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An economic analysis of the establishment of forest plantations in the United Kingdom to mitigate climatic change

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ABSTRACT

This paper addresses the economic dimensions of climate change mitigation by afforestation in the UK and the necessity of reconciling sustainable development with carbon sequestration forest policy initiatives. Present value costs per tonne of carbon sequestration through the creation of new forests are estimated, and results of a static comparative analysis, aiming to show the influence of key variables on the costs, are presented and discussed. The paper provides empirical evidence of the cost effectiveness of the establishment of forest plantations for climate change mitigation in different locations in the UK, identifying also the importance of placing forestry for carbon sequestration in the general context of rural land use, where significant policy reforms can be anticipated. The evidence from this research suggests that the choice of location for forestry development, and of appropriate species and management regimes to be applied, are important factors in determining economic costs. Afforestation with relatively fast growing tree species (e.g. Sitka spruce) on low grade agricultural land (e.g. currently used for sheep grazing) may be a cost effective option. The general conclusion is that there is a case for forestry in the UK to contribute to climate mitigation, that woodlands expansion is likely competitive with other means of removing carbon from the atmosphere, and that in certain cases and locations, afforestation projects may provide relatively low cost options for carbon sequestration.

1. Introduction

In the light of the Kyoto Protocol to the United Framework Convention on Climate Change (UNFCCC), the Parties committed themselves to stabilising atmospheric greenhouse gas (GHG) concentrations, including those of CO_2.[1] The commitment of the UK under the EU burden-sharing target is 12.5% GHG emissions reduction for 2008–2012, relative to the base year.[2] The target is to be achieved by both reducing emissions (sources) and removing GHG from the atmosphere (enhancement of sinks). Since the COP-7 in 2001, afforestation, reforestation, forest management and soil carbon have become eligible strategies (Read et al., 2009).

The UK has one of the lowest percentages of wooded land (12%) in Europe, but it has significantly expanded its wooded cover in the last hundred years (FC, 2010). The maximum rate at which the forests expanded during the 20th century was about 40 000 ha yr^{-1} in the early 1970s (Cannell, 2003). However, the rate of forest expansion has fallen to an average of about 10 000 ha yr^{-1} (FC, 2011). Currently, about 4 million tonnes of carbon is sequestered annually in forests in the UK, with 0.5 million tonnes of carbon from trees planted since 1990. Terrestrial carbon sequestration is considered important in the postponement or reduction of climate change, as it allows time for adaptation, learning and technological innovation. Read et al. (2009) suggested a UK planting target of 23 000 ha yr^{-1} and this, over 40 years, would involve changing the use of only 4% of the UK's land, producing substantial carbon reductions.

Forestry development in the UK is supported by financial instruments which vary across the territory. For example, in England, the Forestry Commission (FCE) administers the English Woodland Grant Scheme (FCE, 2011). Grants and annual Farm Woodland Payments also encourage farmers to convert productive land into forest (FCE, 2011). In Scotland, as part of the Scottish Rural Development Programme (SRDP), new grants have been introduced bringing together a range of

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[1] The COP-17 (UNFCCC, 2011) held in Durban agreed on a decision by Parties to adopt a universal legal agreement on climate change as soon as possible, and no later than 2015.

[2] A series of targets for reducing CO_2 emissions have been set out — including making the UK's targets for a 34% cut in emissions on the 1990 levels by 2020 (HMG, 2009a). The Climate Change Act (DEFRA, 2008) – the first of its kind in any country – set out a framework for moving the UK to a low-carbon economy, with a target of 80% emissions reduction by 2050.

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formerly separate support schemes which aim to deliver targeted environmental, social and economic benefits. Grant support is delivered through a number of forestry-specific (e.g. short rotation coppice crops of willow or poplar) and non-specific (e.g. support for renewable energy) options, including those of tackling climate change (Scottish Government, SG, 2011).

In the light of the policy implications described above, the last decade has seen an upsurge in the number of publications which address the role of UK forestry in tackling climate change (e.g. Bateman and Lovett, 2000; Brainard et al., 2009; Broadmeadow and Matthews, 2003; Cannell, 2003; Matthews and Robertson, 2003; Milne, 2002; Moran et al., 2008; Morison et al., 2012; Price, 2008; Read et al., 2009; Rollinson, 2007; Tipper et al., 2004; Valatin, 2011; Valatin, 2012a; Valatin, 2012b). Stern (2006) explored the economic impacts of climate change and the cost of stabilising GHG in the global atmosphere. Numerous studies carried out worldwide have addressed the cost effectiveness of afforestation/reforestation for carbon sequestration (Brainard et al., 2009; Newell and Stavins, 2000; Nijnik, 2005; Nijnik and Bizikova, 2008; Slangen et al., 1997; Stavins and Richards, 2005). van Kooten et al. (2004) carried out a meta-analysis of 68 such studies, with a total of 1047 observations, and identified substantial variability in marginal costs in different countries and in different settings.[3] The analysis showed that carbon sequestration through the establishment of new forests could be costly, particularly in EU countries, but that it often compares well with the cost of technologies for carbon capture and storage (which is in the order of US$150 per tonne C). Also, it was shown that in some regions, marginal cost estimates from carbon mitigation by forests can be compared well with market prices of carbon (e.g. prices in the EU's Emissions Trading Scheme (ETS) stand at around €55.5 per tonne C,[4] Point Carbon, 2011a).[5]

