# Heterogeneous Economic and Behavioural Drivers of the Farm Afforestation Decision

**Mary Ryan, Cathal O'Donoghue,**
**Vincent Upton, Michel Handgraaf**
*Teagasc Rural Economy and Development Programme*

**Contributed Paper prepared for presentation at the 89th Annual Conference of the Agricultural Economics Society, University of Warwick, England**
**13 - 15 April 2015**

**Heterogeneous Economic and Behavioural Drivers of the Farm Afforestation Decision**

**Mary Ryan[1]*, Cathal O'Donoghue*, Vincent Upton***

*** Teagasc Rural Economy and Development Programme**

## Abstract

In the context of incentivising farm afforestation to provide ecosystem services such as carbon sequestration to mitigate greenhouse gas production, this paper sheds new light on the complexity of the farm afforestation decision and the characteristics of the farms and the farmers who are likely or unlikely to afforest land. Using a panel dataset of farm level micro-data, we observe whether farming intensity changes as a result of planting. We generate forest and agriculture income streams and employ a life-cycle theoretical framework to analyse the relative importance of agricultural and forest financial drivers in the decision-making process at farm level. We find that for many farmers the afforestation decision involves a wider complex of contemporaneous farm decisions. We find that there is a relationship between financial drivers and the likelihood of planting but we also find that there is a cohort of older smaller farmers that will never plant, and for whom negative cultural attitudes are stronger than financial drivers. We also identify a cohort of large, younger farmers who might plant if the forest income is greater than the agricultural income. This paper describes the farm and farmer characteristics of these cohorts and concludes that a "one size fits all" programme based solely on financial incentives may not be the most appropriate means to encourage further farm afforestation.

Key Words: Afforestation decision, life-cycle analysis, afforestation policy incentives

[1] Corresponding Author. Mary.ryan@teagasc.ie

**Heterogeneous Economic and Behavioural Drivers of the Farm Afforestation Decision**

## 1. Introduction

The conversion of land from agriculture to forest involves a complex decision-making process and the influencing factors can be difficult to isolate. Nevertheless it is an important policy objective across many EU countries (EU Commission 2013). The decision to plant involves a major land use change from a relatively flexible pastoral agricultural enterprise to locking the land into an alternative enterprise for the foreseeable future. It entails the foregoing of an annual agricultural income and agricultural subsidies and replacing it with forest subsidies and a long-term forest income. In this paper, we try to unpick the complexity of the decision, understand the farm level and behavioural characteristics that influence this inter-temporal land use change and arrive at some policy recommendations.

Many western European countries, have had extensive policy supports to incentivise farmers to afforest agricultural land, although the success has been relatively modest in countries such as Belgium, Netherlands, Ireland, Wales, Scotland and England (Van Gossum et al. 2010 and 2012; Edwards and Guyer 1992; Forestry Commission 2013). While the drivers of these policies are based on the multifunctional timber and ecosystem benefits provided by forests, the potential for afforestation to mitigate agricultural greenhouse gases has recently gained in prominence[2]. 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). Ireland's recent forest policy review (DAFM 2014a) calls for an afforestation rate of 15,000 ha/yr to avoid a significant supply slump in future wood supply. Analysis of the impact of afforestation rates on forest sinks in Ireland shows a significant fall off in the strength of the forest sink post 2035. In order to attenuate this, annual afforestation rates would need to be maintained at around 10,000 ha for the period up to 2035 and beyond (Hendrick and Black 2008). However, despite significant and prolonged financial incentive programmes aimed primarily at farmers, annual afforestation in Ireland has consistently been below 7,000 hectares in recent years (DAFM 2014b).

Much has been written about the diversity of landowners towards forestry Beach et al. (2005) synthesise much of the literature in a meta-analysis of econometric studies of private forest owners. They identify four factors driving decision-making among forest owners: owner characteristics and preferences; soil type and plot size; policy variables that affect the forest investment decision; and costs and returns from forestry and alternative enterprises. Their analysis refers to both afforestation and forest management but shows that while country specific studies differ in the relative importance of these factors, there is strong commonality around the drivers of the afforestation decision.

A recent synthesis of the literature carried out by Lawrence and Dandy (2014), explores 42 studies on the decisions and behaviours of private forest owners internationally in order to understand the factors behind the low level of uptake of policy incentives for both woodland creation and woodland management in the UK. In relation to afforestation/woodland creation, common factors include insufficient financial incentives, the long time period involved in forest, and a cultural gap between farming and forestry that often manifests as a resistance to

---

[2] The 2014 European Council agreement on climate and energy targets for 2030 (EUCO 169/14) will bring increased focus on the greenhouse gas (GHG) mitigation potential of agriculture. The agreement recognises the contribution of agriculture through both GHG mitigation and carbon sequestration.

forest (Lawrence and Dandy 2014). The review concludes that a land use change such as afforestation is more widely embedded in socio-cultural factors than previously acknowledged.

In summary, it would appear that much of the literature around forest owners' attitudes and behaviour relate to forest management decisions, rather than the attitudes and behaviours around the actual planting decision. In addition, many of the studies that relate to the afforestation decision tend to have a narrow focus on either the economic or socio-cultural aspects of the decision and treat the decision as a straightforward land use substitution. We would like to explore whether (a) the decision may actually involve a more complex interaction of financial, physical and socio-cultural factors than has been previously considered in the literature and (b) whether a disaggregation of the components of agricultural and forest income streams would reveal new information on the role of financial drivers in the overall decision. Using Ireland as a case study, this paper investigates the interaction of the financial, physical and socio-cultural components of the afforestation decision using farm level data. We focus primarily on the complexity of the afforestation decision at individual farm level and the relative importance of financial drivers and socio-cultural barriers.

First we define a theoretical framework to suit the context of the afforestation decision based on international literature and adapting existing frameworks to suit the factors involved in the decision making process around the land use change from agriculture to forest. In the methodology and data sections we generate forest datasets using a forest subsidies model and a forest bio-economic model developed by the authors and utilise a panel dataset of farm level micro data to generate farm incomes and subsidies. We characterise farmers who have planted according to the level of farming intensity after planting. We generate summary statistics to analyse the characteristics of farms and farmers whose forest income on a per hectare annual basis is greater than their agricultural income and estimate regression models using net present value (NPV) to incorporate the life-cycle financial attributes in terms of relative income streams of planting/not planting. We also analyse the characteristics of those who will never plant and use these variables to estimate binary logit models to examine the characteristics of those farms that have higher forest income streams. Ultimately we draw conclusions about the types of farms and farmers that are primarily motivated by financial drivers.

## 2. Theoretical Framework and Literature Review

The physical and environmental characteristics of the farm have a large influence on the planting decision. Previous studies have highlighted the overall size of the farm as a determinant of the likelihood of planting (Ryan and Kinsella 2008; Howley 2012; Upton 2013) as farms with spare capacity are more likely to afforest land. These studies also indicate that most farmers plant only a relatively small portion of their farms (in recent years, the average area planted is 9 ha (DAFM, 2014b)). Land quality is also a factor in that farmers are more likely to plant land that is unproductive or difficult under agriculture but may be more productive under forest (Ni Dhubhain and Gardiner 1994; Duesberg et al. 2012 and 2013). We also know from existing literature that many farmers simply wish to continue farming and display a negative cultural bias towards planting land (Watkins et al. 1996; Howley 2012; Duesberg 2013, 2014; Beach 2005).

Commercial forestry is less reliant on site quality than other potential land uses and high productivity levels can be attained in areas considered marginal for agriculture. The returns to agriculture on a given farm type also depend on the intensity (measured as Livestock Units LU/ha) and efficiency of management and on the agricultural subsidies available (e.g. Less Favoured Area payments, Single Farm Payment, Agri-environment (AE) Scheme payments.

On the forest side, the availability of afforestation grants and premium payments for farmers makes forestry a financially attractive enterprise for many farmers but particularly for those engaged in extensive livestock rearing (Breen et al. 2010; Upton et al. 2013). For this reason, this paper will focus on livestock enterprises.

