changes in Output, Value Added an GHG Emissions Resulting from Scenarios A and B Relative to the 2007-2009 Average

	Scenario A	Scenario B	Change (Average per year)
Output (€m)	123.0	164.7	41.7
Value Added (€m)	18.9	80.0	61.1
GHG Emissions (ktCO2e)	0.2	-124.3	-124.5
Carbon Sequestration (ktCo2e)	1611.8	1888.6	276.8
Net Emissions	-1611.6	-2012.9	-401.3

The results show that both beef and afforestation targets could have been reached while realising an overall decrease in GHG emissions and a larger overall decrease in net emissions. Hitting the afforestation target in Scenario B by reallocating 3.7% of land used for beef production in Scenario A also results in greater economic output and higher overall value added. These results suggest that agricultural intensification can exist in accordance with GHG emissions reduction goals.

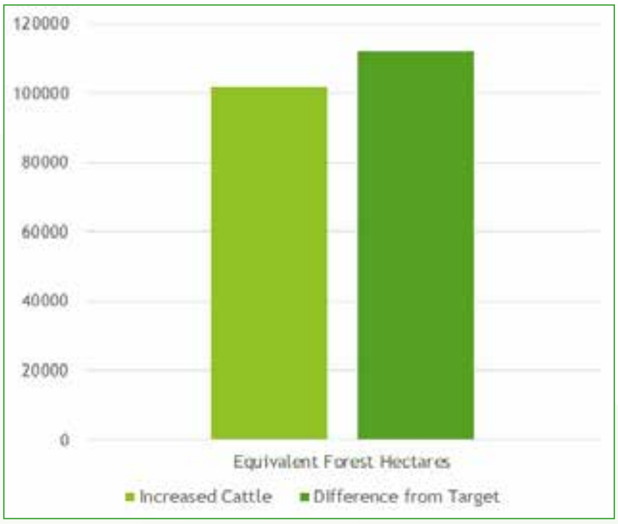
These results are however different to the KPMG report, Ireland's 2030 Carbon Emissions Targets - An Economic Impact Assessment for the Agriculture Sector[37]. Although utilising a variant of the model used here constructed by this author with colleagues in Trinity College Dublin, the scenario assumptions as outlined by a recent review article by Prof Alan Matthews are quite different. The KPMG report looks at reductions in agriculture, rather than alternative land uses. The change scenario is also more extreme. We make the assumption that if land was lost to agriculture that it was lost by the sector with the lowest return as this makes more sense from an economic point of view than reducing different sectors in the same way. As a result, in the KPMG report the large loss in dairy with larger returns has a higher economic impact. Focusing on a transition from a lower income sector such as beef to forestry, a sector where returns at farm level and processing level are comparable to forestry results in relatively low economic impact, albeit it would have required individual farmers to have made land use changes.

37 https://assets.kpmg/content/dam/kpmg/ie/pdf/2021/11/ie-ireland-2030-carbon-emissions-targets.pdf

Dairy Expansion and Forestry

Figure 14.

Forest Hectares required to mitigate Cattle Growth and Difference from Target



In a related but simplified analysis, merely looking at the emissions associated with the change in animals and the lost carbon sequestration associated with missing the targets, we assess the net carbon account of the dairy expansion since 2010. Since 2010, the number of livestock units has increased by 386,000 (where live stock units are animal numbers adjusted for feed input). Given that on average each hectare of forest sequesters the emissions from 3.8 Livestock Units, 102,000 Hectares of Forest would have mitigated the emissions from Dairy Expansion. Summing up the difference between the target and actual hectares afforested during this, period, Ireland missed the target by 112,000 over the 12 years to 2022 (Figure 14). In other words if the earlier afforestation had been met, the entire additional emissions from dairy expansions could have been met from afforestation. So in effect the country could have achieved carbon neutral dairy expansion.

11. Licensing and Regulation

11. Licensing and Regulation

Context

Forest related activity such as planting, harvesting, thinning, road building etc requires licensing before activity takes place. There was a relatively stable pattern of afforestation applications between 2009 (2,000 for 16,500 Ha) and 2017 (1,400 for 11,000 Ha), falling in 2018 (1,000 for 8,600 Ha) and again in 2019 to (838 for 6,500 Ha). Most applications were approved with under 3% of applications were refused in 2016 and 2017, over 4% in 2018 but, in 2019, the refusal rate has risen to just under 8%. The number of submissions on forestry applications however has risen significantly from 10% of applications in 2017, to over 50% of applications in 2018 and about 43% in 2019.[38] The number of felling license applications, from 1,700 in 2010 to almost 6,000 in 2018. (Mackinnon Report)[39]

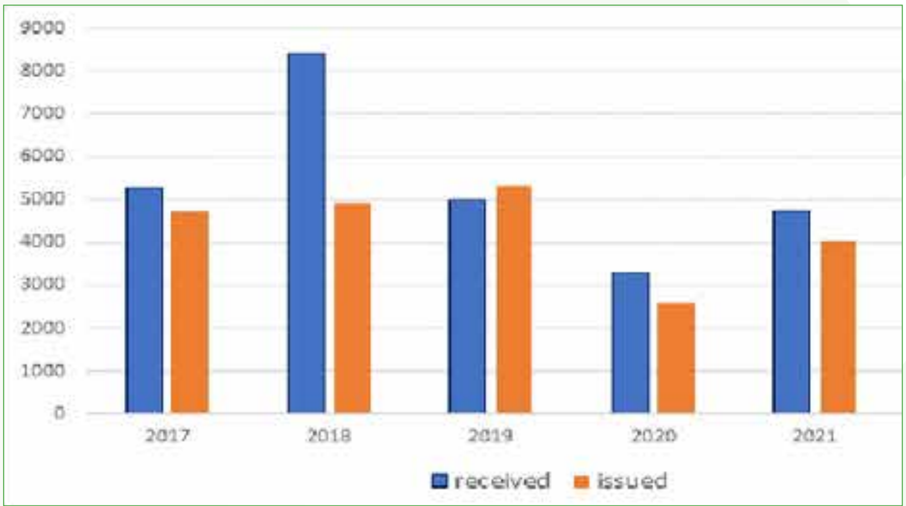
Table 21. Licence Output 2017 TO 2021

Year	No. of licences issued	Afforestation	Forest roads	Felling Coillte	Felling private
2017	4726	1243	480	1691	1312
2018	4919	855	461	2154	1449
2019	5310	588	542	3134	1046
2020	2592*	525	350	865	852
2021	4050	502	671	1532	1345

*Licence output was affected by court judgements and their interpretation that led to a much more onerous Appropriate Assessment procedure and the need for ecological input for most licences.

Source: DAFM

Figure 15. Total Licence Applications Processed from 2017-2021



The number of licenses received rose significantly in 2018, but with issuing the same number of licenses in 2018 as 2017, a big gap developed with license applications falling substantially in later years (figure 15, table 21).

However the reduced share in license approvals in 2018 saw a large increase in the waiting period for afforestation license approvals. For private licenses, 100% of licenses were issued within 4 months in 2017, falling to 51% in 2018 and only 8% in 2019.

