Socio-economic drivers of farm afforestation decision-making

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Abstract
The decision to convert land from agriculture to forestry has previously been considered in a number of studies which have variously assessed attitudinal and economic factors affecting the afforestation decision. However, none of these studies has fully taken into account the heterogeneity of individual farms in Ireland, particularly in terms of farm and farmer characteristics. This review paper presents a summary of recent research undertaken by the authors which delves deeper into the economic decision-making process at the individual farm level by examining the characteristics of the farms and farmers that planted land and comparing them to those farms without forests over almost 30 years, using data from the Teagasc National Farm Survey. The results show that soil type and the agricultural market income and subsidies prevailing in the year of planting all have an effect on the economic attractiveness of afforestation. The potential relative returns to both agriculture and forestry on these farms was also investigated and was found to be a significant driver of the afforestation decision. The research presented also shows that the drivers of afforestation decisions may be influenced by contemporaneous farm management decisions. The results of an additional survey undertaken in 2012 highlight the magnitude of the challenge facing policy makers in designing afforestation incentive schemes as 84% of farmers surveyed would not consider planting in the future, regardless of the financial incentives offered. This challenge is particularly important in relation to national objectives to move to carbon neutral farming in the medium term. Drawing on the behavioural economics literature, the authors present a range of policy measures that go beyond financial incentives that could potentially increase afforestation rates.

Keywords: *Farm afforestation, decision-making, behaviour, carbon sequestration, GHG mitigation.*

Introduction
Forests are increasingly valued as a natural resource and for their potential to enhance ecosystem services (Kanowski 2010). Thus increasing forest cover is an important policy objective across many EU countries (EU Commission 2013). 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 (Nijnik and Bizikova 2008). In common with other EU member states, Ireland has sought to increase its forest cover for some time, with rural employment and economic diversification benefits being important drivers in the 20th Century, while broader ecosystem services have been increasingly recognised in modern Irish forest policy (DAFF 1996, OCarroll 2004, DAFM 2014).

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Yet in recent years, the rate of afforestation in many European countries has been declining (Eurostat 2013). In Ireland, despite the availability of strong financial incentives, afforestation has fallen short of policy targets over the last 20 years. This has long-term consequences for downstream timber processing, for the wood fibre supply for renewable energy and fossil fuel displacement and for the potential of forests to sequester carbon. This is compounded by competing demands for land to provide these services in addition to expanding agricultural production to meet global food demands (FAO 2009). The largest constraint on the expansion of both agriculture and forestry is land availability, which is limited by biophysical, biological and environmental restrictions (Farrelly and Gallagher 2015). The availability of land for afforestation in Ireland is currently under review (COFORD 2016). Agricultural expansion is also likely to be constrained by limits on greenhouse gas emissions. The ability of forests to sequester carbon and mitigate greenhouse gases generated by the agriculture sector, could potentially facilitate agricultural expansion. Thus, a holistic examination of all aspects of the afforestation decision is merited.

The conversion of land from agriculture to forest involves a complex decision-making process and the influencing factors can be difficult to isolate. Physical, economic and behavioural drivers that are relevant to the afforestation decision can be identified from literature:

- soil quality and the resultant forest productivity;
- financial incentives;
- opportunity cost of planting;
- relativity of agricultural and forest income streams;
- permanence of land use change from agriculture to forestry;
- changes in farming intensity associated with planting;
- socio-cultural attitudes towards afforestation.

The forest economics modelling capacity developed by Teagasc in recent years facilitates a broad range of analytical techniques to assess the impact of these drivers. In the context of addressing the role of farmers in relation to potential future expansion of afforestation, this review paper focuses on drawing on lessons from this economics research programme in order to inform future policy options. The farm level and behavioural drivers that influence the inter-temporal land use change from agriculture to forestry are examined in order to ascertain whether there is a relationship between the relativity of forest and agriculture income streams and the likelihood of planting. To do this we first examine the physical and policy drivers of the economic returns to farm forestry and the associated agricultural opportunity cost foregone. We examine the characteristics of farms with forests and also examine farm decisions contemporaneous to the year of planting, to inform the degree to which the decision to afforest land is merely a substitute land use or alternatively, is part of the long-term objectives of the farm. The results are discussed in relation to the design of future afforestation incentive measures.

Policy context

Ireland's forest policy has undergone a number of significant changes in emphasis since the founding of the State when forest cover represented just one per cent of the land area, to the current forest cover of 11%. Successive forest policy strategies have set policy objectives and annual targets for private sector afforestation. Following high levels of annual afforestation in the early 1990s, the ambitious planting targets of 20,000 and 25,000 ha yr^{-1}(DAFF 1996)[1] were revised downwards as afforestation started to decline (See Figure 1). Since 2005 even these reduced targets have not been met, despite the higher forest premium payments in place over this period. This may be explained in part by previous research which shows that forest subsidies available to many farmers (since 1984) have been less attractive financially than the subsidies associated with remaining in cattle farming (Ryan et al. 2014).

The most recent revision of forest policy (DAFM 2014) re-affirms the importance of forestry as a national land use policy and sets targets to increase the total area under forest to 18% of the land area by 2046. This is in part due to the need to maintain and increase the store of carbon sequestered in Irish forests (Hendrick and Black 2009).

In the wider land use context, the drive to produce more food to feed the rapidly expanding global population has led to the development of Irish agricultural expansion strategies (Food Harvest 2020 and Food Wise 2025 (DAFF 2010, DAFM 2015). Due