Many agricultural economic models assume that farmers are rational profit maximisers (Edwards-Jones 2006). However, while financial gain is important it may not be the core motivation for farming. There is a growing literature on the psychology of farmer's decision-making (see Edwards-Jones 1998; Willock et al. 1999; Edwards-Jones 2006). In specifically addressing the motivations of farmers undertaking afforestation, Key (2005) and Key and Roberts (2009) describe how attributes associated with farming such as independence and pride associated with business ownership are valuable to farmers and these attributes may not be achievable in other work areas. Howley et al. (2015) found that positive perceptions regarding lifestyle benefits associated with farming may act as a barrier for farmers in taking up off-farm employment.

This leads to the consideration of the consequences of farm afforestation on livestock farms and may give some insight into the longer term motivations and plans of farmers who afforest part of their grazing land. What happens as a result of planting? Does the farmer reduce livestock numbers (de-intensify) or wind-down Or do efficient farmers see the afforestation decision as an opportunity to optimise the return from marginal land and increase livestock density on the reduced area (intensify)? Or do farmers see afforestation as a practical and economic trade-off and maintain the status quo in terms of intensity after planting? Analysis of the change in intensity of farming after planting could reveal valuable information on the motivation for afforestation.

Afforestation implies investment in a land resource and disinvestment in other land-use activities. In the case of farm afforestation, farmers must consider the opportunity cost of the land use change. A fundamental criterion for choosing forestry over alternative land uses is that forestry provides the largest land rent i.e. the biggest average return per hectare per year (Helles and Lindaal 1996). Moreover, while financial objectives such as maximising profits are important to farmers, they may not in many instances be the core or the sole motivation for farming (Vanclay 1992). Vanclay (2004) highlights the importance of the socio-cultural nature of farming as the primary motivating factor for farmers …"farming becomes a way of life". Vanclay's second principle maintains that different farmers have "different priorities, different understandings, different values and different ways of working" (Vanclay 2004). These characterisations of farmers highlight the range of motivations and the heterogeneity of farm and farmer characteristics that could influence the afforestation decision.

In addition to these financial, physical and socio-cultural factors, the afforestation of agricultural land is further complicated by the long-term nature of the decision (Newman et al. 1993; Ananda and Herath 2009; Alig et al. 1999; Adams et al. 1996). Farmers who plant are essentially making an inter-temporal choice by electing to have their land and capital tied up for a period of from 30 to 100 years (depending on soil quality and tree species planted) and is essentially an irreversible decision. A financial decision is considered "irreversible "if it reduces for a long time the variety of choices that would be possible in the future" (Henry 1974). Because of the inter-temporal nature of this decision, we need to analyse the financial consequences of different land use choices available to the farmer using an approach that looks at the decision as a life-cycle investment.

The theoretical framework adopted in this paper draws on the life-cycle model originated by Modigliani and Brumberg (1954) and focuses initially on the financial drivers of the farm afforestation, rather than the behavioural decision. Although the classic life-cycle theoretical framework has been in existence for many years, it is widely used today and is still largely consistent with the theory of consumer choice (Deaton 2005). The theoretical framework was developed around life-cycle decisions based on the underlying assumption that people make rational, consistent, inter-temporal plans, that they act as if they are maximizing a utility function defined over the periods of life. This hypothesis continues to provide the framework in which economists think about inter-temporal issues as it has "a generality that accounts for much of its durability" Deaton (2005). In this context, we use farm level characteristics to look at both agricultural and forest income streams on the basis of the relative life-cycle income accruing to the farmer from choosing to either remain in agriculture or convert the land (permanently) to forestry. Using the life-cycle approach enables us to incorporate net present value (NPV) as an explanatory variable in our analysis. In this analysis we explore three distinct hypotheses:

1. The conversion of agricultural land to forestry is a straight-forward land use substitution decision

2. There is a relationship between the relative incomes from agriculture and forestry and the likelihood of planting.

3. The cultural beliefs associated with the decision are not affected by financial factors.

The variables included in our life-cycle model include financial incentives, land quality, opportunity cost of planting, farm consequences of planting, along with a range of socio-economic farm and farmer characteristics. Using these variables we characterise farms with forests on the basis of subsequent livestock density change. We explore how the productivity of farms dictates the financial potential for either agriculture or forestry and we investigate whether farmers who would "never plant" are influenced by financial return or whether their reluctance is simply a cultural factor. From the literature we also expect factors such as farm system, Family Farm Income (FFI/ha), intensity of farming measured as livestock units (LU)/ha, farm size and farmer age to be significant in relation to afforestation.

## 3. Methodology

In planting land, farmers forego the agricultural market income (gross margin) and farm subsidies relating to that area of land and are incentivised to do this by the forest market income and forest subsidies available for that land quality. Market gross margin (GM) is defined as gross output minus direct costs and is reported at the farm level as opposed to the enterprise level. The assumption therefore is that a farmer who afforests land would reduce average land use equally across all their enterprises, rather than selecting their lowest gross margin enterprise. In reality, farmers plant areas of land that are marginal for agricultural production, outlying/fragmented parcels and areas that are steep or difficult to manage. In relation to opportunity cost, this essentially means that farmers planting a portion of their land still retain the overhead costs that relate to the farm as a whole as they continue with their former agricultural enterprises. The purpose of this paper is to relate the forest planting decision and other contemporaneous farm decisions to the heterogeneous characteristics of farms. In summary we have identified a number of drivers in the literature that are relevant to the forest planting decision:

- Change in farming intensity after planting
- Financial incentives
- Quality of land
- Opportunity cost of planting
- Irreversibility of afforestation decision
- Socio-cultural attitudes towards afforestation.

*Developing Net Present Value Estimates of the Opportunity Cost of Afforestation*

Key to understanding the financial drivers within an inter-temporal decision is the calculation of the net present value of a marginal change in land use to forest. This paper employs a cost benefit analysis (CBA) to generate cost and revenue streams for livestock farm systems on a range of soil types reflecting four conifer forest productivity options. Agricultural and forest life-cycle income streams are presented as the net present value (NPV) of income which discounts the costs and revenues that occur during the rotation to present day value to allow for the comparison of net revenue streams assuming the same or broadly similar investment periods. This paper considers pre-tax incomes only and does not take into account the preferential tax treatment of afforestation subsidies as this would involve additional complexity. In order to generate life-cycle income flows for the afforestation decision, there are essentially four components that drive agricultural and forest income (NPV) over time. These are:

- market income and farm subsidies on the agricultural side; and
- market income and forest subsidies on the forest side.

Income measures such as Family Farm Income (a measure of Total Income) are often used as a proxy to represent farm incomes (Hennessy et al. 2013). However, we disaggregate the individual components of farm and forest income to more accurately reflect the incomes and opportunity costs of the land use decision. Thus our model contains separate sub modules for each of the four financial drivers. All four income streams are analysed on a per hectare basis to allow for comparison.

*Net Impact of Forest Decision*

For the purposes of this study, we calculate the net present value (NPV) of the actual income stream and the opportunity cost for the period to the first harvesting and second planting. This period $n_j$ for farm j depends upon the soil conditions of the farm. Although the afforestation decision is permanent, the time period is sufficiently long at 40+ years to the first harvesting that this approximation is sufficient.