38 One individual made 72 submissions on afforestation licenses in 2018; the figure rose to 403 at the end of September 2019. If submissions on roads and felling applications are included the figure rises to over 1,000.
39 https://www.gov.ie/en/publication/87233-review-of-approval-processes-for-afforestation-in-ireland/

Figure 16. **Afforestation Licences: Timescale for Decisions**

Table 22. **Percentage of Planting Program (Ha) and the year the F1 Application was made**

	Planting Program					
	2021	**2020**	**2019**	**2018**	**2017**	**2016**
1 year	11%	7%	8%	9%	16%	18%
2 years	45%	59%	59%	75%	76%	75%
3 years	44%	35%	33%	15%	8%	7%

Source: Private Communication with Forest Contracting Company

In a private communication with a Forest Contracting Company we can see the impact of the delay in forest planting approvals (Table 22). In 2017 and 2016 only 7% to 8% of their planting program related to applications made more than 2 years ago. This increased to 44% in 2021. From a forest contractor perspective, the contractor has to pay a forester for nearly 3 years to get a site planted in 2022, when previously this was only 2 years, increasing labour costs associated with afforestation. Increased environmental assessments mean that nearly all sites now need some form of ecological report, which cost, on average, between €1,000 and €1,400 per application. A side effect of the length of time taken to approve an application is that land owners often change their mind over the period.

Mackinnon Report

The Review of Approval Processes for Afforestation in Ireland, prepared by Jim Mackinnon CBE undertook a review of the issue and presented a very clear set of recommendations to overcoming these challenges. These recommendations focused on a number of dimensions including

- Strategically raising the political profile and commitment to woodland creation and prepare a Forestry Strategy for Ireland. Raise awareness of value of woodland creation and a vibrant forest industry. Dealing with inter-institutional challenges to woodland creation, there is a need for greater commitment by all to partnership working, involving a revision of MOUs with NPWS and NMS. Ensure all State Bodies play their part in implementing the Strategy.
- From an administrative basis, focusing action on reducing current backlog of applications and to introduce Pre-Application discussions with Issues/Action Log.
- Echoing the cost highlighted by forest contractors to cover the cost of producing an Environment Report in the Establishment Grant.
- To aid applications to effectively apply the Habitats Directive, develop guidance on how it affects licensing applications. and to discuss with the European Commission the impact of the Directive and woodland creation to support the Climate Action Plan.
- From a human resource point of view, recruit additional Inspectors and Environmental Specialists. Raise the status and profile of the Inspectorate. Review education and training of forestry professionals
- From a stakeholder engagement point of view, introduce genuine KPIs, take stock of the multiplicity of campaigns and initiatives to promote woodland creation; Develop a Customer Service Charter and Introduce fees for submitting applications, making submissions and lodging appeals.
- From an operational point of view, establish an Irish Forestry Standard, conduct pilot studies on land availability, including the potential for woodland creation on areas of unenclosed land. In the longer term review the legislation on forestry and consider the introduction of a single consent, covering planting, road construction, management and felling.

12. Nursery Sector

12. Nursery Sector

A necessary pre-condition for the afforestation and reforestation strategy to be successful, is for sufficient plants of sufficient species to be available at a time that land-owners require them to be planted. This is quite a challenge from a planning point of view as the lead in time is 2-3 years, depending upon the species, with conifers requiring 3 years. To achieve climate action targets of 8,000 hectares will require the nursery to produce approximately 30 million plants per annum. To reach the proposed 18,000 ha required to achieve our mitigation targets, would require an extra 23 million plants.[40]

As this resource is delivered by the private nursery sector, confidence in the capacity of the market to absorb any seedlings is critical. The falloff in recent demand within the sector, in conversation with industry representative has dented this confidence, with export markets helping to cushion some of the fall in domestic demand.

There are particular challenges in sourcing seed. Seed Collection networks for native broadleaves are expanding as demand for these species continues to increase, given the changing balance over time between Sitka Spruce and Broadleaves. Industry projections would see a demand for 6.5 million broadleaves to achieve the 8,000 hectares with this increasing to 14.5 million to reach the 18,000 target. It is necessary that as much as possible of these plants would be from native provenances to enhance productivity and minimise risks associated with imported seeds. A specific need of the sector is to establish and develop "Seed Hedges" created from home collected stock in nurseries to underpin the national seed collection for native species, such as Rowan, Hazel etc...

Although not as dominant as the past, Sitka Spruce remains the workhorse species of the Irish forestry industry. Ireland has no Sitka tree-breeding programme, no seed Orchards, and therefore no bank or seed supply of improved material. A key risk, therefore, for the sector is that the Irish forestry programme is completely reliant on the UK for Sitka seed. The UK's exit from the EU and ongoing trade related issues exacerbate this risk. To provide a high quality secure seed supply for the Irish market, it is therefore necessary to build up a register of Irish Select Stands from improved QCI or Washington origin and that a seed stand activation programme should be initiated to increase the number of seed stands from which seed is collected. Having enough seed and plant storage is necessary, given their vulnerability. Current capacity remain below the level required to reach the ambitions of the sector

In tandem with the systems approach taken in wider government strategies, it is essential that the Forestry Strategy takes an integrated systems approach from nursery to forest to processing to consumer to waste and recycling. Weak links in this chain are likely to lead to an unsuccessful strategy. Appropriate value chain governance is essential where all value chain have similar expectations as to likely to demand and where risks are managed across the chain. Excessive risk in one element of the chain will see a sub-optimal outcome. Areas where the state can assist in reducing the risk and encouraging investment and productivity in the first link of the forestry value chain include:

- Increased and continuous engagement with the nursery sector
- Official recognition and support for the concept of seed hedges for native broadleaves
- Grant support to allow nurseries establish additional seed orchards underpin plant supply.
- Grant support to enable the upgrading and expansion of storage facilities
- Improve information flows by developing demand projections in advance of each planting season regarding demand, potential stock shortages. Consultation with the sector where issues arise to help identify what solutions may be possible i.e. Derogations, Species substitutions etc.
- The option to restore old native hedgerows and establish new hedges, given their valuable role in carbon sequestration, and their role as habitats and corridors should be an ongoing practice, and funded continually.

40 Gleaned from personal communications with industry representatives

13. The Delivery of Other Public Goods

13. The Delivery of Other Public Goods

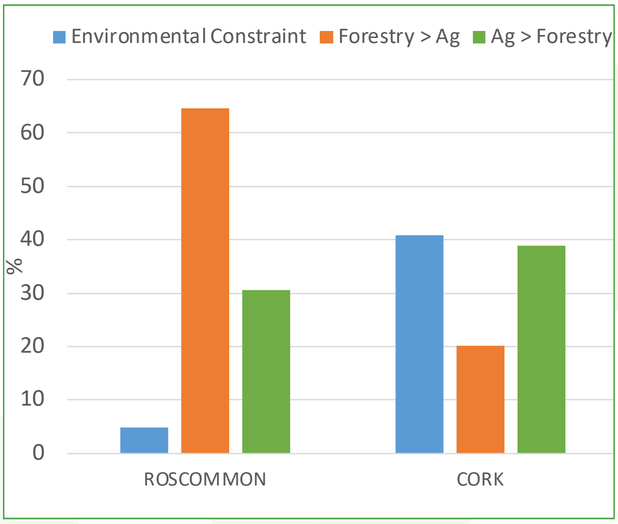
Given the important role forestry plays in carbon sequestration, this paper has mainly concentrated on carbon sequestration as a forestry related public good. However clearly forestry impacts other dimensions.

The impact on wider environmental issues is an increasing issue. Farrelly and Gallagher (2015) in their land availability study examined the area of land that was unsuitable for forestry given environmental constraints. Combining economics with Farrelly & Gallagher (2015) we can identify a potential land pool of 1.3 million hectares of grassland is marginal for agricultural production but suitable for forestry. It is clear that opportunities for further afforestation vary with location depending on environmental constraints (such as Hen Harrier SPA, acid sensitive areas and High pH) and income potential for forestry versus agriculture. For example in a two county case study (Figure 17), we find that in Co. Roscommon with fewer environmental constraints showed over 60% share of farms suitable for forestry and with earnings from forestry comparatively higher than from agriculture. On the other hand, only 20% of farms in Cork were suitable for forestry when environmental constraints were factored in while forestry revenue was lower than agriculture.

