

Impact of Global Warming on Forestry Investments

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Abstract

Up until recently afforestation projects had been looked at from the viewpoint of timber production. Efforts to combat climate change have added a new dimension to investment in forestry which has been encouraged by the Kyoto, Marrakech and Cancun Deals. As trees grow overtime, they capture CO₂ from the atmosphere which moderates the problem of global warming. The article 3.3 of the Kyoto Protocol states that “the net changes in greenhouse gas emissions by source and removal by sinks resulting from human induced land use change and forestry activities limited to afforestation, reforestation and deforestation activities since 1990 measured as verifiable changes in carbon stock in early commitment period, shall be used to meet commitments in the Protocol.” In this respect Kyoto granted carbon credits to newly created forests. Such credits can now be used directly by firms with greenhouse gas emissions or could be traded into a future emissions scheme at prevailing prices. The rules for the implementation of the Kyoto Protocol were agreed at the Marrakech Conference in 2001 which placed limits on the amount of credits which can be obtained from forest management.

Trees because of their large biomass content make an important contribution to the global carbon cycle. Unfortunately, as more and more greenhouse gasses are released into the atmosphere every year deforestation is continuing unabated especially in the tropics. It has been estimated that about a quarter of the global warming problem stems from forest destruction as deforestation adds about 1 gigatons of CO₂ to the atmosphere per annum. That is, if we slowed down forest destruction and increased our efforts in afforestation this would give us precious time to construct more comprehensive policies in dealing with the climate problem. This paper estimates how long planted trees with carbon sequestration will stay on the ground as compared with wood only situation. In order to find out this we use a British data on Sitka spruce which is the most favoured species planted extensively throughout the United Kingdom and the Republic of Ireland.

Introduction

Like fish stocks forests are renewable resources. However, if this endowment is misused and depleted badly, the process of its replenishment can be extremely long and painful. In this the British experience is the most conspicuous which has now been referred to as a standard case material, Samuelson (1977) and Kula (2012).

In almost all countries the forestry policy has been shaped by

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historic events. In the 18th, 19th and the first half of the 20th centuries forestry was a contracting sector in Europe as well as many other parts of the world. There were mainly three reasons for this. First, the growth of the population increased the pressure on agricultural land to grow more food, which resulted in forest clearances. Decline in forestry in many regions became inevitable to sustain the growing population. Second, the use of wood as fuel and construction material took its toll on forests which was most reckless in the early industrialised countries. For example, in Britain the iron smelting industry relied heavily on wood supply from forests. Also, timber was used extensively in coal mining as pit props. Forest depletion was so extensive in most parts of Britain that trees which clothed the landscape for centuries were almost completely gone. In the 18th century a traveller to Scotland wrote that 'a tree here is as rare as a horse in Venice'. Third, wars had a devastating effect on forests, especially in Europe.

In Britain, a major maritime nation, it was taught that if domestic stock were exhausted timber could always be imported from the colonies. However, this turned out to be a big mistake. During the First World War Britain suffered a severe shortage of timber. The German submarine campaign reduced imports almost to nothing and there was not much by way of domestic resources. British government was in great difficulty to supply timber to the coal mining industry, nation's vital supply of energy, and the construction sector which was undermined by the shortage. Forests in remote regions were felled and the merchandise was transported long distances to areas where it was needed. After the war the British Premier, Lloyd George, confessed that the country was nearer to losing the war from lack of timber than from lack of food.

After the war an organisation, Ackland Committee, was set up to examine the implication of insufficient supplies of home-grown timber. The Committee recommended establishing a forestry authority to rejuvenate British forestry. On this basis the Forestry Commission was established in 1919 which in later years became the largest landowner in the U.K. In Northern Ireland a Forest Service of the Department of Agriculture was created in 1922 with similar duties to the Forestry Commission but has been independent from it. Within the first decade of its creation the Commission tried to establish 200 000 acres of new plantations as well as improving 50 000 acres of existing but impoverished woodlands. These target rates were not achieved because in 1924 a persuasive anti-forestry lobby convinced the government that forestry was not a profitable venture and as a result afforestation budget was cut substantially. Then came the Second World War which reminded

the government of the reasons why the Forestry Commission was established in the first place. Bulky timber imports by sea provided an easy target for the German Navy and whatever was planted in the 1920s was not ready for felling.