We assess the opportunity cost of afforestation by comparing the total income from planting that hectare relative to the existing farm activity. Total income can be defined as follows:

$$Total\ Income = Market\ Gross\ Output + Subsidies - Direct\ Costs - Overhead\ Cost$$

As farm afforestation generally takes place on an existing farm with existing overheads, (primarily in relation to pre-existing sunk costs), the overhead costs for afforestation should also include a component to account for the farm enterprise. Specifically therefore for the forest enterprise, we can define

$$\begin{aligned}Total\ Income = {} & Market\ Gross\ Output + Subsidies - Direct\ Costs \\ & - ForestryOverhead\ Costs - FarmOverhead\ Costs\end{aligned}$$

To summarise, this can be defined as

$$Total\ Income = Net\ Margin\ + Subsidies - FarmOverhead\ Costs$$

In order to assess the sensitivity of the method of calculation of opportunity cost, we employ three different assumptions for calculating the NPV of the afforestation decision. The net cost of planting assumes full substitution. The most comprehensive definition incorporates the NPV of Forest Market Income (net margin) less Overhead Costs plus Forest Subsidies, treating the opportunity cost as the Gross (market) Margin (defined as Output minus Direct Costs) less Overhead Costs plus Farm Subsidies. All amounts are expressed on a per hectare basis and discounted at a rate *r*.

$$\boldsymbol{NPV\_ha_j^0} = \left(\left(\sum_{t=0}^{n_j} \frac{ForestNM_{\_ha_j}}{(1+r)^t} - \sum_{t=0}^{n_j} \frac{FarmOheadCosts_{\_ha_j}}{(1+r)^t}\right) + \sum_{t=0}^{n_j} \frac{ForestSubsidy_{\_ha_j}}{(1+r)^t}\right) - \left(\left(\sum_{t=0}^{n_j} \frac{GM\_ha_j}{(1+r)^t} - \sum_{t=0}^{n_j} \frac{FarmOheadCosts\_ha_j}{(1+r)^t}\right) + \sum_{t=0}^{n_j} \frac{FarmSubsidy\_ha_j}{(1+r)^t}\right)$$

However, we know that farmers plant only a portion of their farms, therefore, a farmer wiill still incur agricultural overhead costs on a per hectare basis after planting. However, these costs cancel each other out and on this basis, $NPV^0$ (GM+Subs-OH) simplifies to $NPV^1$ (GM+Subs).

$$\boldsymbol{NPV\_ha_j^1} = \sum_{t=0}^{n_j} \frac{ForestNM_{\_j}}{(1+r)^t} + \sum_{t=0}^{n_j} \frac{ForestrySubsidy_{\_ha_j}}{(1+r)^t} - \left(\sum_{t=0}^{n_j} \frac{GM\_ha_j}{(1+r)^t} + \sum_{t=0}^{n_j} \frac{FarmSubsidy\_ha_j}{(1+r)^t}\right)$$

As previous research has also shown, the level of afforestation has been affected by the range of agricultural and forest subsidies available to farmers (Ryan et al. 2014). The farm gross margin excludes subsidies, even prior to decoupling when subsidies were coupled to production. In general terms, agricultural subsidies were historically paid on the basis of livestock numbers and were not paid on afforested land. For the purpose of this analysis it is presumed that a farmer who afforested land prior to the introduction of Single Farm Payment (SFP) in 2005 would only have considered forestry if he/she was farming extensively and had scope to carry existing livestock numbers on less land, thereby not suffering a significant loss in subsidies which were based on animal numbers. However, farmers planting since 2000 were able to consolidate their single farm payment entitlements and farmers planting land since 2008 are eligible for full SFP. The Disadvantaged Area Scheme (DAS) was based on the area of land farmed up to a maximum threshold. Once farmers didn't drop below the area threshold, planting some land would not have negatively affected their payment.

On the other hand, farmers in an Agri-Environment (AE) scheme (REPS - Rural Environment Protection Scheme) who planted some of their land, would have lost REPS payments on that land. Larger REPS farmers would have been more likely to plant as the REPS payment decreased as agricultural area increased, so larger farmers would stand to lose a smaller proportion of the REPS payment. The possible loss of REPS however, was considered to be a factor in the reluctance of many farmers to plant (Breen et al. 2010). It is recognised that the exclusion of the consequential change in agricultural subsidies and direct payments as a result of afforestation is a limitation of this study, but inclusion would be complex and is beyond the scope of this paper. Therefore we also we also consider a version of the net present value, $NPV^2$ (GM) which ignores farm level subsidies. This will enable us to test the effect of the inclusion/exclusion of agricultural subsidies in the calculation of the opportunity cost.

$$\boldsymbol{NPV\_ha_j^2} = \sum_{t=0}^{n_j} \frac{ForestNM\_ha_j}{(1+r)^t} + \sum_{t=0}^{n_j} \frac{ForestSubsidy_{\_ha_j}}{(1+r)^t} - \sum_{t=0}^{n_j} \frac{GM\_ha_j}{(1+r)^t}$$

We would also expect to observe a cohort of farmers who choose not to plant, regardless of the relativity of forest and agricultural income streams. From the literature and drawing on previous work based on average incomes across farm systems (Breen et al. 2010, Upton et al. 2013), we expect higher income dairy farmers to intensify and we expect older farmers with large farms to de-intensify. Additional information is available from an NFS Supplementary Survey conducted in 2012, which sheds more light on the characteristics of these farms. We utilise all of these variables to estimate logistic regression models of the characteristics of farms that might plant/will never plant in relation to their relative forest and agricultural incomes. Finally, we examine the consequences of planting in relation to the decision to intensify or de-intensify agricultural production on the remaining land.

*Forest market income and subsidies*

We need to model forest market income streams which reflect the soil quality and consequent timber yields on individual farms, therefore we need to utilise a model that applies relevant timber prices over time to timber yields to generate the life-cycle income streams. The Teagasc Forest Bioeconomic Model BEM was developed to generate forest market income streams on the basis of soil productivity. Land quality dictates the type of enterprise possible and its level of profitability. Forestry is frequently identified as a robust land-use option that is less restricted than agriculture by poor site conditions. The fact that much of Ireland's forests exist on poorer quality sites is a result of both state policy and land-owner decision-making (Upton et al. 2014). In order to capture the relative productivity of land under agriculture and forestry, the forest BEM utilises a classification of Teagasc National Farm Survey (NFS) soil categories which translates these into forest productivity (yield class) estimates (Farrelly et al. 2011) as presented in Table 1.

**Table 1. Forest Yield Classes equivalent to Teagasc NFS soil categories**

| Soil Category | | Soil Description | Associated Yield Class |
|---|---|---|---|
| 1 | Wide | No limitations | 24 |
| 2 | Moderately wide | Minor limitations | 24 |
| 3 | Somewhat limited | Higher elevations, heavier, poorer structure | 20 |
| 4 | Limited | Poor drainage | 20 |
| 5 | Very limited | Agricultural potential greatly restricted | 18 |
| 6 | Extremely limited | Mountainous, steep slopes, shallow soil | 14 |

The forest BEM generates timber yield, cost and income projections across a range of species and soil types using yield models (Edwards and Christie 1981). The inputs include forest establishment and maintenance costs, afforestation subsidies, harvested timber volumes and ten year average timber prices. Income streams are presented in terms of NPV. On the farms that chose to afforest, forest market income streams are generated on the basis of planting 80% Sitka spruce (Picea sitchensis (Bong.) Carr.) and 20% Japanese larch (Larix kaempferi

(Lamb.) Carr.), which is the most commonly planted forest composition over the period (DAFM, 2014b).

The forest subsidy model developed by Ryan et al. (2014) captures the historical and current forest subsidy payments paid to farmers for the relevant species category of forest over the period 1984 to 2012.

*Modelling Choices*

Thus we have sufficient information to determine NPV's for the forest/agriculture actual choices made on farms. However, we would like to investigate whether individual farms would generate higher income streams from agriculture of from forest given the physical and production constraints of the farm. One way to achieve this is to use microsimulation techniques to generate income streams to represent the alternative choices. Microsimulation models are evaluation tools that generate synthetic micro-level data which represent counterfactual situations that would prevail under alternative conditions, *ceteris paribus* (O'Donoghue 2014). A variety of models have been developed internationally that have simulated biological, market and policy changes at farm-level that can be used to compare the relative competitiveness of different farming systems, (Thorne and Fingleton 2006) and are particularly suitable where there is a paucity of micro data such as in relation to organic farming (Zander et al. 2007). Here we utilise a microsimulation model to generate forest income streams for the farms that chose not to plant (on a per hectare basis) based on planting between 10 and 20% of total farm area. We also generate agricultural income streams for farms that afforested land and also bring them to a 10-20% forest share.