Given the differential environmental constraints and the aim to improve the biodiversity-forestry interaction, more nuanced approaches may be required. Some measures proposed by industry include more targeted initiatives focusing on natural regeneration of woodlands to be available in areas with specific environmental constraints and move flexible approaches to biodiversity elsewhere i.e. no maximum % for biodiversity but % is based on required biodiversity[41] or new native woodland GPC's for conifer native woodland with flexible biodiversity. There are also merits in exploring greater synergies with national ambitions in relation to organic land use; where a perhaps a new "Organic forest type", that is compatible between afforestation and the organic farming scheme. Involvement of professional registered foresters in the Native Tree Area Scheme can ensure the right tree in the right place for the right reason, with the right management "to support a sustainable and thriving economy and society and a healthy environment".

Figure 17.

Share of farms with suitable forest land by county with (i) environmental constraints (ii) higher forestry income (no env constraints) (iii) higher ag income (no env constraints)



The species of tree is also important. There are opportunities to increase biodiversity as there is a high citizen willingness to pay for mixed forests, as there is a societal preference for mixed broadleaf and conifer.[42] [43] This is reflected in afforestation decisions with about 30% of the national estate containing broadleaves compared to a much higher historic share of Sitka Spruce.

In relation to water quality, forest depending upon the life-cycle stage of the forest has different impacts. Disturbance events such as planting and in particular clearfell can have issues in relation to sedimentation. However, overall forest cover replacing agriculture can be positive as there is less disturbance and lower nutrient loads over a longer period of time relative to a pre-existing agricultural use.[44]

41 Biodiversity on the site should be protected as per DAFM Environmental Requirements
42 O'Donoghue, C., Hynes, S., Kilgarriff, P., Ryan, M., & Tsakiridis, A. (2020). Assessing preferences for rural landscapes: An attribute based choice modelling approach. Bio-based and Applied Economics Journal, 9(1050-2021-221), 171-200.
43 DAFM Public Attitudes Survey on Forestry https://assets.gov.ie/217582/53226427-d33c-4660-ab43-9deb5a11e12c.pdf
44 Duffy, C., O'Donoghue, C., Ryan, M., Kilcline, K., Upton, V., & Spillane, C. (2020). The impact of forestry as a land use on water quality outcomes: An integrated analysis. Forest Policy and Economics, 116, 102185.

14. Economic Impact of Carbon Sequestration Scheme

14. Economic Impact of Carbon Sequestration Scheme

Thus far we have seen some key drivers and barriers related to afforestation decisions. At a high level they relate to

- Financial Incentives
- Culture and replanting decisions
- Licensing, administration and transaction costs

An increased emphasis on carbon and carbon sequestration provides a number of opportunities to deal with these drivers.

Firstly as we have seen the increasing value of carbon sequestered as outlined in the DPER carbon price. As the carbon price represents the opportunity cost of not reducing carbon or increasing carbon sequestration, the increase of the carbon price to €265 per tCO2 indicates the high value of the carbon stored in trees and wood products. While the carbon price is the target value of carbon taxation or the levy on the cost of emissions and likely to be similar to the cost of buying carbon credits. Future strategies will have to define the cost of released carbon from either wood energy or carbon emissions form waste wood and paper products.

Current legislation imposes a replanting obligation on those who harvest trees. While it may seem like a sensible approach in maintaining the current estate after harvest, it has the implication of increasing the restrictions on land use and acts as a significant disincentive for land owners who are contemplating afforestation. Behavioural economics is extensively used in long term decision making as in the case of pensions. Pensions are similar to forestry in that one invests now to receive a return potentially decades later. Behavioural economics has been used in designing policies such as voluntary opt out strategies that increase the likelihood of taking up pensions.

Alternative behavioural strategies in relation to afforestation might also be impactful in relation to planting decisions. Exploiting carbon sequestration and release across the forest life-cycle and later harvested wood products can enable this. As we saw in figure 10 above carbon sequestered over the forest life-cycle, with quite a lot of carbon release around the time of harvest including the biomass in branches and wood (above ground and below ground) not used in timber production, the waste wood used as a source of energy in timber production and in other wood energy. The remaining carbon is stored in wood products. This carbon is released at different rates depending upon the wood product. As the end user becomes the emitter of this carbon and potential subject to future policies in relation to this carbon release, the forest owner generates a net surplus of carbon each cycle. Thus, given the net increase in carbon each cycle, there is an opportunity to provide a carbon sequestration benefit each rotation.

Pending ways to finance the scheme, the carbon value provides an opportunity both to provide a significant incentive to plant in the first place and also a way to factor in the economic cost of deforestation should a forest owner choose not to replant.[45] The considerable additional cost of reconverting forest land which would have to be covered by the land owner plus the foregone net carbon value resulting from replanting represent a very strong disincentive to taking land out of forestry. Another potential disincentive that is possible is the 100% tax relief on income resulting from clearfelling.

The last issue relates to the need to deal with licensing and administrative transaction costs. The waiting time to undertake forest related activities has a clear disincentive both to plant and for timber mobilization, particularly in relation to thinning, where the immediate economic return is low. Recognising differential environmental benefits from different land vis a vis greenhouse gas emissions, water quality and biodiversity via a National Land Use Strategy can prioritise different environmental public goods on different land and thus help to short circuit and speed up environmental impact assessments required for forest activity. Defining environmental trade-offs on different land in advance of land use change decisions can assist regulation, reducing regulatory burden.

A particular challenge of a carbon sequestration scheme is that the carbon is sequestered later in the forest cycle, while from a land owner's decision making point of view, it would be preferable to make an upfront payment or payments as is the case in the current afforestation scheme where an establishment grant is paid and is followed by 15 years of forest premia.

Carbon Cost Benefit of Current Afforestation Supports

Before defining the structure of the carbon sequestration scheme, let us first define cost benefit structure from a carbon emission point of view the current afforestation scheme (Table 23). The Current forest premium is €510 for Sitka Spruce per hectare and is payable for 15 years. On annual equivalized Net Present Value (aeNPV) basis over a

45 This policy could only apply to newly planted forestry under the carbon sequestration policy, with existing regulations applying to the existing forest estate.

full rotation with a 4% discount rate, this amounts to an average of €138. On an aeNPV basis, the establishment grant is worth €227 on average over the rotation. The value of the tax relief varies from €174 to €234 due to the fact that clearfell income varies by yield class. At €32 per tCO2, the carbon price in 2020, the value of the carbon saving, incorporating both the carbon sequestration in the forest and the saved carbon emissions on the farm varies from €427 to €674. At this carbon price the benefit of saved carbon emissions and additional carbon sequestration from a one hectare afforestation of farmland is higher than the scheme payments for yield class 22 and higher. A carbon price of €40 per tCO2, a little bit more than the carbon price in 2021 would cover the scheme costs for all yield classes of Sitka Spruce. Therefore from a purely carbon point of view, there is a positive return to afforestation from the scheme, independently of any other public policy objectives such as farm income support, forest sector development or rural development.

Carbon Sequestration Scheme

The goal of the Carbon Sequestration scheme is to take net carbon sequestration over a forest life-cycle to pay an upfront payment of (say one third of the value), followed by an annual premium for a period. For simplicity we mimic the current scheme with a one third up front payment followed by 15 annual equal payments. We use the public spending code discount rate of 4% to discount the value of future carbon sequestration to produce parameters for this scheme.

Table 23.