Having had two bitter experiences during the two world wars the British government decided to move ahead with afforestation projects especially under labour governments. Today the Forestry Commission buys land, plants trees, harvests and sells timber, establishes and maintains forest recreation centres for the benefit of the community, provides cash grants and technical advice to private foresters, does research in most aspect of forestry and cooperates with similar institutions in Europe and elsewhere.

However, despite nearly 100 years of effort forestry in the United Kingdom has not flourished. Only about 13% of the land is under forestry. Compare this figure with some other European countries; Turkey 18% , France, Italy and Belgium over 20% , Portugal, Germany and Norway over 30 p.c. and Finland over 70% This is despite the fact that in the United Kingdom trees grow much faster than in many other countries of Europe. On average it takes about 30 years to grow coniferous timber in the United Kingdom. The gestation periods for similar species of trees are much longer in Germany, Benelux countries and Scandinavia.

One important factor for the underdevelopment of the forestry sector in the United Kingdom is its alleged poor profitability. In order to dispel such objections in 1971 the Chairman of the Forestry Commission Lord Tylor of Gryfe stated that “The Forestry Commission should not be regarded as a large commercial state enterprise but should be recognised for what it is – as the forestry authority concerned not only about the state enterprise but concerned about the propagation and development of forestry as a whole in Britain. Therefore, I consider it my mandate and responsibility to speak as effectively as I can for forestry as distinct from any particular sector”, The Times (1971).

At present the forestry policy in the United Kingdom is governed by three factors. First, there is a compelling need to reverse the forest destruction that took place in the past to create domestic resources of timber. It is now well acknowledged that in the European Union much land is used for agricultural activity resulting in glut in some sectors. On the other hand, the United Kingdom and some other EU countries are continuing to import large quantities of timber from outside. This is putting pressure on the forest resources of exporting countries. The European Union is only about 50% self sufficient in wood. The figure

for the United Kingdom is much lower. Second, there is a need to provide productive work in rural areas where structural unemployment prevails. Afforestation projects and dependent sectors offer a solution to the problem. Third the British government also believes that the private sector should be encouraged to participate in the expansion of forestry. In this respect it allocates public money in the form of cash aids and tax exemptions to private individuals or companies who are investing in forestry.

Forestry and Climate Change

Global warming or the greenhouse effect of atmospheric pollution is a major environmental problem causing concern throughout the world. The rate at greenhouse gases that are released into the atmosphere has been gathering pace largely due to burning of excessive fossil fuel in combustion engines. On the other hand, deforestation is continuing unabated. The two together is creating a sort of double barrel shotgun effect which is increasing the anxiety about the problem. In economics the excessive discharge of greenhouse gasses involves overuse of a common property resource, atmosphere, which belongs to everybody. When individuals, governments and firms do this they create a public bad that affects the entire humanity.

Scientists figured out a long time ago the adverse effects of releasing too much greenhouse gasses into the atmosphere. Nobel Prize winning Swedish scientist Arrhenius argued towards the end of the 19th century that increased use of coal, which is the dirtiest form of fossil fuel as opposed to oil or gas, would lead to increased concentration of CO₂ in the air and warm the earth, Arrhenius (1896). During the last 100 years or so the greenhouse gas emissions have grown dramatically warming the global climate and if nothing is done it will get even worse in not so distant future. According to Intergovernmental Panel on Climate Change there has been an irregular increase in global surface temperature amounting to 0.5 centigrade, IPCC (2010).

What we need is to slow down CO₂ emissions and also increase our efforts globally in carbon sequestration which is about capturing CO₂ from the air through biological, chemical or physical process. In this CO₂ can be arrested as a pure by-product in process relating to petroleum refining or from flue gasses from power stations. In forestry it involves planting or replanting of trees on land to transfer CO₂ from the air to new biomass. It has been estimated that since mid 1950s about 50% of carbon sequestration came from the trees and about 40% from the soil and the

rest from the litter and products in the United Kingdom, Dewar and Channel (1991). No individual firm or country in isolation is likely to change its established trend of greenhouse gas discharge or to take steps to plant trees on a large scale and thus we need a global effort to tackle a global problem, greenhouse effect.