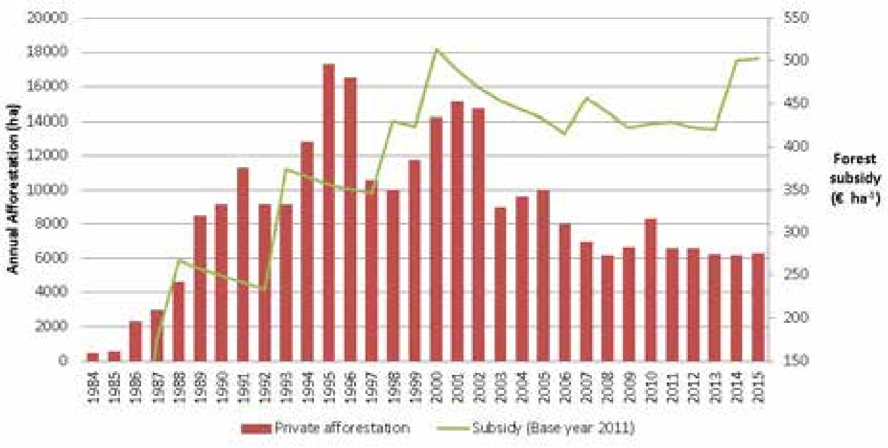

Figure 1: *Annual private afforestation (ha) and forest premium payments (€ ha^{-1}expressed as 2011 values) for Sitka spruce conifer plantations (1984 to 2015). Source: DAFM 2015 and author's personal data.*

[1] To achieve forest cover of 17% by 2030.

to the large role played by the agri-food sector in the Irish economy, agriculture already accounts for 33% of total national greenhouse gas (GHG) production (EPA 2015). Thus it is likely that expansion will be constrained by EU Climate and Energy policies that impose limits on the level of carbon that can be released to the atmosphere in the form of GHGs.

A number of pathways to reduce or mitigate agricultural GHG production are currently being investigated. These include efficiency measures such as the reduction of "per kilo of product" emissions from the production of food products (Ryan et al. 2015a); identifying technologies to reduce emissions directly (Lanigan and Richards 2014); and integrated land management options such as increasing carbon sequestration through increased afforestation (Schulte et al. 2013). The decision of the EU Council of Ministers (EUCO 2014) to allow for the inclusion of Land Use, Land Use Change and Forestry (LULUCF) in the 2030 greenhouse gas mitigation framework opens up the possibility of pursuing "carbon neutrality" as a horizon point for Irish agriculture, whereby "national GHG emissions from agriculture are fully offset by carbon sequestration by grassland soils, forestry and other land use" (NESC Secretariat 2013).

The permanent nature of the afforestation decision

However the complexity of the decision to change land use from agriculture to forestry in Ireland is increased by the fact that the decision essentially involves a permanent land use change. Under the 2014 Forestry Act, it is necessary to acquire a felling licence prior to harvesting timber from forests. In general, one of the conditions imposed by the relevant Minister on granting the licence is the replanting of the harvested forest. This imposes a restriction on the flexibility of land use and a substantial replanting cost which is currently not compensated to the forest owner.

Theoretical context

On many levels, farming and forestry differ hugely as land uses. Factors such as inherent preferences for either forestry or farming, the externalities generated by forests, the risks associated with long-term investments, the length and permanent nature of the forest rotation are specific to forestry and must be taken into account in an analysis of the land use change.

Theory of land use change

In understanding the economic drivers of land use change, we need to understand the differential preferences and returns to farming (F) and forestry (trees) (T). Traditional economic theory suggests that individuals make decisions based on the expected change in their level of "well-being", where the term used for well-being or welfare is "utility" (Edwards-Jones 2006). Thus economists use utility maximisation frameworks, rather than profit maximisation frameworks in determining the drivers of behaviour.

We can describe the utility (U) or happiness that derives from alternative land uses i.e. farming and forestry (L_F and L_T), in terms of returns to land use (p_F and p_T) and farmer preferences for either farming or forestry, respectively α and β

$$U = \alpha . L_F . p_F + \beta . L_T . p_T \quad [1]$$

where $\alpha > \beta$ as we already know from literature that farmers generally prefer to farm than to afforest land (Ní Dhubháin and Gardiner 1994, Duesberg et al. 2013, Howley et al. 2015).

In economics, the marginal rate of substitution (MRS) is the rate at which a consumer is ready to give up one good in exchange for another good while maintaining the same level of utility. In developing an understanding of the MRS between Farming (F) and Forestry (T) planting, we model the ratio of marginal utility.

Marginal rate of substitution between farming and forestry:

$$\begin{aligned} MRS_{FT} &= \frac{MU_F}{MU_T} = \frac{\delta U}{\delta L_F} . \frac{\delta L_T}{\delta U} \\ &= \alpha p_F . \frac{1}{\beta p_T} \\ &= \frac{\alpha p_F}{\beta p_T} \end{aligned} \quad [2]$$

If the return to land use from farming is the same as planting a forest, i.e. if $p_F = p_T$, then

$$MRS_{FT} = \frac{MU_F}{MU_T} = \frac{\alpha}{\beta} > 1$$

This implies that farmers prefer to farm rather than plant forests and tells us that in order to counter-balance these preferences, the return to land use needs to be higher from forestry than from farming. This also applies, due to inertia, to any move from the *status quo* to an alternative land use.

Marginal private benefit and marginal social benefit

Afforestation, results in the provision of public goods in the form of carbon sequestration so that the benefits from planting forestry extend beyond those of the farmer. Such public benefits arising from private land are known as externalities which can be positive in the case of public goods such as carbon sequestration, or negative in the case of atmospheric emissions or pollution (public bads). The rationale for the state to "step in" to control pollution arises from the existence of these externalities, which are costs (or benefits) imposed by the polluter on others.

In theory, farmers should plant when the marginal private benefit equals the marginal private cost. In other words, the extra income and costs, respectively, associated with an incremental land use change into forestry, at least balance each other out. However as the benefits to society are larger due to the presence of externalities, the socially optimal intersecting point is located at a higher level of forestry than is privately optimal (see Figure 2). This difference motivates the concept of Pigouvian subsidies, or payments to the provider of the public good, to equalise the marginal social benefit and the marginal private benefit. If this happens, then in theory, the level of planting would be expected to coincide with the socially optimal level.

Forestry is also associated with other risks such as fire and storms (wind blow) which can cause extensive damage (as in the case of Storm Darwin in 2014). Natural disasters have a low probability of occurrence in any particular stand of timber but research suggests that forest damage caused by disturbance is increasing (Schelhaas 2008). Without the support of a well-developed insurance market, farmers or potential investors may be reluctant to consider forestry as an option (Zhang and Stenger 2014).

