Impact of Afforestation on the C Density of Irish Forest Soils.

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Abstract

Presented here is preliminary data on the impact of afforestation on Irish soil C densities. In total, 42 sites are to be sampled for bulk density and C content of the soil along with C content and volume of the forest floor over a range of 3 forest types (conifer, broadleaf and mixed) and 4 soil types (brown earth, brown podzolic, podzol and gley) using the paired plot method. Thus far for broadleaf brown earth and conifer brown earths there is a reduction in soil C density after afforestation, -18.6 and -14.4 t/ha respectively while for the mixed brown earth sites there is an increase in soil C stocks by 6.8 t/ha. The difference between each forest type appears to be due to forest age as the difference between the forest and paired site reduce as the forest gets older and eventually starts to gain C.

Introduction

At the beginning of the twentieth century forests accounted for only 1% of the total Irish land cover (Pilcher & Mac an tSaoir, 1995). However, due to the efforts of successive governments there has been rapid afforestation since the 1960s resulting in a 10.0% forest land cover as of 2007 (National Forest Inventory, 2007). This specific land use change provides an opportunity for Ireland to meet international obligations set forth by the United Nations Framework Convention on Climate Change (UNFCCC, 1992). Article 3.3 of the Kyoto Protocol allows changes in C stocks due to afforestation, reforestation, and deforestation since 1990 to be used to offset inventory emissions. Therefore, due to the rapid rate of afforestation and the corresponding increased carbon sequestration, Ireland has the potential to significantly offset GHG emissions.

There is little known as to the impacts of afforestation on the carbon density of soils over time, and even less known about the impact on Irish soils. The FORESTC project aims to analyse this impact by undertaking a nationwide study using a method similar to that of the paired plot method in Davis and Condron, 2002. The study will examine 42 forest sites across Ireland selected randomly from the National Forest Inventory (National Forest Inventory, 2007). This data should provide an analysis of the carbon stocks of the soil and litter of both the forest site and its pair site allowing for comparison and thus the impact of afforestation on carbon stocks.

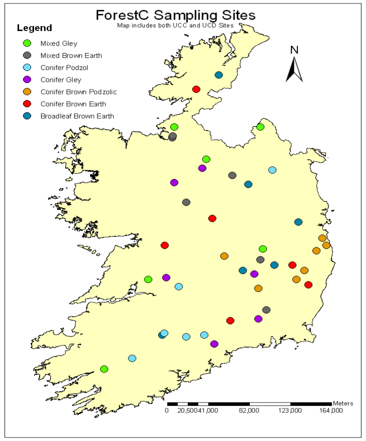

Figure 1 – Map of the 42 Mineral Sites chosen for Sampling.

Methods

The paired plot approach was used to investigate the effect of afforestation on mineral soil carbon densities. 21 forested sites listed have been chosen from the list of NFI sites (21 to be sampled by our group, the remaining 21 to be sampled by a group based in Dublin). Each of these mineral soil sites have a paired site which has the same soil type and physical characteristics as the forest site and is located in close proximity. The only difference between the two sites is the current land-use of the pair site, which should represent the pre-afforestation land-use of the forest site.

Each site is 20 by 20 m and is divided into four quadrants. Within each of the four quadrants one point was chosen at random and a soil pit dug for classification. Bulk density samples were taken at 0-5, 5-10, 15-20, and 25-30 cm depth, at each of the soil pits (see figure 2). At 8 points surrounding the soil pit a dutch auger was used to sample the soil (see figure 2) at depths: 0-10, 10-20, and 20-30 cm depth for SOC %. Also, at each of the four randomly selected points and at 2 points one meter to the east and west of the randomly selected point fine woody debris, litter and humus layers within a 0.1 m² area were be collected. All samples were dried at 55°C before being sieved to <2 mm to determine bulk density and further ground to a powder for C% of both the soil and forest floor by combustion in a C/N analyser (Elementar – Vario Max CN).

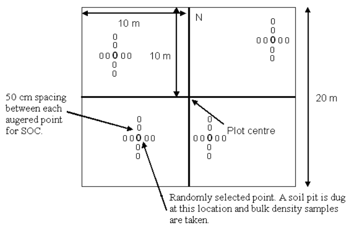

Figure 2 – Showing the layout of the sampling plot.