A pilot evaluation of the cost effectiveness of forest establishment in the UK for carbon sequestration was published in the Final Report to the Committee on Climate Change (Moran et al., 2008). A national assessment of the potential of the UK forestry to mitigate climate change coordinated by the Forestry Commission (FC) was published in Read et al. (2009). In their contribution to these reports, the authors of the current paper showed that the mitigative role of new forests is mediated by externalities and uncertainties, and shaped by environmental, economic and policy drivers, market signals, institutions and governance, and public attitudes and behavioural patterns, at various scales (Nijnik et al., 2009a). It was stressed that there is a need for further research on the cost effectiveness of climate change mitigation forestry opportunities for the UK, with identification of projects which will be coherent, effective, efficient, widely accepted by the public, and consistent with other aspects of policy for sustainable development (Nijnik et al., 2009b).

The current paper extends work done previously on the economics of afforestation for carbon sequestration in the UK and internationally (e.g. Adger et al., 1997; Huang and Kronrad, 2001; Nijnik et al., 2009b; Pajot, 2008). It modifies some of the earlier assumptions made by the authors and expands the scope of the analysis. The aim is to explore the economic justification for afforestation in the UK to mitigate climate change and to provide benchmarks for possible cross comparison analysis of different carbon sequestration options. The paper first presents the research methodology. Next, carbon sequestration rates and the potential of climate change mitigation through afforestation in the UK are analysed. Present value costs per tonne of carbon sequestration in new forests are estimated to provide empirical evidence of cost effectiveness. The paper takes into account various initial land uses and discount rates, spatial dimensions, various yield classes and regional timber prices of 2010. Results of a static comparative analysis showing the influence of key variables on cost are also shown and discussed. The paper concludes by offering some insights into the feasibility of climate change mitigation through afforestation and by providing ideas for future research.

2. Methodology

2.1. Key approaches available

The IPCC (2007) identified the following measures to increase the forestry contribution to carbon sequestration:

1. afforestation of abandoned and marginal agricultural land;
2. forest management to increase carbon density at the stand and landscape levels (e.g. maintaining forest cover, minimising forest carbon soil losses, increasing rotation lengths, increasing growth and managing drainage);
3. increasing off site carbon stocks in wood products[6];
4. enhancing product and fuel substitution.[7]

The current paper analyses the cost effectiveness of the first policy measure identified.[8] Stavins and Richards (2005) distinguish three methodologies to analyse the economics of carbon sequestration through afforestation: econometric studies; sectoral optimisation models and a ‘bottom up’ approach. The ‘bottom up’ approach (Valatin, 2012a) is considered as the most straightforward way to carry out cost effectiveness analysis relevant to our research objectives[9] and is used in this paper.

2.2. Baselines and carbon sequestration potential

Consideration of the UK carbon sequestration potential of afforestation was based on targets for planting set by the devolved forestry administrations. Thomson and van Oijen (2008) have developed three scenarios for forestry in the UK until the year 2020, in which the Tier 3 carbon accounting model *CFLOW* was used and annual planting statistics and management practices, including thinning regimes and rotation lengths, were considered (CEH, 2009). A high emissions scenario did not take into account any new planting. A second scenario projected the 2005 planting rate to occur every year until 2020. This is the mid emissions scenario which is considered as the baseline for afforestation. The third scenario projects a high planting rate of 30 000 ha yr^{-1}. It is described as the low emissions scenario

[3] Baseline estimates of the costs of sequestering carbon through forest conservation (based on analysis of 981 estimates from 55 studies of the costs of creating carbon offsets using forestry) range from US$46.62 to US$260.29 per tonne C. Tree planting and agroforestry activities increase costs by more than 200% (van Kooten et al., 2004). Although such variation is partly due to the diversity of methods and assumptions used, it indicates that terrestrial carbon sequestration is case specific and involves a great deal of uncertainty.

[4] The conversion factor from CO_{2e} to C is 3.67 (i.e. 44/12).

[5] However, prices in markets do not necessarily reflect the social value of carbon reductions, but rather current demand and supply, and the institutional aspects of such markets (Nijnik et al., 2009b). Recent reforms of the CAP are likely to have significant effects on land prices which will change the net cost of afforestation. The rule change in late 2009 to allow continued receipt of the Single Farm Payment after afforestation is of importance, and world food prices can have additional effects (Slee et al., in press).

[6] Carbon fixation alone has a one time effect, and eventually, through the decay of wood all the above ground carbon is released to the atmosphere. However, when trees are usually cut after they reach mean annual increment the carbon stored in wood products is an addition to the terrestrial carbon sink.

[7] Wood received can be used as a substitute for fossil fuels, or timber used in wood products can later get burned. If energy required for harvesting and processing of wood is not taken into account, the use of timber as a substitute for fossil fuel is carbon neutral. The net gain here is the amount of CO_2 that would have been released by burning fossil fuel if not replacing it with wood.

[8] As shown by van Kooten (2004) on examples, particularly of forests in British Columbia, the social benefits of carbon capture and storage, and substitution effects, under wood product and bio energy scenarios are repeatable over rotations, and therefore expected to be considerably higher than under the strategy of carbon fixation alone.

[9] It compares forestry and farming incomes and climate benefits (carbon sequestration in trees).