The timing differential of agricultural and forest income streams was the motivation for the historic structure of policy payments with upfront forest establishment subsidies (grants) and annual forest premium payments until timber revenues arise. The higher

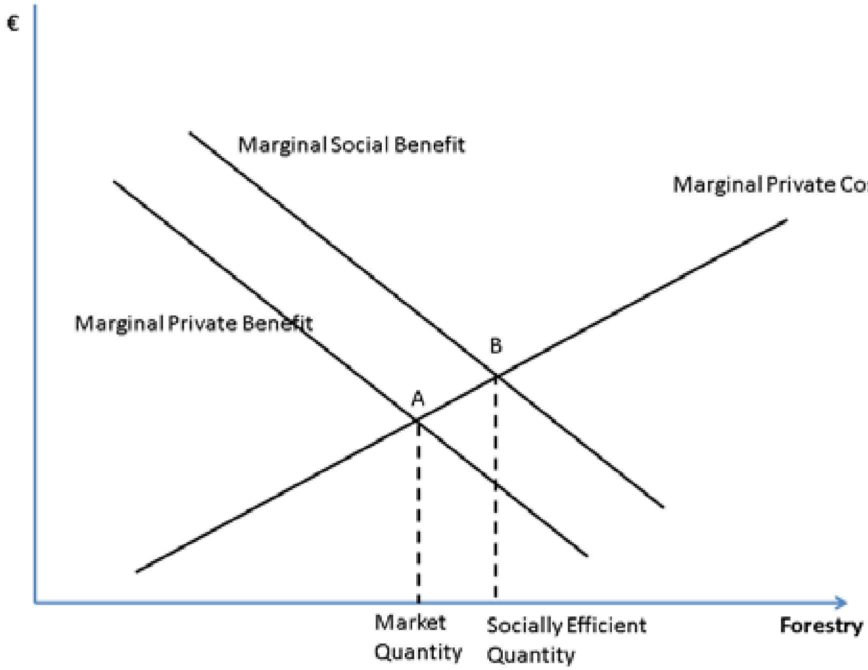

Figure 2: *Marginal social benefit and marginal private benefit of afforestation.*

[2] In the presence of positive externalities, those who receive the benefit do not pay for it and the market may under-supply the product. Similar logic suggests the payment of a Pigouvian subsidy to make the users pay for the extra benefit would spur more production

preference for income now, relative to future income, (known as the discount rate), means that there is less incentive for a land use change that substitutes current income from farming for future income from forestry. The question that arises here is whether the structure of these subsidy schemes sufficiently mitigates this preference.

Socio-economic drivers of farm afforestation decision-making

Life-cycle returns

The economic return to farm afforestation is comprised of two elements – the return to afforestation given the particular soil and environmental context of an individual farm; and the income foregone from the superseded agricultural enterprises on that farm. In turn, both agricultural and forest incomes are comprised of market and subsidy components. Thus, there are both physical and policy drivers of the economics of farm afforestation.

Afforestation involves significant establishment costs at the start of the life-cycle, followed by "lumpy" thinning returns with the majority of income arising at the point of harvesting (see Figure 3). This compares with a "flatter" income profile from the alternative land use of farming.

Therefore a life-cycle approach such as the calculation of net present value[3] (NPV) of alternative income streams is necessary when comparing the two land uses. Both the agricultural and forest income streams are calculated as the sum of the present

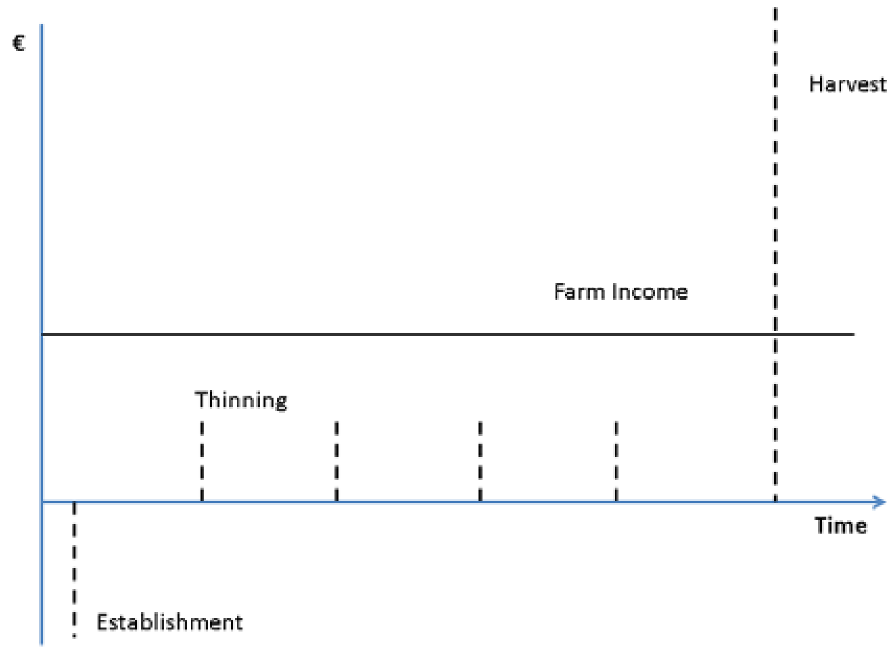

Figure 3: *Timeline of income streams of farming and forest income.*

[3] NPV is the discounted value of net incomes over a rotation, presented in today's money.

values of the annual net amounts (revenue less costs) in the income stream (assuming a constant discount rate (r) where n = year in which cost/revenue occurs).

$$NPV = \frac{I_0}{(1+r)^0} + \frac{I_1}{(1+r)^1} + \frac{I_2}{(1+r)^2} + \cdots + \frac{I_n}{(1+r)^n} = \sum_{i=0}^{n} \frac{I_i}{(1+r)^n} \quad [3]$$

The forest income stream varies over time whereas the agricultural income stream is held constant over the forest rotation as illustrated in Figure 3. The NPVs of forest and agricultural income streams are generated for the forest rotation and converted to annualised equivalent (AE) values to facilitate comparison with farm income measures where:

$$AE = \frac{r.NPV}{1-(1+r)^{-n}} \quad [4]$$

Measuring net present value of afforestation

In analysing the economic return to forests, a forest bio-economic systems model[4] (Ryan et al. 2016) is utilised to generate annual equivalised (AE) NPVs of forest income streams for a range of forest productivity (yield) classes. These forest yield classes measure timber productivity in terms of the average volume production per hectare per year. Figure 4 illustrates the larger (AE) NPV achieved by higher yield classes and shows a strong upward trend in forest (subsidy plus market) incomes over time, regardless of yield class.