Now most scientists believe that managing the emission of greenhouse gasses in a collective effort is vital in the struggle against climate change. The Kyoto Protocol includes the reduction in the consumption of fossil fuels and options involving carbon sequestration through afforestation. Article 3.3 of the Protocol states that “The changes in greenhouse gas emissions by sources and removals by sink resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and de-forestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet commitments under this Article of each Party included in Annex I”, (UN Framework of Convention on Climate Change, 1997). That is, Kyoto Protocol gave carbon credits for newly created forests which can be traded in the carbon market.

A number of research institutes including forestry authorities have been developing integrated carbon accounting systems to provide confidence in carbon sequestration figures for a number of regions and tree species. Normally conservative use of growth models adopted with assumptions available for scrutiny. Spatial linkages can be used for updating as more and more information becomes available. These efforts in time are likely to become refined increasing confidence in carbon accounting.

Finding the optimum rotation for profitability in afforestation

One of the most interesting cases in forestry economics is to find the optimum cutting age of a tree or an even aged forest, which refers to a stand composed of trees of only one age group and species. This problem has been known since the work of Martin Faustman (1849) in the Nineteen Century. In practice the harvesting period depends upon a number of factors including the final use of tree, e.g. whether it is for pulp, boxwood, saw quality wood, etc. In addition, local market conditions play an important factor. For example, the demand for wood in an area may be buoyant pushing up the prices. Bringing in timber from distant regions take time keeping the prices at an elevated level, at least for a while. In a situation like that it is only a common sense to bring forward the previously worked out felling age.

When the land that trees are planted is marginal, that is the opportunity cost is negligible the optimum rotation can be worked out by specifying a cost and benefit functions.
 Let us have a benefit function

$$B_t = A (1 + t)^{1/2} \dots\dots\dots (1)$$

Where t is time (years), B_t is the wood revenue at time t and A is a constant. Let us have the initial establishment cost be C and the real rate of interest be r, the opportunity cost of capital invested. The net present value, NPV, of this project becomes;

$$NPV = -C + [1/(1 + r)^t] B_t \dots\dots\dots (2)$$

or

$$NPV = B_t e^{-rt} - C \dots\dots\dots (3)$$

In order to find the optimum cutting age we differentiate (3) and set it equal to zero.

$$dNPV/dt = -rB_t e^{-rt} + (dB_t/dt) e^{-rt} = 0 \dots\dots (4)$$

$$rB_t e^{-rt} = (dB_t/dr) e^{-rt} \dots\dots\dots (5)$$

then

$$r = (dB_t/dt) / B_t \dots\dots\dots (6)$$

This tells us that the marginal rate of return on capital must be equal to the real rate of interest. That is, the NPV of this project is maximised when the revenue from selling timber is equal to the interest rate, the opportunity cost of capital. In other words, the stand should be

felled when the incremental benefit from timber equals the real rate of interest.

Financial details of plantation

The British Isles, especially the west coasts, are highly lucrative for forestry projects thanks to their mild, moist climate and long daylight hours during the growing season. Of course, the profitability depends upon the species selected as well as the location. In the western parts some areas especially the low-lying land are unsuitable for lucrative agriculture but good for forestry. The value of land in these parts is low and in some cases it is negligible.

In this analysis the species that we consider is Sitka spruce, an evergreen and quick growing variety planted extensively throughout the British Isles. Sitka is an oceanic species native to North Eastern Canada which was introduced to Britain towards the middle of the Nineteen Century. It grows quickly in oceanic climates such as Ireland and the west coast of Britain. If allowed to, it can grow for about 200 years and in favourable conditions attaining a height of 60 metres yielding plenty of commercial timber.