## 4. Data

From the literature, we know that there is a multitude of factors involved in the afforestation decision. In order to understand the relativity of the drivers of planting behaviour over time, while incorporating heterogeneous characteristics, we need the following data:

- Complementary actions at the time of planting re intensification/de-intensification.
- Existing farms with forests
- Existing farms without forests
- Financial factors of agricultural decisions
- Financial factors of forest enterprise
- Socio-economic and environmental characteristics of farms
- Attitudes towards forestry

As we would like to understand contemporaneous decisions at the time of planting to inform the degree to which forestry is merely a substitute land use or given the fact that resources are under-utilised it can form part of an intensification or diversification strategy, we require a panel dataset. Given the relatively low planting rate of about 1% of farms per year and because of the desire to incorporate market and policy variability, it is necessary to combine data from a number of years.

*Teagasc National Farm Survey (NFS)*

The primary data source, containing most of the attributes required for our analysis, is the Teagasc NFS which is Ireland's contribution to the EU Farm Accountancy Data Network (FADN) and collects detailed information from a representative sample of farms in Ireland. Data from approximately 1,000 - 1,200 farms are collected each year and farm systems are classified into enterprises defined in Commission Decision 78/463 and its subsequent amendments. The study utilizes a time series of NFS micro data from 1984 to 2012 inclusive which contains farm and farmer characteristics of farms that chose to afforest land over the period as well as those that chose not to afforest. NFS data are used to generate long-term agricultural cost and revenue streams for each of six agricultural systems (dairy, cattle rearing, cattle other, sheep, tillage and mixed livestock) on six soil types. In this paper, we focus primarily on livestock farms during the period from the early 1990's when policy incentives were developed at farm level (Ryan et al. 2014). The consumer price index (CPI) for 2013 is applied to all incomes to make them comparable.

As the annual survey primarily collects farm rather than forest data, some data cleaning was required to prepare the dataset. The farm survey records data in relation to farm forests in terms of hectares of land planted along with forest subsidy payments, however, there are some instances, where farms have forest hectares in time t and time t+2, but not in time t+1. Given the irreversibility of forest planting, we clean the data by imputing forest hectares for these missing years.

In 2012, we also collected a supplementary survey to understand basic attitudinal drivers of the land use change to forest. The sample asked a number of additional questions which included whether farmers would plant if financial incentives were increased and whether they were aware of the permanency of the afforestation decision. In order to incorporate these into the analysis, we can only consider the set of farms that were contained in the survey in 2012.

*Agricultural market income and subsidies*

Actual farm micro panel data, described below are used to calculate farm incomes per hectare. As outlined above we calculate three versions of the farm level opportunity cost incorporating respectively, family farm income, total gross margin and market gross margin. Market gross margin is calculated as farm market gross output less direct costs such as fertilisers and feed stuffs, and is a common measure of agricultural profitability. The GM values used in the calculations are net of subsidies. Total Gross Margin incorporates subsidies, while Family Farm Income subtracts fixed overhead costs (Hennessy et al 2013). For the purpose of this analysis, we use two methods of calculating the agricultural opportunity cost:

- $NPV^{1}$ is comprised of market gross margin plus agricultural subsidies
- $NPV^{2}$ is comprised of farm market gross margin only.

*Summary Statistics: Relativity of forest and agriculture life-cycle income streams*

Our first disaggregation is into farms on the basis of whether the agricultural or forest income streams are greater over time for each farm in the population (Table 2). This categorisation is the nub of our analysis as we believe that the relativity of these income streams is a major driver in the afforestation decision. Therefore we generate the variables *Ag>For* and *For>Ag* where forest income streams are defined as annual equivalised NPV of market + subsidy income on a per hectare basis and agricultural income streams are defined as annual equivalised NPV of market farm GM/ha. Farms are further categorised on the basis of having farm forests or not. Because we believe that these variables are critical in enabling our understanding of afforestation behaviour, we would like to test the sensitivity of calculation method of gross margin. The impact of subsidy payments on agricultural incomes is explained by the variable For>Ag $NPV^{1}$ which includes agricultural subsidy payments and is calculated as market GM plus subsidies/ha. For the variable For>Ag $NPV^{2}$, only market farm gross margin (GM)/ha is considered.

**Table 2. Relativity of agriculture and forest incomes contingent on the presence of farm forest**

| | NPV[1] – GM+Subs | | NPV[2] - GM | |
|---|---|---|---|---|
| | Frequency | Per cent | Frequency | Per cent |
| Ag>For / No For | 26,823 | 72 | 19,715 | 53 |
| Ag>For / Has For | 4,059 | 11 | 2,772 | 7 |
| For>Ag / No For | 5,454 | 15 | 12,562 | 34 |
| For>Ag / Has For | 874 | 2 | 2,161 | 6 |
| Total | 37,210 | 100 | 37,210 | 100 |

Note: Income Components are on a per hectare basis. We adjust NPV's to annualised definition, by dividing by $\sum_{t=0}^{n_j} \frac{1}{(1+r)^t}$, varying with the forest rotation for the relevant yield class and soil type.

Only 13% of farms in the longitudinal dataset have forests. We see that the majority of farms have higher agricultural incomes yet haven't afforested land. This is consistent with *a priori* expectations as these farms have a high opportunity cost of planting. We also note that the method of calculation of the opportunity cost of planting seems to have an impact on the income streams as 60% of farms have higher agricultural streams when agricultural subsidies are not taken into account whereas this rises to 83% when subsidies are included. The next largest group has higher forest incomes but these farms don't have forests. The smallest group describes farms where the forest income is higher than the agricultural income but these farmers have forests. It would appear from Table 2 that the calculation of NPV is sensitive to the inclusion of subsidies as the percentage of farms with higher forest incomes drops from 40% (NPV[2]) to 17% when agricultural subsidies are taken into account (NPV[1]). However, this may not be statistically significant.

*Summary Statistics: Farms with and without Forests*

Next we look at the characteristics of the farms with and without forests as presented in Table 3. Farms with higher agricultural income have the highest family farm income (FFI) per hectare (FFI) and the largest number of dairy livestock units (LU) and hours worked on-farm. These are the most intensive farmers who have the highest opportunity cost of converting land from an agricultural enterprise to forest. The highest (self-reported) land value is reported by farms that have a higher agricultural income and don't have a forest and the lowest land value is reported by farms with higher forest income, who have already planted. Those farms with forests are larger and are more likely to participate in Agri-Environment (AE) schemes (i.e. REPS) and are more likely to have an extension contract (with Teagasc – Agriculture and Food Development Authority in Ireland).

**Table 3. Summary Statistics Relative to Has Forest/No Forest**

| | Aware of Irreversibility | Land Value (logged) | Farm FFI € per ha | Dairy LU per ha | Labour Units | Av Age | Farm Size | Teagasc client | Has REPS | Has Off-Farm Job | Medium Soil | Best Soil | Worst Soil |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ag>For / No For[3] | 0.28 | 1.06 | 657.5 | 0.9 | 1.2 | 51 | 35.4 | 0.46 | 0.23 | 0.27 | 0.39 | 0.53 | 0.08 |
| Ag>For / Has For | 0.34 | 1.00 | 626.9 | 1.1 | 1.4 | 50 | 54.6 | 0.59 | 0.30 | 0.15 | 0.35 | 0.56 | 0.09 |
| For>Ag / No For | 0.22 | 0.87 | 229.2 | 0.05 | 0.9 | 56 | 32.3 | 0.35 | 0.35 | 0.42 | 0.44 | 0.41 | 0.15 |
| For>Ag / Has For[4] | 0.37 | 0.82 | 275.3 | 0.09 | 1.1 | 55 | 51.8 | 0.52 | 0.41 | 0.34 | 0.45 | 0.41 | 0.14 |

[3] Agricultural income greater than Forest income – No Forest on farm
[4] Forest income greater than Agricultural income – Has Forest

Note: Income Components are on a per hectare basis. We adjust NPV's to annualised definition, by dividing by $\sum_{t=0}^{n_j} \frac{1}{(1+r)^t}$, varying with the forest rotation for the relevant yield class and soil type. Assumption: Opportunity Cost based on market Gross Margin ($NPV^2$ (GM))

The characteristics of the cohort of farms with greater forest income but who haven't planted is particularly interesting. These farms are the smallest on average, are least likely to participate in AE schemes or have an extension contract, are the oldest farmers, work least hours and are more likely to have an off-farm job. This cohort also has a much lower average Family Farm Income FFI, and would be better off financially if they were to afforest a portion of their land, but they haven't done so. This apparent contradiction or irrationality has been commented on previously in the literature (see Breen et al. 2010, Upton et al. 2013, Howley et al. 2012 & 2015).