Figure 3 – Picture of the Loughrea Site, Conifer Brown Earth with it's Pasture Paired Site.

Results

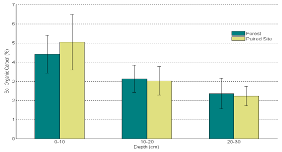

Figure 4 - The SOC % of broadleaf brown earths.

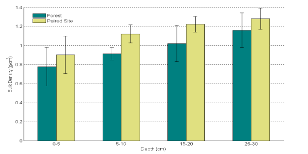

Figure 5 - The BD (g/cm³) of broadleaf brown earths.

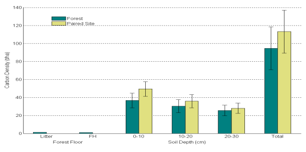

Figure 6 - The C density (t/ha) of broadleaf brown earths.

Figure 6 shows that broadleaf forests on a brown earth soil have smaller C density down the entire soil profile compared to the paired sites. Although it shows a trend of decreased C density in the forest site the difference is only significant in the 0-10 cm layer (n = 8, $P < 0.01$). This is driven primarily by the reduced forest bulk densities (see fig. 5) where the 5-10 and 15-20 cm paired bulk density samples are significantly greater than the forest sites.

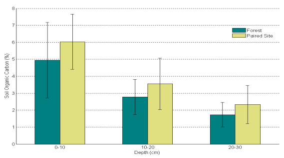

Figure 7 - The SOC % of conifer brown earths.

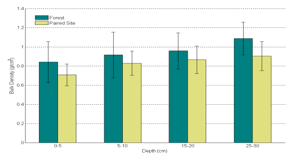

Figure 8 - The BD (g/cm³) of conifer brown earths.

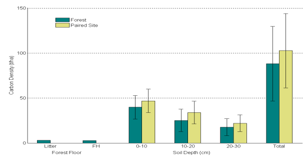

Figure 9 - The C density (t/ha) of conifer brown earths.

Figure 9 shows a very similar trend for the conifer brown earths as that of the broadleaf brown earths (figure 6) with the forest site having a reduced C density compared to that of the paired site. The reduced forest C density is due to the greater SOC content of the pair site down the profile (figure 7). This is in contrast to the increased bulk density of the forest sites to the paired sites bulk densities (figure 8) with the 25-30 cm sample being significantly different (n = 12, $P < 0.01$).

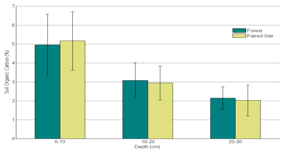

Figure 10 - The SOC % of mixed brown earths.

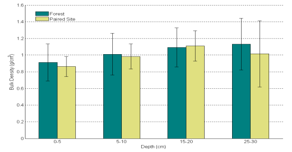

Figure 11 - The BD (g/cm³) of mixed brown earths.

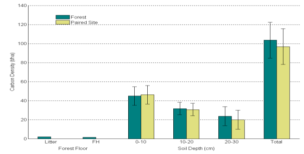

Figure 12 - The C density (t/ha) of mixed brown earths.

Figure 12 shows that mixed brown earths have a slightly greater C density with 103.9 t/ha compared to the 96.7 t/ha of the paired site. With the soil C densities being very similar the litter and F/H layers have made a greater impact upon the totals than on the conifer and broadleaf brown earth sites.

Discussion

Figures 6, 9 and 12 show that across forest types there are differences in the impact of afforestation on the total C density, however this may be misleading and due to the age of the forest rather than forest type. The loss of C from the broadleaf brown earths and conifer brown earths (-18.6 and -14.4 t/ha) are from the youngest forests with an average age of 24 and 32 years respectively while the oldest forest type of 53 years has an increase in C density of 6.8 t/ha. The impact of age on soil C density has been shown in other work and may well turn to be the most important factor of soil C density of the same soil type within Ireland. The results displayed here are a small sample of what will be the total dataset, only showing 8 of the 42 total sites. With the data to come we hope to be able to present a thorough analysis of the variables controlling soil C stock changes due to afforestation and an estimate of the total soil C stocks under forestry in Ireland.

References

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Acknowledgements

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