Yield class also affects the share of forest subsidies in overall forest income as the trend in Figure 5 is consistent over time. For higher yield classes, subsidies form a relatively small proportion of income, but for the lowest yield class, the share of subsidies rises to 100% of income during the period examined. Model outputs show that life-cycle forest incomes vary little with yield class in the early years as income is derived from grant and premium subsidies. However, once forest subsidies cease and thinning commences, higher yield classes have a larger effect on the economic return to forestry. Further research undertaken by Ryan et al. (2016) shows that there is little qualitative difference in (AE) NPV when analysing the economic return from one rotation or from a larger number of rotations (at 5% discount rate) as the value accruing from harvests is so far into the future that it is heavily discounted.

Agricultural subsidy effects

In order to determine the share of subsidies in agricultural incomes, Ryan (2016) examines two measures that include agricultural subsidies. These are presented in Figure 5.

Farm Gross Margin (GM) is a broad measure of output as only direct costs

[4] The forest bioeconomic systems model (ForBES) generates cost and income curves for a range of yield classes and thin and no-thin scenarios and generates annual equivalent NPVs for a range of discount rate, subsidy, rotation and indexation options.

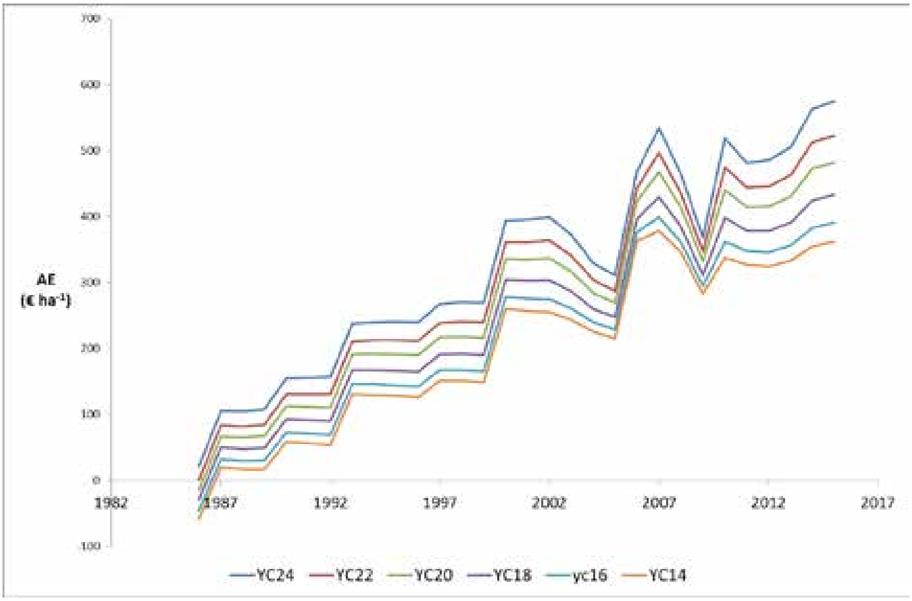

Figure 4: *Annual equivalised forest NPVs (€ ha^{-1}) (1985-2013). Source: Teagasc Forest Bio-Economic Systems Model (Ryan et al. 2016).*

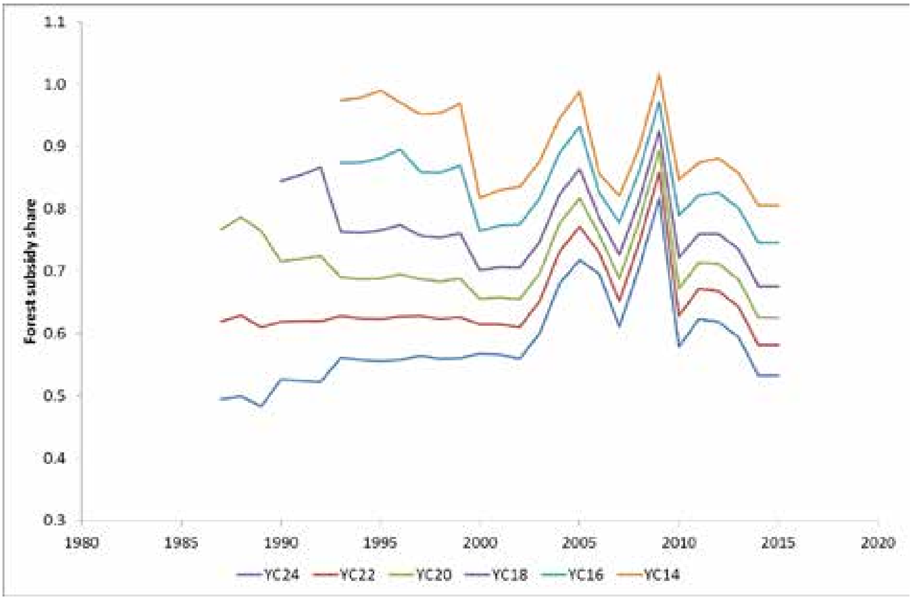

Figure 5: *Share of subsidies in forest income streams (1985-2013). Source: Ryan (2016).*

such as fertilisers and feed stuffs are deducted. As overhead costs are not deducted, GM can be used in making short term decisions, while Family Farm Income (FFI) is a longer-term measure of agricultural incomes. Figure 6 shows that there is a