Observations are carried out on a location owned by the public in Fermanagh, the United Kingdom. The plot, 30 hectares, is in a low-lying area facing the south where the land is wet with a mild slope, unsuitable for lucrative agriculture and thus left idle for many years now is transferred to forestry. The wood output on this location has been estimated as yield class 22 (YC 22) meaning that trees planted here would have maximum mean annual increment of about 22 cubic metres per hectare, greater than 21 but less than 23. Figure 1 in the appendix, the top curve, shows the growth pattern of this yield class. The trees are widely spaced and thus the growing stand will not undergo thinning; that is, a no thinning regime is employed, which is now quite common in many parts of the British Isles. It is anticipated that the trees will be sold standing, that is, harvesting and haulage costs will be incurred by the buyer. All costs and benefits are worked out on the basis of per hectare and in terms of 2019 prices.

In cost-benefit analysis of forestry it is inappropriate to take the market value of land to represent its opportunity cost because it may also reflect or include some element of capitalised value of subsidies to agricultural production. Where applicable an adjustment to exclude all subsidies from the market price of land (including rent) should be made.

In this example we exclude the value of land because its opportunity cost, i.e. alternative agricultural output, is near zero.

Relevant costs are; ground preparation which involves draining, ploughing to raise grass mounds so that roots can spread between the grass on the surface and the grass on the inverted sod. Then comes the planting of the saplings, fertilising and fencing the area so that young trees can be protected against animals. Fencing is not needed for this plot which is next to well fenced private farms on three sides and natural conditions on the fourth. Road building that will take the cut trees to the roadside which could be a costly item and thus normally takes place towards the end of the rotation. The planting cost, at the beginning of the rotation, is estimated to be £1 923 per hectare. Total amount for road construction is estimated to be incurred in Year 30, just before the felling operation, and it turned out to be £62 700 for the whole site, £2 090 for 1 hectare, see Table 1 in the appendix.

Regarding the output it is estimated on the basis of the Forestry Commission's Forest Management Tables, Forestry Commission (1971). These tables are currently used in the United Kingdom. Over the last few years timber prices in the province has been fluctuated as in many parts of the British Islands due to imports and a notable amount of local produce coming onto the market. In some years, however, prices can go up due to lack of domestic felling and delayed imports. The average wood price used in this analysis is £24.00 per cubic metre. On this basis the estimated wood output benefit turns out to be £6975 per hectare. Based upon these numbers the internal rate of return turns out to be 3 %.

Profitability based upon timber and carbon values

The earth's atmosphere is a global common into which firms, households and governments can discharge pollution including CO₂. Resulting global pollution creates a public bad that affects the entire humanity. Many countries have environmental protection schemes that limit pollution on their national territory. But for global pollution no nation in isolation will take stringent measures for its reduction and thus we need a global effort for this. Although there is uncertainty about the probable scale of the global damage but most believe that the damage will be significant

It is well recognised that trees because of their large biomass make an important contribution to the global cycle. In this respect Kyoto Protocol in order to assist Annex B countries, which the United Kingdom is one, to meet their carbon responsibility identified flexible

measures to ensure maximum emission reduction which includes afforestation. As mentioned above amount of CO₂ that afforestation projects remove from the atmosphere can be used as credits against emissions taking place elsewhere. These credits can also be traded in future emission schemes at prevailing prices just like trading companies share certificates. In 2011 the principles for the implementation of the Protocol were agreed at Marrakech Conference for the nations and also limits were placed on credits that can be obtained from afforestation.

Based upon the work of Forestry Commission (2003) and Galagher et al (2014) carbon sequestration figures for the stand has been estimated. See Figure 1 in the appendix 1 (the lower curve). Carbon capture is low at the early stage of the rotation when the trees are young then it gathers pace eventually levelling off as we get closer to the felling age. Incremental carbon storage, in terms of tons and per hectare, is shown in Table 1, column 3.

Next, we need the value of the captured carbon. There is a considerable debate about the social value of carbon ranging from £5.00 to £70.00, Kula and Gunalay (2012), Gillingham (2019) and UK Government (2019). As a moderate figure we used the work of a private company who estimated that the average price for one ton of carbon is likely to be in the region of £17.00 for some years to come, JC Consultants (2010). 4th column of Table 1 shows the incremental carbon value in this investment. The last column of Table 1 gives us the net annual benefits which we need for internal rate of return calculation. With the added carbon benefits the internal rate of return of this project increases from 3% to 4.5%, a fifty per cent improvement.