*Summary Statistics: Characteristics of farmers who Might/ will Never Plant*

As previously discussed, there is a wide divergence in attitudes among farmers towards afforestation in the literature. One of the negative attitudes is a cultural bias against forestry. On this basis we would expect to observe a cohort of farmers who choose not to plant, regardless of the relativity of forest and agricultural income streams. An examination of the data from the 2012 NFS supplementary survey shows that almost two thirds of farms will never plant even when the forest NPV is higher than the agricultural NPV (Table 4). Just over one third of farms would consider planting in the future, depending on the level of subsidy offered. We also see an impact of the inclusion of agricultural subsidies in the NPV calculation. When subsidies are not specifically taken into account, the percentage of farms with higher forest income is considerably larger.

**Table 4. Farms in 2012 NFS Supplementary Survey farms categorised according to intention to plant and by relative Agriculture and Forest incomes under different NPV measures**

| | Total | Ag >For | For>Ag | Ag >For | For>Ag |
|---|---|---|---|---|---|
| | | $NPV^1$ (GM+Subs) | | $NPV^2$ (GM) | |
| Might plant | 36.5 | 30.2 | 6.3 | 18.1 | 18.5 |
| Never plant | 63.5 | 55.4 | 8.1 | 35.5 | 27.9 |
| Total | 100.0 | 85.6 | 14.4 | 53.6 | 46.4 |

On the basis of this information, we also generate a *mightplant/neverplant* variable to categorise farms on the basis of those farms who might plant and those who will never plant. To get a deeper understanding of the impact of these financial drivers, we re-categorise these farms relative to their respective forest and agriculture income streams and present the results in Table 5.

**Table 5. Summary Statistics Relative to Might Plant/Never Plant**

| | Aware of Irreversibility | Land Value per ha | Farm FFI/ha | Dairy LU per ha | Labour Units | Av Age | Farm Size | Teagasc client | Has Reps | Has Off-Farm Job | Medium Soil | Best Soil | Worst Soil |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ag>For / Might Plant | **0.23** | **1.19** | **810.1** | **0.9** | **1.1** | **54** | **51.2** | **0.63** | **0.29** | **0.23** | **0.25** | **0.68** | **0.07** |
| Ag>For / Never Plant | **0.78** | **1.09** | **804.9** | **0.8** | **1.2** | **55** | **49.5** | **0.63** | **0.28** | **0.20** | **0.32** | **0.62** | **0.06** |
| For>Ag / Might Plant | **0.19** | **0.84** | **291.0** | **0.07** | **1.01** | **54** | **47.7** | **0.52** | **0.29** | **0.44** | **0.38** | **0.38** | **0.24** |
| For>Ag / Never Plant | **0.69** | **0.95** | **266.5** | **0.04** | **1.06** | **58** | **42.0** | **0.45** | **0.24** | **0.32** | **0.44** | **0.42** | **0.14** |

Note: Income Components are on a per hectare basis. We adjust NPV's to annualised definition, by dividing by $\sum_{t=0}^{n_j} \frac{1}{(1+r)^t}$, varying depending with the planting cycle for the relevant yield class and soil type. Assumption: Opportunity Cost based on market Gross Margin (NPV$^2$ -GM)

First we examine the characteristics of the farms that have higher agricultural income streams. Whether these farms would consider forest or not, they show similar trends. These farms have high family farm income (FFI/ha), high land values and high dairy stocking rates, all of which make it unlikely that they will consider a land use change to afforestation as the opportunity cost of agricultural income foregone is high for these farms. These are on average the most intensive farms and are likely to continue in agriculture.

The cohort of farms that will never plant despite having higher forest income streams also present a definite pattern. These farms have the lowest FFI/ha, the smallest farm size, the lowest livestock numbers and are the oldest farmers on average. These farms are the least intensive and display a strong negative cultural bias against forestry.

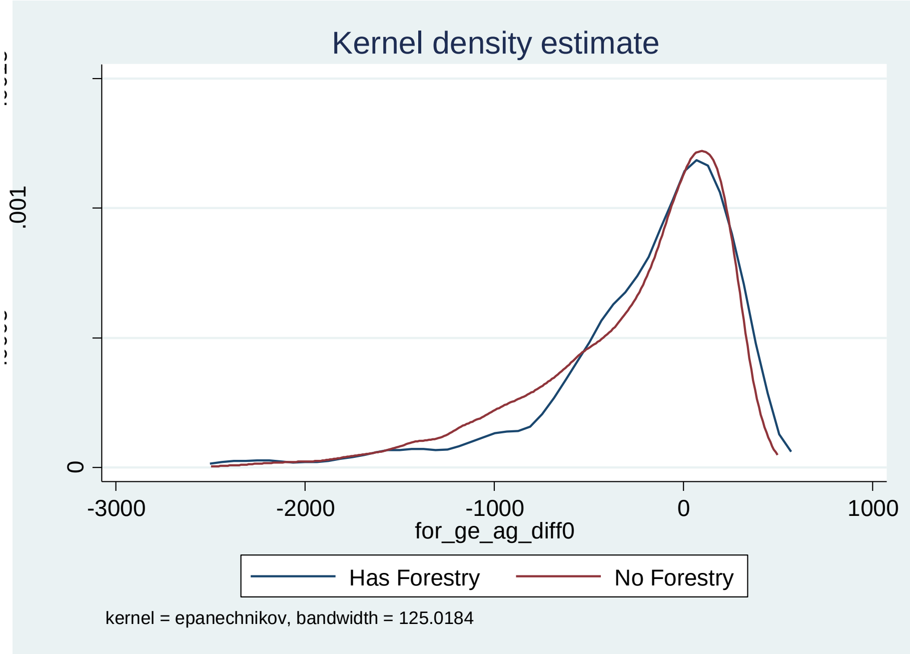
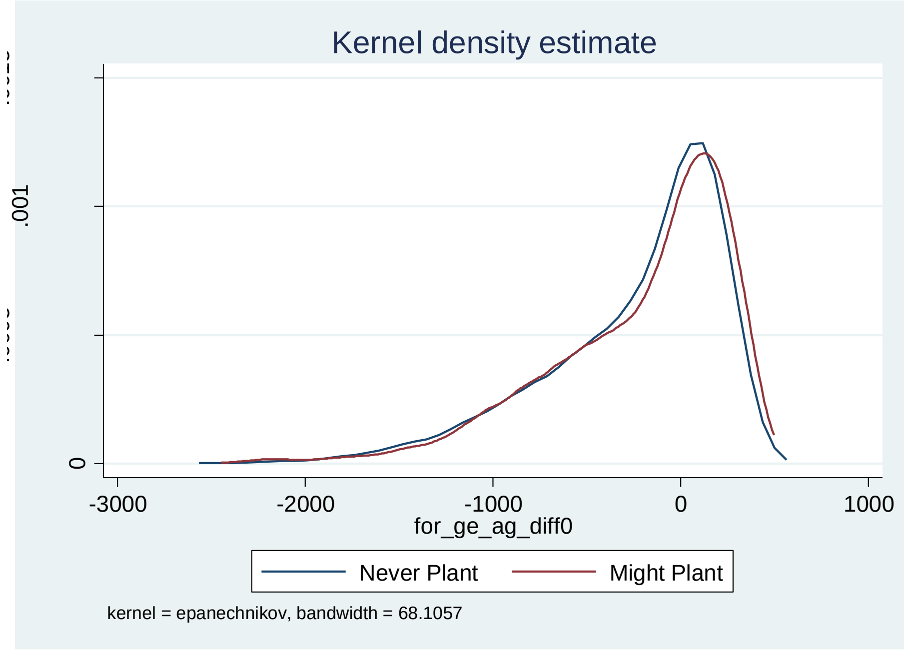
The characteristics of the farms and farmers that might plant in the future depending on the financial incentives offered are particularly interesting for both policy makers and extension agencies. These farms represent just over one third of the farm population. Those with higher agricultural income streams are again quite intensive farmers: they have high FFI, 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 who might plant and who have higher forest incomes, almost half of these farmers on average have an off-farm job; these farms have the lowest self-reported land value and; on average have the highest proportion of worst soil and a high proportion of medium soil. Their willingness to consider afforestation is possibly a diversification strategy to optimise both their land and their time resources.