Cost Benefit Analysis from a Carbon Sequestration Point of view of Current Incentives (€ per hectare, annualised Net Present Value)

Yield Class	Grant	Premium	Tax Relief	Forest tCO2	Farm tCO2	Scheme Cost	Carbon Saving	Net Cost	Revenue Neutral Cost
14	138.9	226.8	174.2	241.8	185.2	539.9	427.0	113.0	40.5
16	138.9	226.8	183.1	273.9	185.2	548.8	459.1	89.7	38.3
18	138.9	226.8	198.4	291.7	180.7	564.1	472.4	91.7	38.2
20	138.9	226.8	207.4	306.4	221.5	573.1	527.9	45.1	34.7
22	138.9	226.8	194.8	308.8	277.8	560.5	586.5	-26.0	30.6
24	138.9	226.8	199.1	327.0	277.8	564.9	604.8	-39.9	29.9
26	138.9	226.8	206.9	341.9	277.8	572.6	619.7	-47.1	29.6
28	138.9	226.9	217.5	351.0	277.8	583.3	628.7	-45.4	29.7
30	138.9	226.9	221.4	366.1	277.8	587.2	643.9	-56.7	29.2
32	138.9	226.9	231.0	386.2	277.8	596.8	664.0	-67.2	28.8
34	138.9	226.9	234.0	396.7	277.8	599.8	674.4	-74.6	28.5

Table 24.

Upper Bound Parameters from a Cost Benefit Analysis of a proposed Carbon Sequestration Scheme

Yield Class	Forest tCO2 value	Fire Wood	Farm tCO2 value	CSS Premium	CSS Grant	Clearfell NPV
14	21699	3953	16055	1301	7233	4744
16	23657	4819	15310	1418	7886	6029
18	24716	5601	14084	1482	8239	7256
20	25496	6107	16684	1529	8499	8066
22	25336	6433	20124	1519	8445	8695
24	26175	6859	19703	1569	8725	9369
26	26953	7289	19265	1616	8984	10068
28	26925	7773	18335	1614	8975	11032
30	27795	8034	18335	1667	9265	11381
32	28478	8535	17842	1708	9493	12247
34	29141	8737	17842	1747	9714	12519

Using the carbon price of the public spending code (less the value of the current scheme), the total value of the net carbon sequestered in a Sitka Spruce plantation (as above only considering sequestration of above ground timber, net of harvest losses and excluding the energy use) of one hectare discounted at 4% varies from €21,700 to €29,100 depending upon the yield class (Table 24). The carbon price of each year of growth from €52 per year in 2023 to €265 in 2050 is utilised, less the €32 to fund the existing programme. By comparison, at this carbon price, the discounted carbon value is higher than the discounted clearfell value as the environmental return becomes higher than the market return. Turning to the potential scheme parameters, with one third being paid as an upfront payment akin to the establishment grant and the remainder paid as a flat premium for 15 years, we can support a grant of up to €7,200-€9,700 depending upon the yield class and an annual premium of between €1,300 and €1,700. It should be noted that we should change the terminology of the payments as the first payment is not to compensate for the cost of planting, but rather an earlier incentivisation payment or down payment for the future discounted benefit of carbon.

These numbers relate to the upper bound in relation to the value of net carbon sequestered by forests. As outlined above, the capacity to fund the programme depends upon choices in relation to charging for life-cycle emissions from burning wood energy and managing the release of carbon from wood products, avoiding the purchase of carbon credits and a contribution from direct taxation to support carbon sequestration efforts. Nevertheless, the results illustrate the substantial value that carbon has. The proposed scheme does not consider carbon sequestered in below ground livewood, branches and leaves, tree mortality or litter, assuming that either these will emit carbon after the harvesting of the tree or stored in soil carbon. To be conservative these gains are assumed to accrue to the state. Similarly avoided animal emissions from agricultural land use change, varying from on average €14,084 to €20,184 per hectare, about two thirds of the net carbon sequestration in the trees are also assumed to accrue to the state. Much of the large variation in farm tCO2 value NPV relates to differential harvest ages. There is thus a win win for the forest owner and the state.

15. Regional Development

15. Regional Development

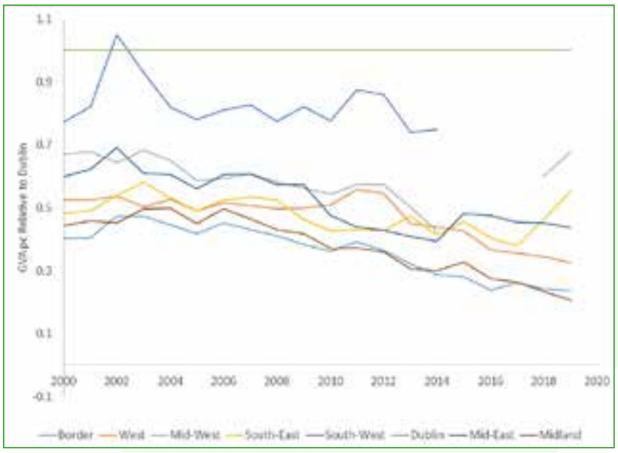
Improving the balance between the regions is a challenge in a very centralised country such as Ireland. Figure 18 highlights the size of the regional economy as measured by gross value added per capita for a region relative to Dublin. The dominant trend has been one of divergence, with the gap widening over the past two decades between Dublin and the rest of the economy. The Midlands in the most recent year of data availability, 2019 had a GVA per capita of 20.6% of Dublin's. Two regions with the highest share of Foreign Direct Investment outside of Dublin, the Mid West and the South East were closest, with respectively 67% and 55% of Dublin's.

While GVA measures the size of the economy in terms of what is produced, Household Disposable Income (HDI) is a better measure of local welfare as it captures the difference between where economic development occurs relative to where incomes are spent (Figure 19). Commuting and transfers between transfers account for the difference. Prior to the financial crash there was a convergence in incomes between regions, with regions catching up with Dublin in relation to relative incomes and purchasing power. In 2006, the Mid-East HDI per capita was 95% of Dublin, while in 2008, the South-East had disposable incomes per capita of 91% of Dublin's. In 2009, the Mid-West's was 89%.

At the closest point each region except for the border was within 85% of Dublin's HDI per capita. However during both the economic recession after the financial crash and during the recovery period to 2019 the gap between this measure of living standards has widened between each region and Dublin. The midland's saw the biggest fall from 88% of Dublin's in 2005 to 67% in 2019.

Figure 18.

Trend in Regional Gross Value Added per Capita relative to Dublin



Source: Central Statistics Office

Figure 19.

Trend in Regional Disposable Income Per Capita

Source: Central Statistics Office

One of the historic objectives of the sector has been as a source of economic growth and development in rural areas and in particular in remote rural areas. To this day in reports such as the Commission for the Economic Development of Rural Areas (CEDRA)[46] or more recently Our Rural Future, Rural Development Policy 2021-2025 have recognized the importance of utilising resources including natural resources such as forestry to support the rural economy. Both in terms of economic development in timber value chains and in relation to the increasing importance and value of sequestered carbon, the forestry sector provides an opportunity to address some of these divergent trends through the provision of economic and environmental development in rural areas.

