CLIMIT

CARBiFOR II

Carbon sequestration by Irish forest ecosystems

PROJECT TEAM
Prof. Maarten Nieuwenhuis, University College Dublin*
Dr Brian Tobin, University College Dublin
Paul Gardiner, University College Dublin
Samuel Olajuyigbe, University College Dublin
Prof. Bruce Osborne, University College Dublin*
Dr Matt Saunders, University College Dublin
Guiseppe Benanti, University College Dublin
Prof. Thomas Bolger, University College Dublin

** Address correspondence to:*
maarten.nieuwenhuis@ucd.ie and
bruce.osborne@ucd.ie

COMPLETION DATE
December 2011

OBJECTIVES
The overall objective is to provide information to determine the influence of disturbance, land use change, soil type and forest age on carbon budgets relevant to reporting land use change and forestry (LUCF) activities under the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC).
Specific targets are:

- Provision of a harvested tree database for the development of biomass algorithm and allocation models for different species.
- Assessments of current annual increment (CAI) using repeat surveys and tree stem analysis on four afforested chronosequences.
- Validation of litter input models using litter traps and fine roots in growth bags over four afforested chronosequences.
- Estimation of emission factors associated with land use change to forestry on three soil types.
- Estimation of emission factors associated with deforestation of peat soils for the major forest species.
- Estimation of emission factors associated with thinning for major forest species.
- Development of decomposition models for woody debris (timber and coarse roots) and litter (brash, leaf and fine root inputs) to parameterise CARBWARE.
- Assessment of non-forest vegetation and soil C stock changes for four soil types and decomposition of non-forest vegetation over time (i.e. four afforested chronosequences).
- Assessment of soil C stock changes using paired plot comparisons of afforested and non-afforested areas based on national forest inventory (NFI) sample plots.
- Characterisation of non-CO_2 GHG fluxes over the three afforested chronosequences.
- Development of process-based climate change models using eddy-flux and NPP data.
- Validation of the CARBWARE model using eddy-flux and CAI assessments.

PROGRESS
Quantification of emission factors associated with change of land use to forestry
Management practices, species composition and soil type are being considered for the selection of chronosequences (age series) including Sitka spruce, ash and oak. Three sites have been tentatively selected for another Sitka spruce chronosequence. A Sitka spruce afforestation chronosequence, including an unforested site representing previous land use (grassland) on surface water gley soil has been selected. The approach adopted includes the measurement of current biomass annual increment and litterfall (≈ NPP), using repeat surveys, and eddy covariance, which measures the net annual carbon balance (NEP). The assessment of NEP of different aged forests will be achieved using a permanent eddy covariance tower, established since January 2001, and a roving tower (Figure 1). The difference between NEP and NPP reflects the emissions, which are otherwise difficult to measure at the site level, associated with land use change and

Figure 1: The roving eddy covariance system designed to move between selected sites to assess net C balance (NEP) of stands following afforestation, thinning and harvest. Insert shows the instrumentation attached to the top of the mobile tower.

management interventions, such as thinning and final harvest.

The provision of emission factors for the CARBWARE model will be an ongoing process; however, an initial emission factor estimate will be submitted to the model component after the first 12 months of the first roving chronosequence.

Litterfall, above- and below-ground decomposition and fine root turnover experiments are under development at the chronosequence sites, including a trenching experiment utilising the thinned forest stand to examine the relative decomposition over time of coarse, medium and fine root material.

The effect of thinning on carbon sequestration

The permanent reference eddy covariance tower and biomass surveys are being used to assess the impacts of forest management (thinning) on carbon fluxes. The site was thinned in late 2006, resulting in a reduction in basal area from 34 m^2/ha in the unthinned, to 25 in the thinned plots. Preliminary results suggest that the magnitude of the carbon fluxes has increased substantially, compared to those measured before thinning (Figure 2). This may be due to an increase in canopy photosynthesis (GPP) through increased light penetration/adsorption and light-use efficiency, or due to a lag response of the total ecosystem respiration (which is expected to increase) through the slow decomposition of thinning brash. However, NEP assessments do not account for the loss of carbon from harvested wood. If this were included in the estimate thinning would result in a substantial temporary loss of CO_2 (i.e. a net emission for 2007).

Paired plot sites

A protocol has been agreed for site selection of paired soil plots. The paired plot approach involves the selection of an afforested site and an adjacent site representing unafforested conditions. Differences in soil carbon content between the paired sites will be used to estimate soil carbon stock change following afforestation.