The issue of optimum rotation

On the basis of equation (6) the optimum cutting age that maximises wood only benefits are calculated and the figure turned out to be 41 years. In this we used %3.5 British discount rate, which is mandatory in all important spending decisions in the country, Green Book (2003).

CO₂ sequestration figures are estimated on the basis of the work done by the Forestry Commission (2003). The net present value maximising equation with wood and carbon benefits is;

$$r = [E_t + dB_t / dt] / B_t \dots\dots\dots (7)$$

where E_t is carbon benefits.

With the inclusion of carbon benefits on top of timber benefits the felling age that maximises the NPV (with %3.5 discount rate) turns out to be 44 years.

Conclusion

One of the best-known articles written in economics of forestry is by a Nobel winning scientist P A Samuelson who chose a title 'Economics of forestry in an evolving society'. Indeed, forestry economics today is different from one in 1976 when Samuelson published his paper. The main difference is our growing concern about the climate change and the role of forestry to minimise the problem.

At a United Nations Climate Change Convention, forest protection, reforestation and afforestation received a robust attention in the battle preventing climate change, (UN 2010). By considering the carbon capture issue, this paper recalculated the optimum cutting age demonstrating that trees should stay noticeably longer on the ground to absorb more CO₂.

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Appendix

Figure 1. Wood volume and sequestered carbon for one-hectare Sitka Spruce forest with yield class 22 (YC-22).

Source: Forestry Commission (1971, 2003) and Gallagher et al (2014).

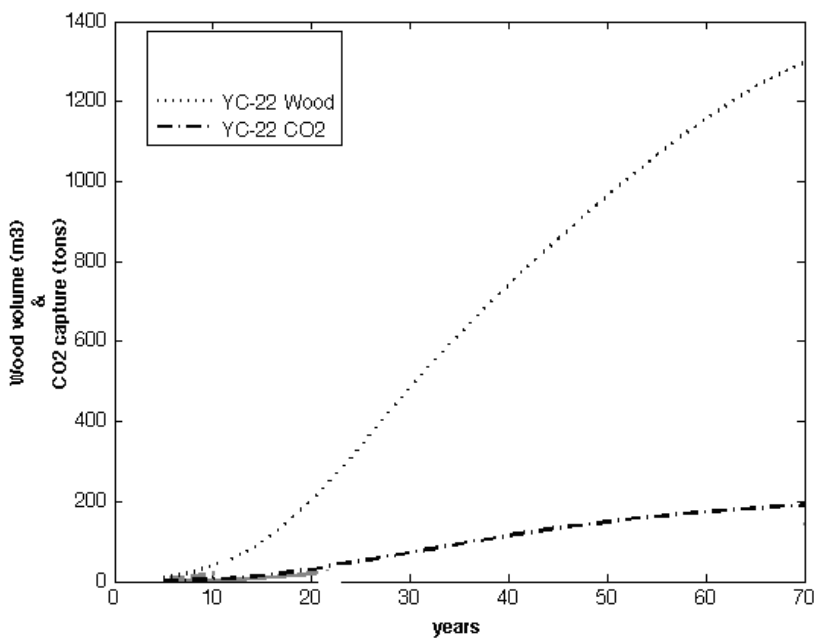


Table1. Net benefit = carbon storage value + wood value

Year	Net wood Benefits £	Annual incremental CO2 storage tons	Annual incremental CO2 benefits £	Cumulative net benefits £
0	-1923	-	-	-1923
1		-	-	-
2		1	17	17
3		1	17	17
4		1	17	17
5		1	17	17
6		2	32	32
7		3	51	51
8		3	51	51
9		3	51	51
10		3	51	51
11		4	68	68
12		4	68	68
13		5	85	85
14		5	85	85
15		5	85	85
16		5	85	85
17		7	119	119
18		7	119	119
19		7	119	119
20		7	119	119
21		7	119	119
22		7	119	119
23		6	102	102
24		6	102	102
25		6	102	102
26		6	102	102
27		6	102	102
28		5	85	85
29		5	85	85
30	-2090 + 6975	5	85	4970
Total	+2962	+133	+2259	+5221