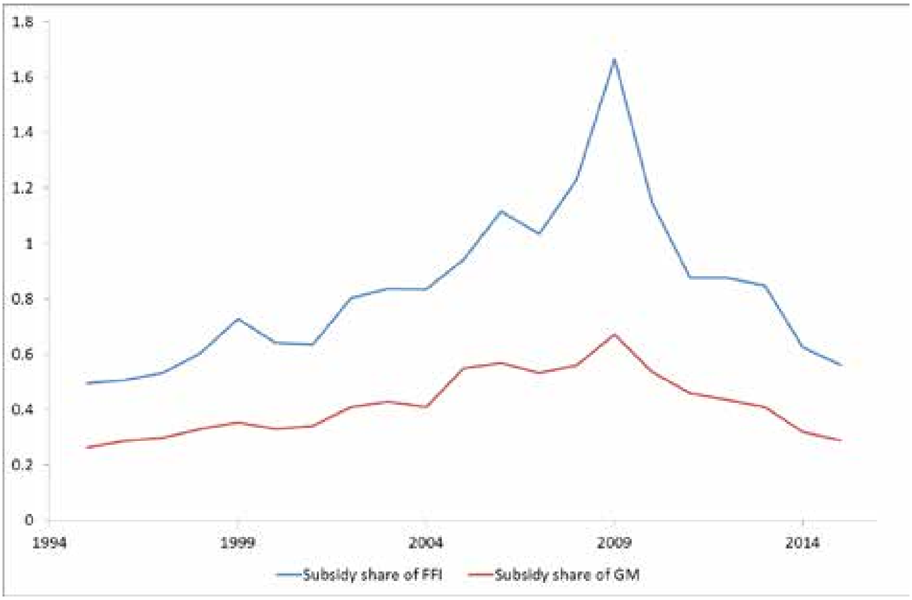

Figure 6: *Share of agricultural subsidies in agricultural incomes measured using Family Farm Income (FFI; € ha^{-1}) and Farm gross Margin (GM; € ha^{-1}) over time. Source: Ryan (2016).*

considerable difference in the magnitude of the share of subsidies for the measures used as the share is higher in the FFI measure of farm income. The trend is similar for both measures as the share rises steadily over time, reflecting a number of increases in agricultural subsidies (McCormack and O'Donoghue 2014). The share of subsidies peaks in the poor market income year of 2009 and declines as a component of income following a recent period of strong market income increases (Hennessy and Moran 2015). This partially explains the reluctance of some farmers to plant as the expectation of future subsidies is recognised as having affected land use decisions as farmers position themselves to ensure they retain eligibility for payments (O'Donoghue and Whitaker 2010). This flexibility no longer exists once land is afforested.

The impact of soil type on economic return

A common measure of productivity is necessary to compare agricultural and forest productivity as represented by forest yield classes and agricultural soil classes. On the basis of their relative productivity for either agriculture or forestry, Upton et al (2013) present the assignment of forest yield class (YC) estimates for Sitka spruce (*Picea sitchensis* (Bong.) Carr.) to NFS agricultural soil classes (SC)[5] which allows for the categorisation of farm data in relation to the relevant Sitka spruce yield class: SC1 and YC24 reflect the highest level of productivity for either agriculture or forestry (Table 1).

[5] Soil Classes (SC) range from SC1 (suitable for wide use) to SC6 (extremely limited for agriculture).

Upton et al. (2013) also shows that in the context of farm afforestation, different farm systems have different opportunity costs as presented which presents the average NPV of a land use change from the NFS farm systems to a conifer (SS) forest (Table 1). On average, the opportunity cost of replacing a dairy enterprise with forestry is high across all yield classes. Therefore the NPV is negative across all soil classes. In making the decision to plant some of their agricultural land, it is assumed that farmers are unlikely to plant land which gives a higher return in another farm enterprise, (such as dairy) thus it is more likely that cattle and sheep farmers with positive returns from planting are more likely to plant.

Agricultural opportunity costs

The values presented in Table 1 are averages across each farm system. In reality, there may not be any "average" farmers so the information that can be gleaned from using average values is limited as approaches which utilise averages do not take account of both farm and farmer efficiencies at the individual farm level. To assess the economic impact of afforestation on farm incomes for individual farms over a forest rotation, Ryan and O'Donoghue (2016) generate income streams for the life-cycle of the proposed afforestation and for the superseded agricultural enterprise (for each planting year from 1985 to 2013, for each farm in the NFS pooled dataset on a per hectare basis). This allows for the investigation of individual farm and environmental characteristics such as soil class, farm system, farm size and livestock density, as well as the impact of subsidies and market prices over the period. While the NFS is not representative of small farms, it is representative of 95% of Standard Output from agriculture and accounts for 81.3% of total Utilisable Agricultural Area (UAA) (Hennessy and Moran 2015).

Soil and policy effects over time

In untangling the effects of decoupling of payments from production, we examined 1998 and 2007 as being representative of the post-MacSharry (coupled payments) and the Single Farm Payment (SFP) (decoupled payments) periods, respectively. Ryan (2016) calculated opportunity costs as the annual forest income stream less

Table 1: *Average soil category (SC) specific NPVs (2009 € ha^{-1}) for forestry replacing the main agricultural systems. Adapted from Upton et al. (2013). Values adjusted using the consumer price index and expressed according to 2009 values.*

Farm System	SC1/YC24	SC2/YC24	SC3/YC20	SC4/YC20	SC5/YC18	SC6/YC14
Dairy	-19,603.05	-27,229.61	-18,380.64	-14,572.27	-9,189.15	-9,167.08
Tillage	-1,951.58	-5,392.43	-5,211.61	554.49	2,322.32	-
Cattle	2,244.23	3,134.88	3,117.51	4,206.74	4,410.44	3,688.20
Sheep	1,052.99	2,244.17	2,880.49	3,405.87	5,426.76	3,765.59

the agricultural income foregone for each year of the forest life-cycle and presented them as Net Farm Afforestation Income (NFAI) per hectare. In summary, Ryan (2016) observed the following in relation to the effect of soil code and year of planting on the net return to farm afforestation:

- It is evident that when higher agricultural incomes (such as those represented by dairy, dairy other and tillage on better soils) are deducted from the forest income stream, the net benefit of afforestation is likely to be negative. Afforestation does not compete financially with the dairy system under any soil conditions, regardless of whether a gross or a net measure of agricultural income is used in the calculation of the opportunity costs. The income patterns for dairy other and tillage are similar to dairy.
- In contrast, farmers engaged in livestock enterprises are the most likely to benefit financially from converting land to forestry, particularly in the latter years of the period. The significance of these results for potential future afforestation lies in the relative size of the livestock sector in Ireland. Livestock systems (cattle rearing, cattle other and sheep) account for over 68% of farms, and the cattle systems alone make up more than half the farms in Ireland (Hennessy and Moran 2015).
- The effect of year of planting on economic return has a large impact as all systems have negative NFAI in 1998 (except for the sheep, tillage and dairy other systems on poorer soils) while the NFAI of afforestation in 2007 is positive (in other words the opportunity cost is lower). The higher NFAI in 2007 is due to (a) market variation rather than subsidies, as market income in 2007 is considerably higher and (b) the effect of subsidies is stronger in the earlier period as farmers would have lost coupled payments on planting however, this is not the case in the later period as farm afforestation is eligible for SFP, reducing the agricultural opportunity cost foregone.