From the perspective of the irreversibility of afforestation, farms that will never plant have the highest level of awareness of the permanency of afforestation regardless of whether their income streams are higher from forestry or from agriculture. The corollary of this is that less than a quarter of farmers that might plant are likely to be aware of the permanent nature of the decision.

*Summary statistics: kernel density*

Finally, we present kernel densities (Figure 1) of *has forest* and *never plant* variables (calculated using NPV$^2$ – GM) which show that the log normal distributions of the incomes are quite similar and overlap slightly, indicating that the distribution of income for planters and non-planters is very similar. We also note that the curves for *has forest* and *might plant* variables are slightly more to the right and positive.

**Figure 1. Kernel Densities of Difference between Forest and Agriculture NPV (NPV$^2$ – GM)**

| Planting Decision | Never Plant |
| --- | --- |
|  |  |





Note: Income Components are on a per hectare basis. We adjust NPV's to annualised definition, by dividing by $\sum_{t=0}^{n_j}\frac{1}{(1+r)^t}$, varying with the forest rotation for the relevant yield class and soil type. Assumption NPV$^2$ used based on Market Gross Margin for Opportunity Cost

## 5. Results

The primary purpose of this paper is to examine whether the afforestation decision is one that involves a straight land use substitution which is made in isolation, or is alternatively part of a more complex lifestyle decision-making framework. To do this we use changes in the level of intensity of farming as a proxy for wider decisions in relation to the farm as a whole.

*Consequences of planting – change in farming intensity in year of planting*

Previous analysis by (Ryan et al. 2014) showed that the livestock density on cattle and sheep farms in particular is likely to be a strong influence on the afforestation decision. The decision to substitute forestry for an agricultural enterprise also changes the intensity of production on the farm as it reduces the livestock carrying capacity. From the literature and drawing on previous work based on average incomes across farm systems (Breen et al. 2010, Upton et al. 2013), we expect higher income dairy farmers to intensify and we expect older farmers with large farms to de-intensify. This presents farmers with the following options:

- Become more intensive – carry the same number of livestock on a reduced land area thereby increasing the number of livestock units (LU) /ha;
- Maintain the same stocking density - reduce the number of livestock to match the reduced land area; or
- Become less intensive – reduce the stock numbers further to farm at a lower stocking density than before planting.

An examination of the stocking density in the year of planting for all farms with forest in the NFS 2012 Supplementary survey dataset shows that the average stocking rate reduces from 1.44 to 1.37 LU/ha (year before planting versus year of planting). The breakdown of the farms on the basis of change in livestock density in the year of planting is presented in Table 6.

**Table 6. Stocking Rate Change in year of planting**

| Stocking rate change | Per cent |
|---|---|
| No change | 30.58 |
| Decrease Stocking Rate by 5% | 44.17 |
| Increase Stocking Rate by 5% | 25.24 |
| | 100 |

Just under one third of farms (31%) had no change in livestock density in the year of planting. A quarter of farms (25%) farms increased stocking rate by more than 5% while almost half of the farms (44%) reduced livestock density by more than 5%. The characteristics of the farms are further examined on the basis of the three stocking density change categories and results are presented in Table 7.

On just under one third of farms, there was no change in intensity of farming as a result of afforestation. These 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 forest than from agriculture. These farms were already reasonably heavily stocked (average LU/ha of 1.6) so they had no choice but to reduce stocking density as a result of having less grazing land.

**Table 7. Average characteristics of farms with new forests by category of stocking rate change**

| Stocking rate change | For >Ag | Land Value €/ha[5] | Farm income €/ha | Dairy LU/ha | Labour Units | Age | Farm Size (ha) | Teagasc Clients | AE Scheme -REPS | Off Farm Job | Direct payment (€) | Previous LU/ha | Medium soil | Good soil |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No change** | 0.32 | 0.75 | 398 | 0.87 | 1.3 | 49 | 68 | 0.53 | 0.18 | 0.12 | 11682 | 1.6 | 0.44 | 0.44 |
| **Increase SR by 5%** | 0.47 | 0.73 | 298 | 0.62 | 1.2 | 48 | 62 | 0.49 | 0.14 | 0.23 | 12796 | 1.2 | 0.48 | 0.31 |
| **Decrease SR by 5%** | 0.52 | 0.77 | 383 | 0.52 | 1.2 | 52 | 55 | 0.42 | 0.33 | 0.17 | 16585 | 1.5 | 0.40 | 0.46 |

It is likely that these farmers did not have spare capacity in terms of land and made an economic decision to optimise their land use and placing 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 increased intensity as a result of afforestation, forest income is greater than agricultural income on almost half (47%) of these farms They have a 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" mindset.

However, almost half of the farms (44%) decreased their stocking rate by more than 5% suggesting that these farms may be "winding down". Prior to planting, this group had the highest average stocking density and just over half of these farms have higher incomes from forest. The farms are smaller on average (55 ha) and the farmers are older. They are more likely to be in AE schemes; and have considerably higher direct payments than the other groups. These farmers appear to have a "de-intensification" mindset.

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 re livestock density, but it would also appear that the decision to afforest may be part of a wider lifestyle decision.

*Logistic regressions of farms with forests (has forest) and farms that might plant*

The secondary purpose of this analysis is to ascertain whether there is a relationship between the relativity of forest and agriculture income streams and the likelihood of planting. We look at the sample of farms who planted in the past and those who might plant in the future. Initially we estimate logistic regressions for the farms with forests (*has forest*) (as presented in Table 8).

*We find that the variable forest income greater than agricultural income (For>Ag) that we had hypothesised would be significant is indeed significant and positive as expected, indicating that those with higher forest incomes are more likely to have afforested land.*

[5] Logged Land Value

**Table 8. Logistic regression of characteristics of farms with forests (with farm income calculated as farm GM with and without subsidies).**

| *has forest* | For>Ag( NPV[2] (GM)) | | | For>Ag NPV [1] (GM+Subs) | | |
|---|---|---|---|---|---|---|
| | Coefficient | SE | | Coefficient | SE | |
| Income: For>Ag | 0.3024*** | 0.08 | | 0.3515*** | 0.10 | |
| Land Value per Ha (logged) | 0.2458*** | 0.07 | | 0.2575*** | 0.07 | |
| Family Farm Income /ha | -0.0005*** | 0.00 | | -0.0005*** | 0.00 | |
| Dairy Stocking Rate | 0.00001 | 0.00 | | -0.00003 | 0.00 | |
| Labour Units | 0.3228*** | 0.08 | | 0.299*** | 0.08 | |
| Age Squared | 0.00002 | 0.00 | | 0.00002 | 0.00 | |
| Farm Size | 0.6011*** | 0.06 | | 0.5964*** | 0.06 | |
| Extension contract - Teagasc | 0.639*** | 0.07 | | 0.6386*** | 0.07 | |
| AE scheme - REPS | 0.5124*** | 0.07 | | 0.5523*** | 0.07 | |
| [6]Region 3 - East | 0.1076 | 0.13 | | 0.1038 | 0.13 | |
| Region 4 - Midlands | 1.479*** | 0.14 | | 1.4607*** | 0.13 | |
| Region_5 - Southwest | 1.0264*** | 0.15 | | 1.0102*** | 0.15 | |
| Region_6 - Southeast | 0.3617*** | 0.11 | | 0.3425*** | 0.11 | |
| Region_7 - South | -0.2636** | 0.11 | | -0.2891*** | 0.11 | |
| Regions 8 - West | 0.7797*** | 0.13 | | 0.8098*** | 0.13 | |
| Off farm income | -0.1678** | 0.08 | | -0.1412* | 0.08 | |
| Soil 2 – medium soils | 0.4415*** | 0.11 | | 0.4501*** | 0.11 | |
| Soil 1-best soils | 0.1151 | 0.11 | | 0.1197 | 0.11 | |
| Constant | -3.7757*** | 0.28 | | -3.6531*** | 0.28 | |
| No of observations | | | 5579 | | | 5579 |
| Pseudo R2 | | | 0.1169 | | | 0.1165 |

Note: *** denotes statistical significance at the 1% level, ** at the 5% level and, * at the 10% level.

