Impacts of afforestation on the net stand greenhouse gas balance in coniferous and deciduous forest ecosystems.

Matthew Saunders[1*], Giuseppe Benanti[1], Brian Tobin[2], and Bruce Osborne[1].

1.UCD School of Biology & Environmental Science. 2. UCD School of Agriculture Food Science and Veterinary Medicine. *matthew.saunders@ucd.ie

Introduction

In Ireland, under the Kyoto protocol, afforestation and reforestation activities since 1990 are used to offset national greenhouse gas emissions. It is important therefore to quantify both the carbon sink strength and the greenhouse gas (GHG) budget of forest ecosystems through various stages of stand development.

Methodology

In this study net stand GHG emissions were quantified using a mobile eddy covariance platform (Figure 1) coupled with measurements of soil derived trace gas emissions. A chronosequence of sites were utilised to assess the impacts of afforestation and stand age on GHG emissions. Each chronosequence consisted of a grassland reference site, representing the land use prior to afforestation and a series of young forest stands up to 14 years in age. The frequency of the tower moves was determined based on the accuracy of the EC gap-filling models which were tested by randomly introducing data gaps of varying duration into EC data sets obtained from other grassland, arable and Sitka spruce forest ecosystems. Based on this analysis the tower was moved at 7 day and 3 day intervals in the Sitka and Ash chronosequence sites respectively.

Figure 1. The roving EC tower *in situ* at the 6 year old Sitka site, at the 11 year old Ash site and in transit between sites

Results and Discussion

- Measurements of Net Ecosystem Exchange showed that carbon uptake increased with forest age at both sites (Figure 2).
- The increase in the carbon sink strength at the Sitka sites was primarily driven by an increase in gross primary productivity (GPP) associated with changing vegetation up to canopy closure (Figure 2).
- The increase in the C sink strength with forest age at the Ash sites was driven by both an increase in GPP and an associated reduction in ecosystem respiration (Figure 2).
- The inclusion of trace gases N_2O and CH_4 as CO_2-equivalents (NEE_{GHG}) resulted in a reduction in the C sink strength (NEE_c) of all ecosystems (Figure 3).
- High CH_4 emissions from the grassland associated with the Sitka chronosequence resulted in an ~12% reduction in the C sink (Figure 3).
- N_2O emissions were observed to increase with forest age in the Sitka chronosequence and resulted in a 8% reduction in the C sink strength of the 14 year old Sitka stand (Figure 3).
- The application of inorganic fertiliser at the grassland associated with the Ash chronosequence lead to an 8% reduction in the C budget at this site (Figure 3).
- Trace gas emissions were low from the 6 and 11 year old Ash stands, resulting in a small ~1% reduction in the C budget at both sites (Figure 3).
- All sites in this study acted as a net GHG sink, however more information is required during the afforestation process to determine long-term GHG budgets associated with forest ecosystems and land use change.

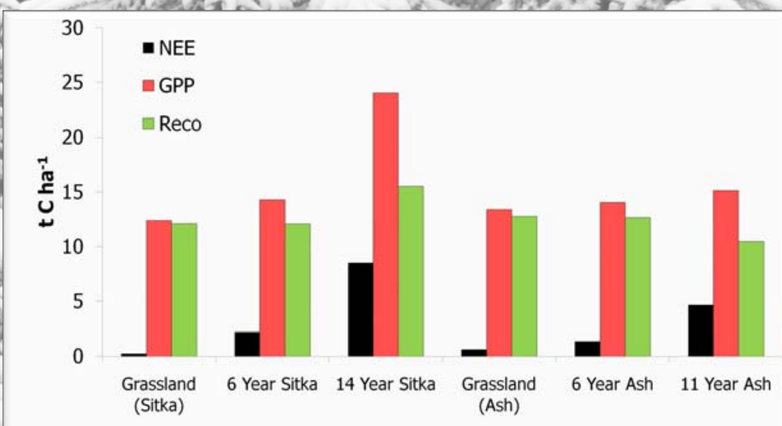

Figure 2. Net ecosystem exchange, Gross Primary Productivity and Ecosystem Respiration at the Sitka and Ash chronosequence sites.

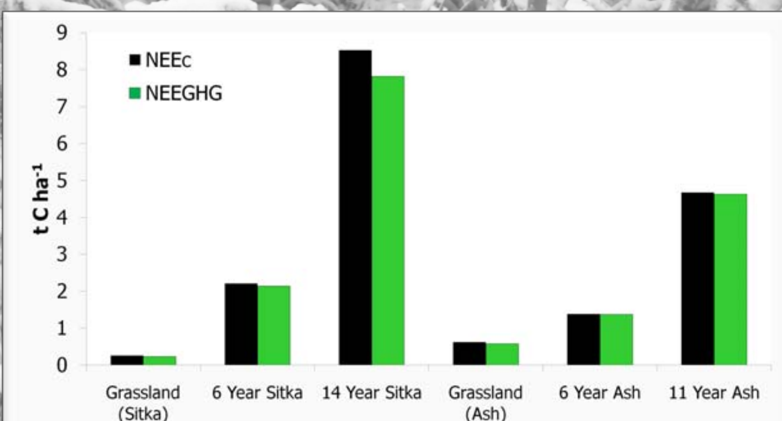

Figure 3. Net ecosystem carbon and GHG budgets at the Sitka and Ash chronosequence sites.