46 https://www.teagasc.ie/rural-economy/cedra/

A separate regional issue associated with forestry is community acceptance of forestry. Prof Aine Ni Dhubháin and colleagues in UCD undertook an extensive study of the socio-economic impact of forestry in Leitrim. [47] Leitrim, given its advantageous growing conditions for forestry (with growth rates are estimated to be 20% higher than the average in private stands nationally) and poor conditions for agriculture has a disproportionate share of forestry with the percentage forest cover higher than the national target for 2050 at 18.9%. However Sitka Spruce at 61% is higher than the national figure of 51.0%. Divergent options were reported in Prof Ni Dhubháin's study with some expressing the positive contribution of forests to those living in the area. However there were also strong views that "that forestry makes rural life more difficult" resulting from land going into forestry not being available for farming or housing. Current strategies were not felt to "contribute to the vision that local people have for their community, but that other ways of managing forests would. A further opinion was that there was a lack of public consultation and it was proposed that the local public's vision for the local communities should be combined with the governmental goals for rural areas." Given the experience of the most planted county and similar experiences with other major land use changes such as wind turbines or rewetting of bogs, it is essential that the social impact of forestry related land use change be managed and in particular that efforts be made to retain as much income within the local economy.

Rural Development Policy 2021-2025 have recognised the importance of utilising resources including natural resources such as forestry to support the rural economy.

47 https://www.leitrimppn.ie/wp-content/uploads/2019/09/The-Socio-Economic-Impact-of-Forestry-in-Co.-Leitrim-Final-Report_compressed.pdf

16. Policy Recommendations

16. Policy Recommendations

When the NESC report was written in 1979, Ireland faced a cross-roads for the Forestry sector in relation to processing capacity of trees planted by the public sector in 35 years since the second world war, waning afforestation rates and an increased demand for public goods. Ireland faces a similar cross-roads, with similar issues in relation to timber mobilisation for trees planted by the private sector over the past 35 years, a waning again afforestation rate and increased need for environmental public goods from the sector.

Afforestation

Achieving the long standing goal of achieving the 18% forest cover target by mid-century has to remain the key long term goal against which we judge the success or failure of afforestation policy. The current target of 8,000 hectares per year and the reality of closer to 2,000 hectares puts off this goal into the far future putting the national objective of carbon neutrality by 2050 in jeopardy, particularly in the Agriculture, Forestry and Land Use sector. Agriculture has recently been asked to reduce emissions by 25% and with targets for the rest of the sector remaining to be defined. The less forestry delivers, the more agriculture will have to deliver in terms of emission reductions. It also limits the economic capacity of the sector to deliver economic benefits into rural and particularly remote rural areas.

There are important public policy drivers for afforestation including carbon sequestration to counter-balance GHG emissions from agriculture. From an environmental economics point of view, the marginal benefit to a farmer from planting is less than the marginal benefit to the state for planting. There is therefore, a rationale for Pigouvian transfers to farmers to motivate them to provide this environmental public good. The adoption by the State of carbon prices that value carbon sequestration and emissions in relation to the marginal abatement cost provides a cost-benefit analysis framework that can support the development of a carbon sequestration related afforestation scheme.

Recommendation 1

Retain the longstanding target of achieving the 18% forest cover target by mid-century. Given the time lag between planting and sequestration, there is need to deliver significantly higher planting earlier, well beyond current targets.

Going beyond compensation

For many farmers, negative cultural or attitudinal values are deeply held and can outweigh the greater pecuniary benefits sometimes offered by afforestation. Therefore, monetary compensation purely for foregone agricultural income may not be sufficient to incentivise the change to a less preferred land use option. In other words grants and premia should not merely cover 100% costs and losses but go beyond these levels to overcome inertia and provide an incentive.

An approach to potentially overcome the attitudinal "hurdle" associated with, in the first instance, considering afforestation, is the concept of the "compensating differential" in labour economics literature (Carpenter et al. 2015), which refers to the additional income that a worker must be offered as compensation to undertake less desirable tasks. Where a proposed change represents a worse outcome for the farmer due to for example a move from farming to forestry and the associated lower flexibility of planned use, then incentives may need to go beyond merely compensation for the financial cost of a change but to go beyond to provide an additional financial incentive.

At a minimum forest premia, therefore should go beyond compensation for land lost to agriculture. Reflecting the behavioural barriers to afforestation consideration should be made, where possible as flexible as possible in for example the timing of payments, i.e. Monthly, Quarterly, or annually.

Recommendation 2

Improve the design of forest payments to improve their compatibility with behavioural incentives including going beyond basic compensation.

Carbon Payments

A particular opportunity to beyond basic compensation to incentivise afforestation is to link payments to public good provision, particularly in relation to carbon sequestration, where additional payments potentially payable reflecting the cost of carbon and payable for longer as in the case of earlier schemes.[48] The value of the carbon sequestered under the state carbon prices is very high. As a result, potential series of payments is possible that would provide a post cost-benefit appraisal of payments that would be far in excess of current payment levels. This would provide a much greater financial incentive to plant that current levels.

Timing of Payment

The long-term nature of the economic return from forestry is contrary to the preference for income now, rather than later. At present, initial establishment costs and loss of income (for 15 years) are compensated however the return on investment arises primarily through harvesting at potentially over 40 years from planting. A challenge of a carbon sequestration related afforestation scheme is that the gains in terms of the value of the carbon sequestered are higher later in the forest life-cycle, both in terms of the volume of carbon sequestered and in terms of the value of that carbon.

While in theory, the timing of payments does not matter, in reality farmers cannot easily borrow against future income. Bacon (2004) suggested that the State should have an option or right to purchase the timber in the plantation from year 10 at a price that would equate to the final timber value. Similarly financial incentives by institutional investors could potentially pay farmers a bond for future planting rights, incorporating a greater degree of income front-loading, say in exchange for a share of future harvesting income. We propose a simpler measure built upon the current afforestation programme, with an upfront payment or down payment for future carbon sequestration, followed by a flow of income for a period or up to a full rotation. Scheme details would have to be worked out to ensure that harvest times corresponded to a date the delivered most carbon, while insurance mechanisms would be required to cover the cost of emissions due to unplanned deforestation due to fire and storms.

Establishment costs of second and subsequent rotations

In the carbon sequestration scheme, we propose, given the net carbon sequestration in forests in each rotation, there is ab opportunity to make payments over all rotations. Providing for re-establishment costs and annual premia for second and subsequent rotations would widen the financial gap between reforestation and re-converting the land to agriculture and reduce concerns in relation to the cost of reforestation.

Recommendation 3

Link afforestation public good payments to carbon prices. Develop alternative financial instruments to continue to deliver up front payments in a carbon sequestration scheme and over multiple rotations.

Targeting land

There are some low hanging fruit in relation to potential land availability for afforestation such as the 284,000 ha of land limited for agriculture or not currently being farmed identified by Farrelly & Gallagher's (2015) land availability study. Soil type is an important physical driver of both the economic return to afforestation and the agricultural opportunity cost of farm afforestation and that fibre and sequestration demands can be optimised on land which is not necessary economically attractive for agriculture.

Inflation

The national forest programme in its current format has not had to operate in an external, inflationary environment as there exists at present. Inflation in adding greater uncertainty in relation to margins can stall long-term investments like forestry and indeed the shorter component of it relating to the initial establishment of forests.

Given the rapidly changing external environment there is a need to regularly review the value of payments. Consideration should be made to index linking payments. Given the unexpected nature of the current crisis there is a merit in amending second grant payments for currently established forest to reflect the real increase in direct costs that have occurred. Reflecting the high inflation rate, payment timelines can impact on the net return, particularly as costs are paid upfront. There, for example, should be maximum timeframes on the payment of all grants, of say 4 months. Consideration should be made in increasing the time frequency of maintenance grants from two points to for example annual to mitigate price risk. A move to multi annual budgeting for Forestry Programme can also reduce risk and aid planning.