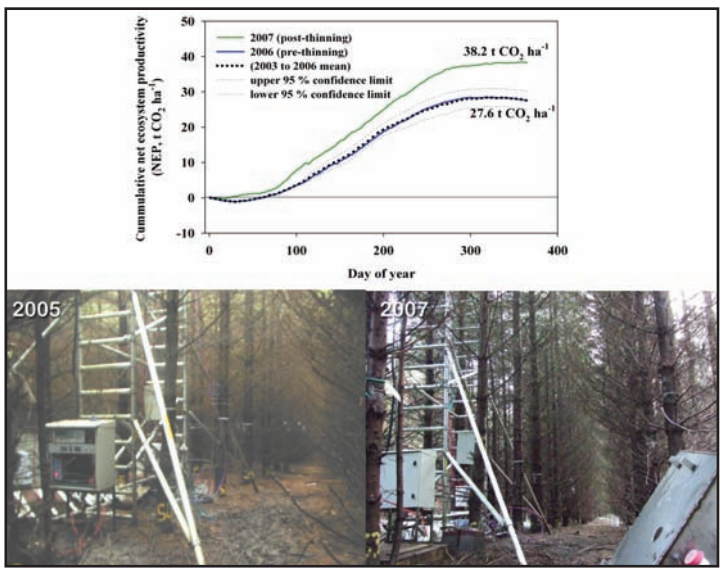

Figure 2: Changes in NEP and canopy characteristics before (2005/6) and after thinning (2007). Positive NEP values (excluding C losses in harvested wood) represent an uptake of CO_2. Note the reduction in green leaf area after thinning.

Using stratified sampling a series of stands on representative soils has been selected from the national forest inventory (NFI) database (Figure 3). Identification of a full set of sites will continue, as it will require site visits to ensure the selection of appropriate paired sites. A soil sampling protocol has been developed and agreed following collaboration with the FORESTSOILC project.

ACTIVITIES PLANNED

Work Package 1: Identification of chronosequences will be completed. Above-ground coarse wood debris (CWD) decomposition experiment will be set up. Four chronosequences will be surveyed before the 2008 growth season. The thinning experiment will be resurveyed (following first growing post-thinning operation). Litter collection will be set up in conjunction with WP 2. Biomass and CWD sampling will begin.

Work Package 2: The roving eddy covariance tower will be deployed at all chronosequence sites. Decomposition, litterfall and fine root turnover experiments will be finalised. Collars will be permanently installed at all chronosequence sites and N_2O and CH_4 measurements will start. Measurements of the species composition and biomass estimation of non-timber vegetation will be undertaken.

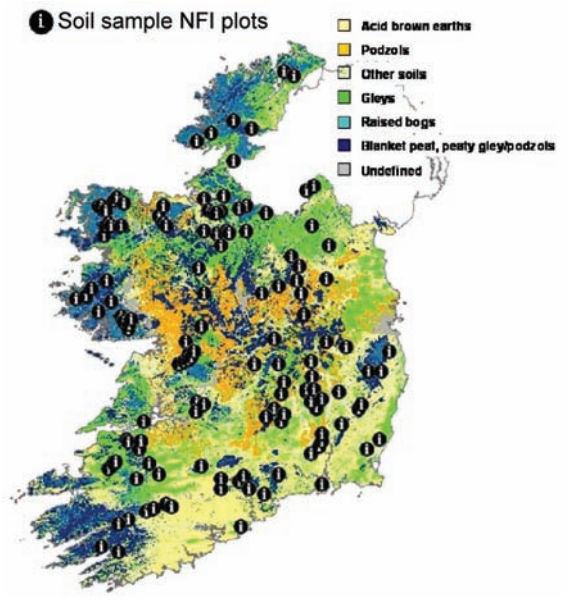

Figure 3: The selected paired plot sites to be used for the estimation of soil carbon stock changes following afforestation.

Work Package 3: Sampling of paired plots at NFI sites will commence. Discussion regarding cross collaboration with WPs 1 and 3 regarding the monolith experiments and below-ground decomposition experiments will refine what is planned for this study.

OUTPUTS

Papers and articles:

Tobin, B. and Nieuwenhuis, M. 2007. Mitigation of GHG emissions by forests – the CARBiFOR project. *Irish Timber and Forestry* 16 (3): 31-32.

Tobin, B., Black, K., McGurdy, L. and Nieuwenhuis, M. 2007. Estimates of decay rates of components of coarse woody debris in thinned Sitka spruce forests. *Forestry* 80 (4): doi: 10.1093/forestry/cpm024.

Tobin, B., Čermak, J., Chiatante, D., Danjon, F., Di Orio, A., Dupuy, L., Eshel, A., Jourdan, C., Kalliokoski, T., Laiho, R., Nadezhdina, N., Nicoll, B., Pagés, L., Sande-Silva, J., and Spannos, I. 2007. Towards developmental modelling of tree root systems. *Plant Biosystems* 141 (3): 481-501.

Conferences/meetings:

Tobin, B., Čermak, J., Chiatante, D., Danjon, F., Di Orio, A., Dupuy, L., Eshel, A., Jourdan, C., Kalliokoski, T., Laiho, R., Nadezhdina, N., Nicoll, B., Pagés, L., Sande-Silva, J. and Spannos, I. 2007. *Towards developmental modelling of tree root systems*. Presented at 4th International Symposium on Physiological Processes in Roots of Woody Plants. Bangor, 16-20 September, 2007.

Greenhouse gas fluxes in terrestrial ecosystems in Ireland. EPA, 20 September 2007, Ireland.

5th Annual CarboEurope-IP Project Meeting, 8-12 October 2007, Poland.