In relation to the sensitivity of calculation of agricultural income, both methods of calculation of the NPV (with and without subsidies) have a reasonable pseudo $R^2$ and are both significant at the one per cent level indicating that the inclusion of subsidies is not a major driver of the financial decision. The magnitude of the For>Ag coefficient is slightly higher when subsidies are included but this may be accounted for by historical coupled subsidies which decreased if stocking density decreased after planting. As hypothesised, farm size and age are both significant and have the expected signs. Participation in AE schemes and having an extension contract are both significant and positive. All regions other than Dublin and East are also

[6] NFS Regions:
Region 1 (dropped) Border: Louth, Leitrim, Sligo, Cavan, Donegal, Monaghan.
Region 2 – (not reported) Dublin
Region 3 – Kildare, Meath, Wicklow
Region 4 – Laois, Longford, Offaly, Westmeath
Region 5 – Clare, Limerick, Tipperary NR
Region 6 – Carlow, Kilkenny, Wexford, Tipperary SR, Waterford
Region 7 – Cork, Kerry
Region 8 – Galway, Mayo , Roscommon.

positive and significant. Off farm income is also significant and negative indicating that for higher hours worked, the likelihood is that the farmer is a full-time operator with an intensive system and is more likely to never plant.

*Fundamental Choices about Planting*

Next we look at the farms that might consider afforestation in the future. This is essentially the corollary of farms that will never plant.

**Table 9. Logistic regression of characteristics of the farms that might plant - with farm income calculated as farm GM with and without subsidies.**

| might plant | For>Ag (NPV[2] (GM)) | | | For>Ag (NPV[1](GM+Subs)) | | |
|---|---|---|---|---|---|---|
| | Coefficient | SE | | Coefficient | SE | |
| Income: For>Ag | 0.388 ** | 0.193 | | 0.498 * | 0.261 | |
| Land Value per Ha (logged) | 0.209 | 0.153 | | 0.206 | 0.153 | |
| Family Farm Income /ha | 0.0003 | -0.0003 | | 0.96 | -0.335 *** | |
| Dairy Stocking Rate | -0.0001 | -0.0001 | | -1.27 | -0.203 *** | |
| Labour Units | -0.569 *** | 0.197 | | -0.579 *** | 0.196 | |
| Age Squared | -0.0001 | 6.1E-05 | | -0.0001 | 0.0001 | |
| Farm Size | 0.428 *** | 0.147 | | 0.409 *** | 0.146 | |
| Extension contract - Teagasc | 0.025 | 0.158 | | 0.02 | 0.158 | |
| AE scheme - REPS | 0.134 | 0.168 | | 0.178 | 0.168 | |
| Region 3 - East | 0.255 | 0.295 | | 0.258 | 0.295 | |
| Region 4 - Midlands | -0.898 *** | 0.328 | | -0.9 *** | 0.328 | |
| Region_5 - Southwest | -0.32 | 0.353 | | -0.307 | 0.353 | |
| Region_6 - Southeast | 0.243 | 0.27 | | 0.24 | 0.27 | |
| Region_7 - South | 1.737 *** | 0.252 | | 1.737 *** | 0.252 | |
| Regions 8 - West | -0.198 | 0.292 | | -0.124 | 0.288 | |
| Off farm income | 0.453 ** | 0.196 | | 0.474 ** | 0.196 | |
| Soil 2 – medium soils | -0.439 * | 0.265 | | -0.391 | 0.269 | |
| Soil 1-best soils | -0.353 | 0.262 | | -0.335 | 0.264 | |
| Constant | -2.295 *** | 0.712 | | -2.128 *** | 0.695 | |
| No of observations | | | 956 | | | 956 |
| Pseudo R2 | | | 0.1301 | | | 0.1298 |

We find that the relationship between the relativity of income streams and the likelihood of considering forestry in future is again significant and positive indicating that those farms with higher forest incomes are more likely to (might) plant. In relation to the sensitivity of calculation of agricultural income, both methods of calculation of the NPV are again significant, though less so in this case. As hypothesised, farm size and age are both significant and have the expected signs. Off farm income is also significant but is positive in this model. This ties in with the fact that hours worked is significant and negative in this model, indicating that part-time farmers are more likely to consider afforestation and more intensive farmers are less likely to consider afforestation. In terms of the location of future planting, while all regions (except East) are significant in the *has forest* model, only the Southern region is significant in the *might plant* model.

In summary, it is interesting to note that while financial drivers and farms size are consistent in their significance across both models it would appear that the likelihood of future planting has shifted away from full-time farmers to part-time farmers and the location of possible future planting has also shifted.

## 6. Conclusions

As analysis of this depth into the heterogeneous distribution of livestock farms and their characteristics has not previously been conducted before to the best of our knowledge, we were unsure of what the results would show. It would appear that the afforestation decision is more complex than previously recognised as it involves at least a multi-enterprise decision which necessitates the consideration of farm livestock density as a consequence of planting and on a higher level, involves lifestyle decisions about the future direction of the farm business.

The relativity of agricultural and forest incomes over the period analysed, has a large impact on the afforestation decision. Only 40% of farms have higher forest income streams over the period, reducing to 14% if we don't include subsidies. However, farms with higher forest income streams are significantly more likely to have afforested land and to consider forestry in the future. While the analysis shows that the inclusion of agricultural subsidies has an effect, the calculation of the opportunity cost is statistically significant whether subsidies are included or not. This may be a time-related issue as prior to decoupling of direct payments from production in 2005, farmers would have lost some of their agricultural payments if they afforested land. Since the introduction of the Single Farm Payment (SFP), this is no longer the case as grant-aided farm forest is an eligible land use for SFP since 2008.

An important result of this analysis is that a large proportion of farmers will not consider forestry, regardless of the financial incentives involved. These farms have the lowest farm income/ha, the smallest farm size, the lowest livestock numbers and are the oldest farmers on average. These farms are the least intensive, are most aware of the irreversibility of the decision and also appear to be "winding down" to some extent. Howley et al. (2015) put forward the view that "perceptions relating to the non-pecuniary benefits derived from farm work will act as a disincentive….certain farmers may be less likely to take up forestry as they may fear losing the enjoyment associated with farm work. Our results are not exclusive to the Irish case as a survey of Scottish farmers reported that for one third of farmers who hadn't planted, there was nothing that would persuade them to plant (Mindspace 2010).

This may be explained by the growing recognition in the literature that farmers are motivated by a range of socio-economic factors and financial gain may not be their core motivation for farming. Bateman (2006) recognised the importance of taking a farmers mindset into account and acknowledged the inability to do so as a weakness in estimating the opportunity cost of farm afforestation. This paper has attempted to address this by including attitudinal information about forestry in the analysis.

Of the farmers who might plant, those farms with higher forest income streams are the farms that are most likely to consider forestry. Our results indicate 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, our results also indicate that this is not a homogeneous group but farmers display common characteristics around decisions to optimise their land and time resources and ultimately their lifestyle.

The objective of this paper was to understand the heterogeneity in afforestation decisions. It seems clear that financial incentives are significant but are not strong enough on their own to incentivise planting and that the decision to afforest may in large part depend on the long-term motivations of farmers in relation to their level of intensity. These findings are important from the perspective of policy makers whose objective is to incentivise farm afforestation to increase timber production, maximise carbon sequestration in an effort to mitigate agricultural greenhouse gas production and improve ecosystem services. This study shows that not all farmers will respond to financial incentives and a more targeted approach may be necessary to improve the uptake of farm afforestation in future. This analysis clearly demonstrates the heterogeneous nature of the livestock farming population but suggests possible typologies of farmers on the basis of their future plans. Further research is needed to test these possible typologies opening up the possibility of future targeting of communication strategies for farmers with very different mindsets.