Recommendation 4

Develop mechanisms to deal with current inflationary environment to reduce risk by stakeholders and increase confidence

48 Consideration should be given for longer term payments for broadleaves, given the longer period until harvesting.

Licensing and Transaction Costs

The transaction costs in terms of regulatory burden, costs and delays in the application have become a significant barrier to achieving the objectives of the forest strategy; “create an impression of excessive bureaucracy and can serve as a disincentive to land owners to bring land forward for woodland creation.” (Mackinnon Report).

The Review of Approval Processes for Afforestation in Ireland, prepared by Jim Mackinnon CBE presents a very clear set of recommendations that relate to overcoming these challenges. Full implementation of the MacKinnon report is necessary in a defined timeframe to deal with uncertainty due to licensing delays.

While enhanced environmental concerns are necessary for the higher environmental ambitions of the country, it is essential that the procedures required to deliver these ambitions are effective and efficient. Efficiency can be delivered not only through resources (which are important), but also through organisation and prioritisation. As in the case of other regulatory processes such as planning there is a need maximum timelines on every application to give applicants greater certainty about the process. As in the case of planning decisions, there should be a maximum timelines on final decisions on all license and scheme applications, at say a maximum of 4 months.

Recommendation 5

Full implementation of the MacKinnon report is necessary in a defined timeframe to deal with uncertainty due to licensing delays.

In light of the conflicting demands on land use and common objectives around the provision of ecosystem services such as carbon sequestration, fibre for timber processing and renewable energy and the provision of biodiversity and good quality air and water, there is merit in developing long-term integrated land use policies. The concept of Functional Land Management (Schulte et al. 2014)[49] recognises the differential capacity of different soils and environmental conditions to sustainably intensify land-based production of food, fibre and ecosystem services. This approach can assist land use planning and prioritisation.

A potential benefit of a land use strategy and related analysis and policy making is to clarify priorities in relation to trade-offs between the delivery of environmental public goods. Greater clarity on prioritisation of different public goods in the context of functional land management can help to streamline environmental impact assessment and thus reduce the regulatory burden and speed up the time administrative time associated with forestry licensing.

Recommendation 6

Develop a national land use strategy to provide a formal framework to make land use planning decisions.

Improving land use planning can provide some of the infrastructure to reducing the complexity of forestry planning. In particular:

Recommendation 7

Review the legislation on forestry and consider the introduction of a single consent covering planting, road construction, management and felling.

Interaction with the Common Agricultural Policy (CAP)

One of the key lessons of this report is the way in which on-farm decision making is intertwined with afforestation decisions by farmers. For many years, forest and agricultural subsidies were mutually exclusive. In the past, changes to agri-environment schemes and direct payments were favourable towards farm afforestation. However, incentives to date have been independent of other decision making at farm level, although. The current afforestation scheme trends afforestation as a straight land use decision converting land to forestry independent of other changes on farm. The analysis of stocking density on NFS livestock farms after planting illustrates that the afforestation decision seems to be part of a wider farm management decision and suggesting that farmers may be more likely to plant if afforestation is linked to things they want to do on their farm. In fact on only 32% of farms is this the case. In other cases afforestation forms part of wider decision making either in terms of diversification of income generating opportunities by younger farmers or as part of a retirement strategy by older farmers. The COFORD (2016) report on land availability recognises the merits of a whole farm incentives approach.

Effecting behavioural change can be a complex, time consuming process, particularly if adoption of a practice is voluntary. Vanclay and Lawrence (1995)[50] find that when changes or innovations are unproven, and/or “contrary to accepted farming ways”, adoption of new technologies/ practices can be lower than anticipated. Vanclay (2004)[51] states that different farmers have “different priorities, different understandings, different values and different

49 Schulte, R. P., Creamer, R. E., Donnellan, T., Farrelly, N., Fealy, R., O’Donoghue, C., & O’huallachain, D. (2014). Functional land management: A framework for managing soil-based ecosystem services for the sustainable intensification of agriculture. Environmental Science & Policy, 38, 45-58.
50 Vanclay, F., & Lawrence, G. (1995). The environmental imperative: eco-social concerns for Australian agriculture.
51 Vanclay, F. (2004). Social principles for agricultural extension to assist in the promotion of natural resource management. Australian journal of experimental

ways of working". This is consistent with our research which suggests that due to the underlying heterogeneity of the farming population, a "one rule for all" approach is likely to have limited success and that a more targeted approach, informed by qualitative research, may be necessary to improve the uptake of farm afforestation in future. Training for farmers is critical in dealing with this heterogeneity. Training on the new Forestry Programme should be made available, similar to that which is available to farmers for the agri-environment climate measure (AECM) and to be administered by registered foresters

The current CAP strategy has only two mentions of forestry, a small acknowledgement of Agro-Forestry with the agri-environment climate measure (AECM) and the planting of plant 3 native trees as part of the Eco-Scheme. In the past agri-environmental schemes have potentially been seen as in competition with forestry. The Forest Environment Protection Scheme was introduced in 2007 to deal with potential conflicts.

It is important to ensure that regulations for future Pillar I and Pillar II agri-environmental schemes at a minimum do not inhibit afforestation. On the contrary, other CAP measures should enhance incentives to plant forestry. In the same way that additional incentives have been created to encourage "young" farmers across the plan, given the importance of delivering on afforestation objectives for all aspects it would be very useful for afforestation to be incorporated as a complementary measure to other measures. These might be delivered by enhanced premia for farmers that also plant as well as engage in afforestation.

Many of the areas that have good soils for forestry, where the return to afforestation is higher than for existing agricultural land uses or are areas identified for afforestation in the COFORD land availability report[52] are also areas with natural constraints. It would therefore be helpful to incorporate additional incentives within the Areas of Natural Capital Scheme that would further encourage afforestation.

Dairy farming is a sector with a high return relative to forestry. It is unlikely, except in the case of very high forest premium payments that there would be an economic incentive for dairy farmers to plant forestry. An integrated approach is likely to be more effective. In the 1980's and 1990's many dairy farms planted forestry. Dairy farmers who wanted to expand had to buy land that had a quota to produce milk and to increase milk production. In the early years, before quotas were ring-fenced, farmers bought and afforested land away from the home farm in order to acquire the attached dairy quota. During this period, dairy farmers, who although had higher farm incomes than forestry could provide, were responsible for a high proportion of annual afforestation.

New land use policies and objectives should aim to span multiple CAP periods. For example, the initial afforestation "hurdle" could be reduced if farmers were confident that planting land would not disadvantage them in relation to future agricultural schemes i.e. if a commitment was given in relation to the continuity of the social benefits generated by farmers who plant. Also as in the case of earlier CAP programmes, Forest land should remain eligible for Basic Payment regardless of forest premium status, provided it was eligible land when afforested.

Recommendation 8

Afforestation incentives and forestry guidelines should be aligned to CAP rules and regulations to reflect the joint forestry and agriculture decision making that happens on farms.

In association with the marketing of Ireland as a source of sustainable food production, measures should be designed that facilitate carbon neutral dairy expansion. At individual farm level carbon neutrality is hard to achieve. However, carbon neutral expansion is a feasible objective. Consideration of an integrated programme with the sustainability plans by cooperatives to develop a carbon neutral dairy expansion certification protocol should be implemented. Given intensity of activity on dairy farms delivering this programme could involve both planting by existing farmers or the use of the Collaborative Farming Scheme to establish links between those who will or have expanded their animal numbers with those with the land to plant forestry (akin to the Carbon Link Scheme proposed by Teagasc).

Given that one of the primary motivations of farm afforestation is carbon sequestration, there are merits in explicitly motivating the linkage between expansion activities that generate carbon emissions such as dairy expansion and measures that mitigate these carbon emissions such as afforestation. An incentive of reduced tax associated with increasing stock values for expanding farmers has already been introduced as an incentive for behavioural change to facilitate expansion by young farmers and to encourage farm partnerships. This tax lever could potentially be used for afforestation associated with carbon neutral dairy expansion.

