Impacts of afforestation on greenhouse gas efflux in a Sitka spruce plantation in Ireland

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Afforestation is thought to be an important factor in determining atmospheric greenhouse gas budgets. Conversion from grassland to forest is known to increase the CO_2 sink capacity. Its impact on other greenhouse gases efflux, such as nitrous oxide (N_2O) and methane (CH_4), is, however, less clear. To investigate this we deployed a static chamber technique (**Fig. 1.A–1.B**) to produce annual field based estimates of N_2O and CH_4 efflux from a Sitka spruce [*Picea sitchensis* (Bong.) Carr.] forest chronosequence on gley mineral soil in the Irish midlands. The chronosequence consisted of a semi-natural grassland (representing year 0) and a 6-, 14- and 20-year-old forest stand (**Fig. 1**).

We have found **a stand-age-dependent effect on N_2O and CH_4 efflux** associated with afforestation; **N_2O emissions increased by at least seven fold with increasing forest age** (**Fig. 2A**), whereas **the opposite was observed for CH_4 emissions**, with the 14 year old forest acting as a net sink (**Fig. 2.B**).

Figure 1: Dooary forest chronosequence. *Juncus effusus* dominated grassland (1.A), 6-year-old (1.B) and 20-year-old (1.C) Sitka spruce forest stands.

Figure 2: Annual cumulative N_2O (2A) and CH_4 (2B) efflux from the Dooary forest chronosequence (vertical bars represent the standard error).

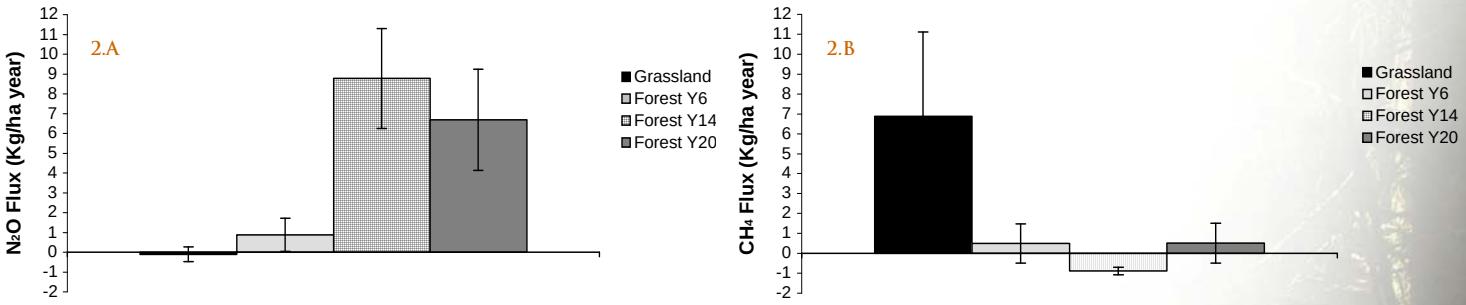
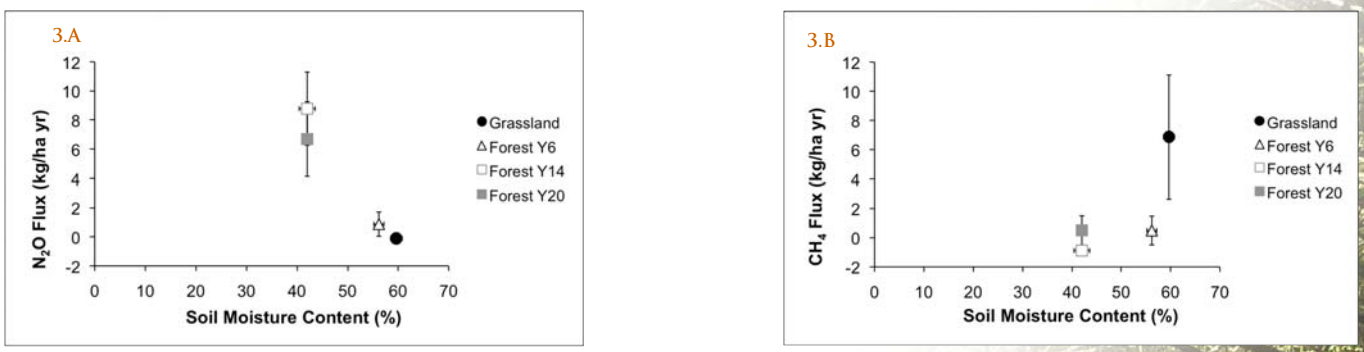


Figure 3: Annual cumulative N_2O (3A) and CH_4 (3B) efflux in relation to average soil moisture content from the Dooary forest chronosequence (bars represent the standard error).



Our findings show a similar pattern to a previous report [1]; our N_2O emission estimates, however, were much higher than those found in similar investigations (e.g. 3.30 kg N_2O/ha yr [2]; 2.80 kg N_2O/ha yr [3]).
There is evidence that these results are a consequence of the **change in water status associated with afforestation-related increases in drainage** (**Fig. 3**). It is known that N_2O emissions increase following drainage [4], whereas CH_4 emissions decrease. This may also be related to a **change in soil microbial population structure as a result of afforestation**, favoring N_2O-producing nitrifiers and denitrifiers species. Our finding of a net reduction in overall microbial activity with increasing stand-age (**Fig. 4**) does not exclude this hypothesis and may indicate significant changes in microbial population structure.

Further ongoing research on different soils (e.g. organic) and different forest cover (e.g. deciduous forests) will provide a more complete assessment of the impacts of afforestation on greenhouse gas dynamics at the national scale.

Figure 4: Overall microbial activity at the Dooary forest site. Soil samples were incubated with fluorescein diacetate (FDA) and microbial activity determined by spectrophotometry on the basis of FDA hydrolysis and fluorescein released [5] (vertical bars represent the standard error).

We would like to acknowledge the support of COFORD through the CARBIFOR II project for financial support

[1] **Brumme R, Borken W, Finke S. 1999.** *Global Biogeochemical Cycles* **13:** 1137–1148.
[2] **Ball T, Smith KA, Moncrieff JB. 2007.** *Global Change Biology* **13:** 2128–2142.
[3] **Ambus P, Zechmeister-Boltenstern S, Butterbach-Bahl K. 2006.** *Biogeosciences* **3:** 135–145.
[4] **Dowrick DJ, Hughes S, Freeman C, Lock MA, Reynolds B, Hudson JA. 1999.** *Biogeochemistry* **44:** 151–162.
[5] **Green VS, Stott DE, Diack M. 2006.** *Soil Biology and Biochemistry* **38: 693**–701.