**References**


Adams, D. M., Alig, R. J., Callaway, J. M., McCarl, B. A., & Winnett, S. M. 1996. *The forest and agricultural sector optimization model (FASOM): model structure and policy applications*. DIANE Publishing.

Alig, R. J., Adams, D. M., Chmelik, J. T., & Bettinger, P. 1999. Private forest investment and long-run sustainable harvest volumes. In *Planted Forests: Contributions to the Quest for Sustainable Societies* (pp. 307-327). Springer Netherlands.

Ananda, J., & Herath, G. 2009. A critical review of multi-criteria decision making methods with special reference to forest management and planning. *Ecological economics*, *68*(10), 2535-2548.

Bateman, I.J., Lovett, A. and Brainard, J.S. 2006. Applied Environmental Economics – A GIS Approach to Cost Benefit Analysis. Cambridge University Press.

Breen, J., Clancy, D., Ryan, M. and Wallace, M. 2010. Irish land use change and the decision to afforest: an economic analysis. Irish Forest 67: 6–20

DAFM 2014a. Forest Policy Review – Forests Products and People. Department of Agriculture, Food and the Marine. Dublin. http://www.agriculture.gov.ie/media/migration/forest/forestpolicyreviewforestsproductsandpeople/00487%20Forest%20Review%20-%20web%2022.7.14.pdf 2014

DAFM 2014b. Forest Statistics 2014. Department of Agriculture, Food and the Marine. Dublin.

Deaton, A., 2005. Franco Modigliani and the Life Cycle Theory of Consumption. *BNL Quarterly Review,* vol. LVIII, nos 233-234, June-September 2005, pp. 91-107.

Duesberg S., O’Connor, D. and Ní Dhubháin, A. 2013 To plant or not to plant—Irish farmers’ goals and values with regard to afforestation Land Use Policy 32: 155– 164

Duesberg, S., Ní Dhubháin, A. and O’Connor D. 2014 Assessing policy tools for encouraging farm afforestation in Ireland. Land Use Policy 38:194-203

Edwards, P.N. and Christie, J.M. 1981 Yield Models for Forest Management, Forest Commission Booklet 48, HMSO, London.

Edwards, C. and Guyer, C. 1992 Farm woodland policy: an assessment of the response to the farm woodland scheme in Northern Ireland. Journal of Environmental Management 34(3):197-209

Edwards-Jones, G., Deary, I. J. and Willock, J. 1998. Modelling Farmer Decision-Making: What Can Psychology Do for Agricultural Policy Assessment Models? Etudes et Recherches sur les Systemes Agraires et Development. 31, pp153-173.

Edwards-Jones, G. 2006. Modelling farmers decision-making: concepts, progress and challenges. Animal Science, 82, 783-790.

EU Commission, 2013 European Commission 2013 Ministerial Conferences www_foresteurope_org 2011

European Council. 2014. The 2014 European Council agreement on climate and energy targets for 2030 (EUCO 169/14)

Forestry Commission, 2013 Forest Statistics Available at: http://www.forest.gov.uk/website/forstats2013 Jan 2014

Farrelly, N., Ní Dhubháin, Á., Nieuwenhuis, M., 2011. Site index of Sitka spruce (Picea sitchensis) in relation to different measures of site quality in Ireland. Can. J. For. Res. 41, 265e278.

Helles, F. and Lindaal, M. 1996. Afforestation experiences in the Nordic Countries. Nordic Council of Ministers. ISBN 92 9120 883 3. Copenhagen.

Hendrick and Black. 2008. Climate change and Irish forestry. COFORD Connects Note. COFORD, Dublin.

Hennessy, T., Moran, B., Kinsella, A. and Quinlan, G. 2013 Teagasc National Farm Survey Results 2012. Teagasc, Oak Park.

Henry, C. 1974. Investment Decisions under Uncertainty: The “Irreversibility Effect”. The American Economic Review, Vol 64, No 6(Dec, 1974), 1006-1012.

Howley, P., Hynes, S., O’Donoghue, C., Farrelly, N. and Ryan, M. 2012 Farm and farmer characteristics affecting the decision to plant. Irish Forest 69 (1&2): 33-43.

Howley, P., Buckley, C., O’Donoghue and Ryan, M. 2015. Explaining the economic “irrationality” of farmers’ land use behaviour: The role of productivist attitudes and non-pecuniary benefits. Ecological Economics (2015) pp186-193.

Key, H. 2005. How much do farmers value their independence? Agricultural Economics, 33, 117-126.

Key, N. and Roberts, M.J. 2009. Non-pecuniary benefits to farming: Implications for supply response to decoupled payments. American Journal of Agricultural Economics, 91(1), 1-18.

Mindspace, 2010. Farmers Research Study. Report to Forestry Commission Scotland. pp77.

Modigliani, F., and R. Brumberg 1954, “Utility analysis and the consumption function: An interpretation of cross-section data”, in K. Kurihara ed., Post Keynesian Economics, Rutgers University Press, New Brunswick.

Newman, D. H., & Wear, D. N. 1993. Production economics of private forestry: a comparison of industrial and nonindustrial forest owners. *American Journal of Agricultural Economics*, *75*(3), 674-684.

Ni Dhubhain, A. & Gardiner, J. 1994. Farmers attitudes to forestry. Irish Forestry 51:19-26.

O'Donoghue, C (Ed). 2014. The Handbook of Microsimulation Modelling. Contributions to Economic Analysis. Vol 293. ISBN 978-1-78350-589-2.

Read, D.J., Freer-Smith, P.H., Morison, J.I.L., Hanley, N., West, C.C., Snowdon, P., 2009. Combating Climate Change: A Role for UK Forests. An Assessment of the Potential of the UK's Trees and Woodlands to Mitigate and Adapt to climate Change. The Stationary Office, Edinburgh, pp. 242

Ryan, M., McCormack, M., O'Donoghue, C. and Upton, V. 2014 Analysing the role of subsidy payments available to a typical cattle farmer in Ireland on their uptake of forestry from 1984 to 2012. Irish Forestry. Vol 71, 1 & 2.

Ryan, M., Kinsella, A. and M. Cushion. 2008. An assessment of farmer intentions to plant a forest. Agricultural Research Forum. Teagasc.

Thorne, F. S., & Fingleton, W. 2006. Examining the relative competitiveness of milk production: An Irish case study (1996). Journal of International Farm Management, 3(4), 49-61.

Upton, V., Ryan, M., Farrelly, N. and O'Donoghue, C. 2013 The potential economic returns of converting agricultural land to forestry: an analysis of system and soil effects from 1995 to 2009. Irish Forest 70 (1&2): 61-74

Upton, v. O'Donoghue, C and Ryan, M. 2014. The physical, economic and policy drivers of land conversion to forestry in Ireland. Journal of Environmental Management 132 79-86.

Vanclay, F. 1992. The social context of farmers' adoption of environmentally sound farming practices. In "Agriculture, Environment and Society". Eds. G Lawrence, F Vanclay, B Furze) pp. 94-121 (Macmillan: Melbourne).

Van Gossum, P., Arts, B. and Verheyen, K. 2012 Smart regulation: Can policy instrument design solve forest policy aims of expansion and sustainability in Flanders and the Netherlands? Forest Policy and Economics 16:23-34

Van Gossum, P Arts, B. van Laar, J.and Verheyen, K. 2010. Implementation of the forest expansion policy in the Netherlands in the period 1986–2007: Land Use Policy, 27 (4):1171-1

Watkins, C., Williams, D., & Lloyd, T. 1996. Constraints on farm woodland planting in England: a study of Nottinghamshire farmers. *Forest*, *69*(2), 167-176.

Willock, J., Deary, I.J., Edwards-Jones, G., Gibson, G. J., McGregor, M.J., Sutherland, A.,Dent, J. B., Morgan, O. and Grieve, R. 1999 The Role of Attitudes and Objectives in Farmer Decision Making: Business and Environmentally- Oriented Behaviour in Scotland

Zander, K., Thobe, P., & Nieberg, H. 2007. Economic impacts of the adoption of the

Common Agricultural Policy on typical organic farms in selected new Member States. Jahrbuch der Österreichischen Gesellschaft für Agrarökonomie, 16, 85-96.