Analysis of the relative profitability of agriculture and forestry on individual farms

Many Irish studies have found that the relative profitability of agriculture and forestry are significant factors in determining afforestation rates in Ireland (see McKillop and Kula (1988), Behan (2002), McCarthy et al. (2003), Breen et al. (2010), Upton et al. (2013)). To characterise farms on the basis of whether they would be better off financially if they planted land or not, Ryan and O’Donoghue (2016) generate variables (Ag >For) to denote farms where the potential life-cycle agricultural income is greater than that from forestry and (For >Ag) where the life-cycle forest income is greater. Ryan and O’Donoghue (2016) examine the sample of farms that planted in the past and those that might plant in the future. Summary statistics from this research are presented in Table 2 where life cycle forest income streams are defined as (AE) NPV of market plus subsidy income. In order to disentangle the effect of agricultural subsidies, agricultural income streams are defined as farm gross margin with subsidies (NPV1) and without subsidies (NPV2). Farms are further categorised on the basis of having farm forests i.e. "Has Forest" and "No Forest".

The calculation of NPV is sensitive to the inclusion of subsidies as the percentage of farms with higher forest incomes drops from 40%) to 25% when agricultural subsidies are explicitly taken into account (NPV1), however, the inclusion of agricultural subsidies in the calculation of the opportunity cost is less relevant for future rather than historic afforestation.

Only 13% of farms in the pooled dataset have forests and that the majority of farms have higher agricultural incomes and haven't afforested land. This is consistent with *a priori* expectations as these farms have the highest opportunity cost. The smallest group describes farms where the forest income is higher than the agricultural income but these farmers already have forests. However, there is a considerable percentage of farms (21% incl. subsidies and 34% without subsidies) that have higher forest incomes but these farms do not have forests.

Post-planting consequential farm management changes

The partial replacement of a livestock enterprise with forestry has consequences for the management of the farm as a whole. In investigating whether the afforestation decision involves a straight land use substitution which is made in isolation, or is alternatively part of a more complex lifestyle decision-making framework, Ryan and O'Donoghue (2016) examine changes in the level of intensity of farming by looking at the stocking density (year before planting versus year of planting) for all farms with forests in the NFS 2012 Supplementary survey dataset. The results show that the average stocking rate reduces from 1.44 to 1.37 LU ha^{-1}. On just under one third of farms with forests, there is no change in livestock density in the

Table 2: *Relative profitability of agriculture and forestry for farms with or without forests. Source: Ryan and O'Donoghue (2016).*

	Gross Margin (incl. subsidies) (NPV1)		**Market Gross Margin (no subsidies) (NPV2)**	
	Frequency	**%**	**Frequency**	**%**
Ag>For/No For	23,546	66	18,772	52
Ag>For/Has For	3,385	9	2,648	7
For>Ag/No For	7,394	21	12,168	34
For>Ag/Has For	1,439	4	2,176	6
Total	35,764	100	35,764	100

Note: income components are on a per hectare basis. NPV's were to an annualised definition, dividing by, varying with the forest rotation for the relevant yield class and soil type.

year of planting. A quarter of farms increase stocking rate (by more than 5%) while the largest proportion of farms (43%), reduce livestock density (by more than 5%) in the year of planting (Ryan and O'Donoghue 2016). On the basis of analysis of the characteristics of these three farming intensity cohorts, Ryan and O'Donoghue (2016) put forward three discrete intensity objectives or farming "mind-sets".

Farms that don't adjust the livestock density per hectare after planting are the largest and most intensive farms with the highest average livestock density, highest dairy livestock density, highest average hours worked and the highest average farm income. Less than one third of these farms have a higher NPV of income from forestry than from agriculture. These farms were already reasonably heavily stocked (average 1.6 LU ha^{-1}) so they had no choice but to reduce stocking density as a result of having less land available for grazing. It is likely that these farms did not have spare capacity in terms of land and took an economic decision to optimise their land use replacing a marginal agricultural enterprise with a more productive forestry enterprise. These farms may be characterised by having an "intensive/optimisation" mindset.

For the 25% of farmers who increase intensity as a result of afforestation, forest income is greater than agricultural income on almost half (47%) of these farms They have a slightly smaller average farm size of 62 ha and the lowest farm income, are younger and are more likely to have off-farm income, suggesting that these are part-time farmers who have planted excess land which they did not need as they maintain similar or greater stock numbers on a reduced land area. These are farmers who may be optimising their work hours by planting land to free up time to supplement overall income with off-farm income. These farmers could be characterised as having a "diversification" mind-set.

However, 44% of farms decrease their stocking rate suggesting that these farms may be "winding down". Prior to planting, this group had high average stocking densities and just over half of these farms have higher incomes from forestry. The farms are smaller on average (55 ha) and the farmers are older. They are more likely to be in agri-environment schemes and have considerably higher direct payments than the other groups. These farmers appear to have a "de-intensification" mind-set.

In summary, it would appear that the decision to afforest land involves consequential decisions in relation to farming intensity. At the very least, this involves decisions in relation to livestock density, but it would also appear that the decision to afforest may be part of wider lifestyle decision-making.

Behavioural drivers of farm afforestation decision-making

Frawley and Leavy (2001), Ní Dhubháin and Gardiner (1994) and Duesberg et al. (2013) all cite reluctance among Irish farmers to plant land that is "good" for farming. McDonagh et al. (2010) find that the most important barriers to planting are (1) the desire to farm and (2) the permanent nature of forestry. In Scotland, the Mindspace (2010) survey reports that for one third of Scottish farmers who hadn't planted, there was "nothing that would persuade them to plant", while in England, Watkins et al. (1996) find that most farmers did not want woodland on their farmland. Farmers interviewed by Duesberg et al. (2014) present the most simplistic view, ascribing their reluctance to engage in forestry as "…simply because it is not farming".