A potential organizing framework that can encourage the achievement of carbon neutral dairy expansion and promote the move to full carbon neutrality by 2050 is the mechanism

agriculture, 44(3), 213-222.

52 COFORD land availability report http://www.coford.ie/research/landavailability/

proposed by Teagasc in 2050 Carbon Neutrality report[53]. This report investigated scenarios whereby sectoral C neutrality could be achieved. It included strategies and technologies that may not yet be readily implemented in the short term, but that may become available or feasible in the period up to 2050. A particular organizational tool identified in the report was domestic offsetting, where by forestry sequestration could offset agricultural emissions. Under the pathways analysed, increased sequestration from forests and grasslands and increased fossil fuel displacement were seen as likely pathways. However, these scenarios would require significant land-use change and potentially the adoption of a national land-use strategy (Teagasc MAC Curve).

Generational renewal has been highlighted as a key goal of many reports including the recent Food Vision Dairy Group[54]. Given that afforestation by many farmers is linked to retirement or semi-retirement decisions, plans for future retirement schemes should consider an element of afforestation, with premia providing a steady low labour requirement source of income for retiring farmers, while the Clearfell income provides a nest egg for successors.

Recommendation 9

Develop a Carbon Neutral Certification with the Cooperatives for Dairy Farms.

Requirement to re-forest (irreversibility)

Given farmers' preferences to farm and their concern about inter-generational attachment to the land, the permanence of the decision to afforest can prove to be quite a significant barrier to planting (McDonagh et al. 2010). This is compounded by the high level of awareness of the potential irreversibility of the decision. The attachment to land in Ireland is evidenced by the fact that on average only half a per cent of total land area changes hands in any given year (Ganly 2009). However, on an annual basis, more land is sold than is afforested.

Policy makers are increasingly looking to behavioural economics for solutions to overcome barriers associated with other long-term investments, such as the decline in personal pensions (Tapia and Yermo 2007). In recent years, the UK and more recently Ireland introduced voluntary opt out pension clauses and found that auto enrolment pension schemes (with the right to opt out) have much higher participation rates (Pensions Commission 2004). The Pensions Commission also find that a high level of inertia prevails after long term decisions are made. In general, opt out rates in the UK are in the region of 1 in 10 in recent years (O'Loughlin 2015). Drawing lessons from behavioural economics applied to pensions, there are merits to considering the possibility of land use reversion, as the barrier to planting in the first instance could be lowered.

Current policy is based on a general requirement to reforest harvested areas but some exceptions are made in practice (e.g. for bog restoration in Special Areas of Conservation). In general replanting of an alternative site is also allowed. Drawing on lessons from behavioural economics applied to pensions, there are merits in considering the relaxing of the reforestation requirement. There is already an element of discretion allowed in relation to reforestation and it is a matter of policy how this is implemented. However, given the high cost associated with forest removal, there are likely to be strong disincentives to reverting the land to agriculture. This cost builds on natural inertia which means that once a land use decision is made, there is a relatively low chance of change in any case. We have identified a mechanism in this report who linking payments to carbon sequestration can deal with the economic costs of deforestation.

As a corollary to this, increased forestry-related land use change, could reduce the socio-cultural barriers to afforestation, in the same way that initial agri-environmental scheme participation in the 1990's reduced the general antipathy towards agri-environmental programmes, significantly changing attitudes and participation levels (Murphy et al. 2014).

Recommendation 10

Improve Afforestation Incentives by Increasing Flexibility in relation to the replanting obligation.

Organisational Structure

The recent national agri-food strategy emphasised the need for a systems approach in the planning and implementation of strategies to deliver complex policy objectives. Forest policy is an example of a highly complex policy environment:

- Afforestation involves a large, long-term land use change
- Returns are long-term with associated risks
- The costs and benefits affect many parts of society and not simply the land owner

53 2050 Carbon Neutrality report https://www.teagasc.ie/media/website/publications/2013/CarbonNeutrality-1.pdf
54 https://www.gov.ie/en/collection/5170e-dairy/#food-vision-dairy-group

- It involves land use competition and engagement with an already complex agri-food sector
- Forests serve many purposes, with a need for different types of forests for different goals
- As an export sector, the value chain is global and complex
- The sector is fragmented with large public and private domains

Policy coordination, development and implementation therefore provides particular challenges. Effective governance or coordination is essential to deliver the complex set of goals in the complex operating environment. The present governance structure of the forest industry eco-system is itself fragmented with different state agencies having responsibility. There is also an overlap between policy and regulatory and development functions. Given the unique circumstances faced by the sector and the large societal benefits that the sector can deliver, there is a merit in exploring new governance structures.

Other natural resource sectors have targeted development agencies such as Teagasc and An Bord Iascaigh Mhara (BIM). State development agencies tend to have a different outlook, perspective on risk and approach to their line departments. As a result, in other spheres development functions and the policy and regulatory functions have been separated. The Mackinnon Report identified a particular tension in these functions with "pre-application consultations is very much the exception because of perceived tensions between the Inspectorate's enabling and regulatory roles".

Given the scale of the challenge and opportunity, there is a merit in establishing Forestry Development Agency to undertake a leadership role in developing the sector and to coordinate and deliver actions within the sector. Mackinnon questioned the commitment of other state bodies to afforestation noting that "State Bodies are not as engaged in helping deliver the afforestation the programme as they could and should be". Engagement by a development agency with the external environment is therefore also critical to leverage their support and deliver goals.

Recommendation 11

Establish a new Forestry Development Agency.

Mackinnon identified some major organizational barriers in Ireland to the achievement of national forestry goals that are handled more effectively via an arms length development agency in Scotland, Scottish Forestry (formerly the Forestry Commission). Lessons drawn by Mackinnon in relation to the Scottish context should be applied in Ireland.

As the focus and structure of the forestry sector has changed over the past century, so has the Government Department in which forestry has been located changed. It has variously moved between Land, Natural Resource and Agriculture departments as the sector evolved from a large state owned land and natural resource sector to one where the recruitment of farmers for afforestation became important. The Mackinnon report identified a "lack of political commitment and priority from the Irish Government to woodland creation". As the relative importance of the carbon sequestration goal of the sector increases, it is timely that a review of the best department location for forestry in achieving national carbon neutrality goals to give the sector an added political impetus.

Recommendation 12

Undertake a review of the optimal department location for forestry in achieving national carbon neutrality goals.

Another organisational issue relates to scale economies. The business model since the 1990's has been farm afforestation, with relative small parcels within farms being planted. Compared with Scotland the Mackinnon report found that economies of scale are less in Ireland, with the average size of application in Ireland is 8 hectares, compared with 40 hectares per afforestation application in Scotland. The organizational challenge of dealing with so many small holder forest owners is very significant. It is a credit to the Forest Service in managing such a large challenge and to Teagasc for the training and education support provided.[55]

However the country seems to be reaching the limits of what this business model can achieve both in terms of the amount of agricultural land that can be converted and in relation the organizational complexity of managing so many individual units. In relation to the former there is a conflict between larger farms being more likely to plant but with cattle rearing farms having a higher relative return to forestry. Thus, many of the larger farms that wished to plant have planted. For smaller farms the inflexibility of the replanting obligation places a disproportionate burden.