On this basis it makes sense that there exists a cohort of farmers who choose not to plant, regardless of the relativity of forest and agricultural income streams. This apparent contradiction has been commented on previously in the Irish farm afforestation context (see Breen et al. 2010, Upton et al. 2013, Howley et al. 2015). However, the size of this cohort of farmers has not been determined until an examination of attitudinal data from the 2012 NFS supplementary survey undertaken by Ryan and O'Donoghue (2016) revealed that over 84% of farms do not intend to afforest their land at any level of forest subsidy.

On the basis of this information, Ryan and O'Donoghue (2016) further categorise farms in relation to afforestation intentions i.e. "Might Plant" and "Never Plant", on the basis of whether these farms would have higher incomes from forestry or from agriculture (calculated with and without the inclusion of agricultural subsidies).

Despite the fact that the largest agricultural subsidy i.e. the Basic Payment (formerly Single Farm Payment) is payable on afforested land, the influence of subsidies is still strong as over 65% of farms would have higher forest income (on a per hectare basis) when agricultural subsidies are not taken into account, but this drops to over 36% when agricultural subsidies are included in the calculation of the NPVs (Table 3). It is also evident that while some farmers who would consider planting would have a higher potential agricultural income, there is a large proportion of farms will not plant even when their potential forest income per hectare is higher.

Characteristics of farmers who might plant / will never plant

Table 3: *Farms in 2012 NFS Supplementary Survey farms categorised according to intention to plant and by relative Agriculture and Forest incomes under different NPV measures. Source: Ryan and O'Donoghue (2016).*

	Total	**NPV1 (GM incl. subs)**		**NPV2 (MGM)**	
		Ag >For	**For >Ag**	**Ag >For**	**For >Ag**
Might plant	15.8	9.7	6.1	5.8	10.0
Never plant	84.2	54.1	30.1	28.8	55.4
Total	100.0	63.8	36.3	34.6	65.4

The characteristics of the 16% of farms and farmers that might plant in the future depending on the financial incentives offered are most interesting for those interested in incentivising further afforestation:

- Those with higher agricultural income streams are intensive farmers: they had high FFI, high dairy stocking rates and large farms, making it unlikely that they would plant unless forest income streams were comparable to or greater than the income from agriculture.
- On the other hand, of those farms that might plant and that have higher forest incomes, almost half (on average) have an off-farm job. These farms also had less productive soils. Their willingness to consider afforestation is possibly a diversification strategy to optimise both their land and their time resources. Farms that participate in agri-environmental schemes and have a (Teagasc) extension contract are more likely to have forests.
- The results of additional regression analysis also show that the relationship between the relativity of income streams and the likelihood of considering forestry in the future is significant and positive indicating that those farms with higher forest incomes are more likely to (might) plant (for both methods of NPV calculation) (Ryan and O'Donoghue 2016). In addition, the most consistently positive explanatory variable in all the analyses reviewed in this paper is farm size. This is also the experience of other studies in the literature that have included farm size as a variable (Duesberg 2013, Howley 2015).

Utility maximisation

Using micro-level data, Ryan et al. (2015b) estimate structural choice models which consider the revealed preferences or utility maximising decisions of farmers in the pooled dataset, when presented with a range of (11) afforestation choices to plant from zero to 50% of their land. A behavioural choice model that assesses how farms maximise their utility when presented with choices to plant between 0 and 50% of their land, reveals that initial "hurdle" of moving from 0 to 5% afforestation is significant and that on balance, many farmers prefer to farm than to afforest land, even if the income from forestry is higher. There is solid evidence that the gain in (forest) income is not sufficient to off-set the decrease in agricultural income, perceived decline in wealth, loss of flexibility of land use and overall loss of utility derived from farming. In addition, while farmers have a preference for more income, the value that farmers place on income derived from agriculture is three times that of income derived from forestry Ryan et al. (2015b).

Discussion

The preferences for agricultural income, land value and hours worked reflect conclusions in the literature in relation to non-pecuniary benefits of farming (Howley et al. 2015, Key and Roberts 2009) and preferences for more flexible uses of land (Duesberg 2013), resulting in low uptake of planting choices.

The largest barriers to afforestation highlighted are the desire to farm and the permanence of afforestation. Critically, in relation to self-assessed land value, Ryan and O'Donoghue (2016) note that farms with forests reduce the self-reported land value after planting. This is likely to reflect the loss of flexibility of land use caused by the permanence of the land use change to forestry. In addition, for many farmers the afforestation decision involves a wider complex of contemporaneous multi-enterprise farm decisions. On a higher level, this involves lifestyle decisions about the future direction of the farm business.

We know from the literature that there is a growing recognition that farmers are motivated by a range of socio-economic factors and that financial gain may not be their core motivation for farming. The low uptake of policy incentives for woodland creation in the UK was examined by Lawrence and Dandy (2014) who find that insufficient financial incentives, the long term nature of the investment and socio-cultural factors act as barriers to uptake and conclude that socio-cultural factors have a larger role in the afforestation land use change decision than previously acknowledged.

The percentage of farmers that will not consider afforestation (84%), regardless of the financial incentives involved, is an important finding. The analysis undertaken by Ryan and O'Donoghue (2016) reveals that these are older farmers who would benefit financially from afforestation but for whom negative cultural attitudes appear to be stronger than financial drivers. This is however not surprising as annually, only 3-4% of NFS farmers state their intention to plant within a three year period (Ryan and Kinsella 2008).

On a more positive note, this analysis also identifies a cohort of large, younger farmers who might plant if the forest income is greater than the agricultural income. The analysis indicates that these farmers are likely to have larger farms and may have off-farm income but are also less aware of the permanence of the planting decision. However, this is not a homogeneous group although the farms display common characteristics around lifestyle decisions to optimise their land and time resources.

Policy options

In the context of trying to understand how to achieve an increase in afforestation rates, the analyses summarised here give us an appreciation of the challenges involved in increasing the uptake of afforestation incentive schemes. Drawing from economic theory, a number of potential options to mitigate such challenges can be suggested, as follows.

Providing environmental public goods

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.

Overcoming inertia

For many farmers, negative cultural or attitudinal values are deeply held and can outweigh the greater pecuniary benefits that may be offered by afforestation. Therefore monetary compensation for income foregone may not be sufficient to incentivise the change to a less preferred land use option. An approach to potentially overcome the attitudinal "hurdle" associated with, in the first instance, the consideration of afforestation, is the concept of the "compensating differential" (Carpenter et al. 2015) in the labour economics literature, which refers to the additional income that a worker must be offered as compensation to undertake less desirable tasks.

Scheme design –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 perhaps 40 years from planting. 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 a 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.

Risk management

Consideration could be given to the establishment of a state insurance scheme for forestry. State provision is justified on the basis of insurance market failures in the forestry sector. The availability of timber insurance in some countries demonstrates that the reduction of transaction costs by the government or by landowner associations is a possibility, and that this can assist the growth of the timber insurance business (Zhang and Stenger 2014). Following devastating losses caused by two winter storms in 1999 and 2009, proposals for legislation and a timber insurance programme have been made in France. However, Brunette and Couture (2008) suggested that governments should not provide direct compensation for forest damage as this would reduce incentives for risk management. They suggested that it is more appropriate for governments to offer aid to landowners who protect their assets through insurance. The question of whether governments might make insurance mandatory for private forest owners, thus reducing risk for insurers and lowering premium prices, is more controversial. So far, no country has adopted this approach (Zhang and Stenger 2014).

Linking afforestation and agricultural land use decisions

Effecting behavioural change can be a complex, time consuming process, particularly if adoption of a practice is voluntary. Vanclay and Lawrence (1995) found that when changes or innovations were unproven, and / or "contrary to accepted farming ways", adoption of new technologies/practices could be lower than anticipated. Vanclay (2004) states that different farmers have "different priorities, different understandings, different values and different ways of working". This is consistent with the research presented in this paper 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.

The analysis of other farm decisions that are contemporaneous with the planting decision illustrates that the afforestation decision seems to be part of a wider farm management decision and suggests that farmers may be more likely to plant if afforestation is linked to things they want to do on their farm. For example, in the early years of the pooled dataset examined, farmers, who would have generated higher incomes from agriculture than from forestry, were responsible for a large proportion of annual afforestation. This was driven by dairy farmers who wanted to expand their dairy production. In the 1980s, before quotas were ring-fenced, farmers had to buy both the quota and the land to which the quota was attached. In many cases where the land was not close to the home farm, farmers bought and afforested the land in order to acquire the attached dairy quota.

For many years, forest and agricultural subsidies were mutually exclusive. In recent years, changes to agri-environment schemes and direct payments have been favourable towards farm afforestation. However, incentives to date have been independent of other decision-making at farm level, although the recent COFORD (2016) report on land availability recognises the merits of a whole farm incentives approach. Linking forestry and agricultural incentives around actions such as the facilitation of land mobility and succession or the protection of watercourses using riparian buffer zones can provide for "win win" outcomes.

Linking carbon neutrality objectives

There are a number of "win win" methods to reduce or mitigate GHG emissions, such as the displacement of fossil fuels with wood biomass or improvements in the efficiency of food production utilising genetic technologies. However, even with the adoption of the suite of options in the carbon mitigation toolkit, it will be difficult for Ireland to meet its GHG reduction commitments from 2020 onwards. There is increasing policy pressure to explicitly motivate the linkage between expansion activities that generate carbon emissions such as dairy expansion and measures that mitigate these carbon emissions such as afforestation.

In 2015 Teagasc made a pre-budget proposal that linked a reduction in the tax-payable to expanding dairy farmers on the increase in value of their herd if it was offset by afforestation (either on their own land or another farmer's land) (Connolly et al. 2015). This would utilise the stock relief policy lever within the tax code. For the expansion to be carbon neutral, research suggests that one hectare of forest would need to be planted for every 5 additional livestock units (Lanigan and Richards 2014). This incentive of tax reductions associated with increasing stock values through stock relief has already been introduced as an incentive for behavioural change for young farmers and partnerships. It could also be considered for afforestation associated with carbon neutral dairy expansion.

Extension

The role of extension in the context of incentivising afforestation is highlighted by Bell et al. (1994) who report that indirect (extension) as well as direct (financial) incentives can lead to better uptake of forest programmes. An examination of the feasibility of structuring afforestation incentives to coincide with whole farm planning actions incentivising farm re-structuring or greenhouse gas mitigation, could overcome some of the barriers that currently hinder the land use change to forestry.

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 is a significant barrier to planting (McDonagh et al. 2010). This barrier is compounded by the high level of awareness of the permanence of the decision among farmers surveyed (Ryan and O'Donoghue 2016). The attachment to land in Ireland is evidenced by the fact that on average only half a percent of total land area changes hands in any given year (Ganly 2009). 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 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. 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 agricultural use. 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. 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 1990s reduced the general antipathy towards agri-environmental programmes, significantly changing attitudes and participation levels (Murphy et al. 2014).

Establishment costs of second and subsequent rotations

Providing for re-establishment costs 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.

Differential land availability

An additional 510,000 ha of afforestation would be required to achieve the 18% forest cover target by mid-century (COFORD 2016). The analyses summarised in this paper show that soil type is an important physical driver of both the economic return to afforestation and the agricultural opportunity cost of farm afforestation. Ryan and O'Donoghue (2016) further report that fibre and sequestration demands can be optimised on land which is not necessarily economically attractive for agriculture. Farrelly and Gallagher (2016) identified a total of 423,000 ha of wet grassland and unimproved land that occurs on the margins of productive agricultural land and in marginal agricultural areas that is suitable for afforestation. However, this research shows that under the current policy incentives, a large proportion of farmers are not prepared to consider afforestation.

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 renewal 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) recognises the differential capacity of different soils and environmental conditions to sustainably intensify land-based production of food, fibre and ecosystem services. However, new land use policies and objectives should aim to span multiple Common Agricultural Policy (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.

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