Organisationally the Mackinnon report presented a very illustrative example. In order to achieve an 8000 hectare

55 Recognising scale economies higher grants may be required for areas less than 5 hectares. For example, they could use the same model as the ecology grant i.e. weighted in favour of smaller area 1ha 450, 2ha 400 etc, added on cumulatively, or for areas less than 5ha, with an additional grant.

target with the 60% success rate in Ireland, over 1,650 application processes would be required, where the average size is 8 hectares. In Scotland where the average application is 40 hectares and nearly 100% of applications are successful, only 250 application processes are required. It seems inevitable that the scale economies of the sector need to be considered. It may not require a move back to the large scale land purchase for planting undertaken by the state, but at a minimum multiple approaches need to be taken. The artificial divide between public and private elements of the sector should be reconsidered in taking a more flexible approach.

Recommendation 13

Review the current afforestation business model to improve scale economies and deliver wider scale.

Tax and Social Welfare Interactions

Although not examined in this report, previous research by the author has indicated significant disincentives for afforestation that result from interactions with the tax and social protection system, whereby incentives that are provided by one arm of the state are withdrawn by another.[56] These issues were highlighted in the COFORD land availability report.[57]

A recent Auxilia-SEEFA report[58] has outlined tax disincentive that arise from the long term nature of the establishment phase of afforestation in terms of tax clearance and grant mandates. The report also highlights issues associated with VAT compliance. These anomalies place an unfair burden on the small and medium businesses that service the forestry sector.

Recommendation 14

Eliminate disincentives and anomalies that arise from the interaction of afforestation and tax and social welfare policy for all stakeholders

Conclusions

Reflecting back on Frank Convery's 1979 NESC report, the good news is that solutions were identified to the crisis faced by the sector at the time and radical operational and organisational changes were implemented and were implemented during a period of greater economic challenges during the 1980's. The challenge now is to show the same ambition as 40 years ago and renew the potential the forestry sector can achieve for national economic, social and environmental objectives over the next 40 years.

- Achieve a viable afforestation programme that will provide the critical mass for an international-scale wood processing and manufacturing industry.
- Contribute to reducing levels of greenhouse gases with benefits for the environment and agriculture.
- Support a quality export driven forest products sector including maximising wood mobilisation.
- Support research, development and training.
- Revitalise many rural communities by increasing sustainable employment.
- Promote non-wood aspects of forestry including biodiversity, water quality and flood control, leisure and rural tourism.

56 Ryan, M., O'Donoghue, C., & Kinsella, A. (2017). The potential impact of differential taxation and social protection measures on farm afforestation decisions. Irish Forestry, 74(1/2), 99-129.
57 http://www.coford.ie/research/landavailability/
58 Auxilia-SEEFA (2022) Forestry Grant Mandating Issues

Appendix

Forest Management Cost Assumptions (Bruton and Phillips, 2021)

Appendix: Forest Management Cost Assumptions (Bruton and Phillips, 2021)

Table 25. Afforestation Cost Structure

	Labour and Machines					Administration Technical Support			Totals/ha	
Afforestation	**Hours/ha**	**Cost/ha**	**% Contract**	**Materials + Fuels**	**Machine Cost**	**Hours/ha**	**Cost/ha**	**% Direct**	**Hours/ha**	**Cost/ha**
Conifer	67.46	€804	92%	€1,510	€207	43.52	€1,132	93%	**111.0**	**€3,653**
Broadleaf Hard	82.04	€1,026	91%	€3,074	€248	43.52	€1,132	93%	**125.6**	**€5,480**
Broadleaf Soft	82.04	€1,026	91%	€2,486	€248	43.52	€1,132	93%	**125.6**	**€4,892**

Source: (Bruton and Phillips, 2021)

Table 26. Reforestation Cost Structure

	Labour and Machines					Administration Technical Support			Totals/ha	
Reforestation	**Hours/ha**	**Cost/ha**	**% Contract**	**Materials + Fuels**	**Machine Cost**	**Hours/ha**	**Cost/ha**	**% Direct**	**Hours/ha**	**Cost/ha**
Conifer	63.36	€777	93%	€1,098	€229	25.79	€679	100%	**89.2**	**€2,783**
Broadleaf Hard	87.96	€1,086	95%	€2,301	€273	25.79	€679	100%	**113.8**	**€4,338**
Broadleaf Soft	87.96	€1,086	95%	€1,712	€273	25.79	€679	100%	**113.8**	**€3,749**

Source: (Bruton and Phillips, 2021)

Table 27. Thinning and Harvesting (Conifers) Cost Structure

	Labour and Machines					Administration Technical Support			Totals/100m3	
Conifers	**Hours/ 100m3**	**Cost/ 100m3**	**% Contract**	**Materials + Fuels**	**Machine Cost**	**Hours/ 100m3**	**Cost/ 100m3**	**% Direct**	**Hours/ 100m3**	**Cost/ 100m3**
First Thinning	31	€502	97%	€396	€1,595	16.8	€432	89%	**47.5**	**€2,924**
Second Thinning	30	€494	100%	€389	€1,559	13.6	€316	81%	**43.9**	**€2,758**
Third + Sub Thinning	26	€408	100%	€345	€1,309	13.6	€312	80%	**39.8**	**€2,374**
Clearfell	19	€308	99%	€269	€883	12.8	€359	90%	**31.8**	**€1,819**
Clearfell Windblow	22	€349	100%	€296	€1,034	15.7	327.2	83%	**37.2**	**€2,007**

Source: (Bruton and Phillips, 2021)

Table 28. Thinning and Harvesting (Broadleaves) Cost Structure

	Labour and Machines					Administration Technical Support			Totals/100m3	
Broadleaves	**Hours/ 100m3**	**Cost/ 100m3**	**% Contract**	**Materials + Fuels**	**Machine Cost**	**Hours/ 100m3**	**Cost/ 100m3**	**% Direct**	**Hours/ 100m3**	**Cost/ 100m3**
Tending	56	€874	100%	€566	€2,461	16.8	€432	89%	72.8	€4,333
First Thinning	46	€737	100%	€542	€2,319	16.8	€432	89%	62.4	€4,029
Second Thinning	43	€687	100%	€504	€2,106	13.6	€316	81%	56.2	€3,613
Third + Sub Thinning	41	€654	100%	€479	€1,964	13.6	€312	80%	54.2	€3,409
Clearfell	51	€506	100%	€417	€1,395	12.8	€359	90%	63.5	€2,677

Source: (Bruton and Phillips, 2021)

Table 29. Roading Cost Structure

	Labour and Machines					Administration Technical Support			Totals/km	
Roading	**Hours/ km**	**Cost/ km**	**% Contract**	**Materials + Fuels**	**Machine Cost**	**Hours/ km**	**Cost/km**	**% Direct**	**Hours/ km**	**Cost/ km**
New Road Construction	401	€6,826	95%	€36,615	€10,011	360	€9,717	96%	**761.1**	**€63,169**
Road Upgrading	140	€2,240	100%	€20,680	€2,730	150	€5,476	99%	**289.9**	**€31,126**

Source: (Bruton and Phillips, 2021)

Table 30. Maintenance Cost Structure

	Labour and Machines					Administration Technical Support			Totals/km	
Maintenance	**Hours/ha**	**Cost/ ha**	**% Contract**	**Materials + Fuels**	**Machine Cost**	**Hours/ km**	**Cost/km**	**% Direct**	**Hours/ ha**	**Cost/ ha**
Inpsection Paths	2.2	€34	98%	€17	€0				2.2	€51
Drainage Repairs	2.0	€32	100%	€29	€29				2.0	€90
Fence Repairs	2.5	€28	95%	€45	€0				2.5	€72
Road Repairs	1.2	€19	0%	€29	€18				1.2	€66

Source: (Bruton and Phillips, 2021)

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