Peatland Programme

## IUCN UK Peatland Programme, Forests and Peatland Science Workshop

Tuesday 3rd June 2014, Edinburgh Centre for Carbon Innovation

# COMPARING GHG EMISSIONS FROM AFFORESTED, RESTORED AND NEAR-NATURAL PEATLANDS – THE STATUS QUO

**1. Key Points**

1. **IPCC default emission factors (EFs) exist for afforested and restored peatlands. The research data included in the IPCC Tier 1 factor calculations suggest that there are substantial soil-based GHG emissions from afforestation on peat, that require sizeable sequestration rates into timber biomass to counter them. The default EF for afforested temperate peatland is largely derived from different peatland forestry practices to those in the UK, with the latter involving far greater peatland soil disturbance and drainage.**
2. **At present, net emissions from afforested peatlands are calculated for the UK National Inventory Report using Tier 3 methodology (FCS CARBINE model). The CARBINE model at present suggests forests are net sinks. However, the input data behind the model is not from deep peat soils but very different peaty podzols. The model may also need to be reviewed to ascertain that all new emissions categories (e.g. $CH_4$ from ditches, DOC losses) are accounted for.**
3. **Emissions from restored peatlands are not currently included in Inventories and discussions are still ongoing as to the appropriate calculation of the emissions/removals from rewetting activities. The IPCC 2013 Supplement chapter on rewetted soils suggest that such emissions/removals could be accounted for indefinitely. However, at some point restoration sites would approach a near natural state. Near natural peatland emissions should not accounted for, and a decision will be required on how to account for a former restoration site that has become 'near natural'.**
4. **There are a number of ongoing UK research efforts aiming to address the evidence gap in net emissions from afforested and restored peatlands. Notable remaining gaps are in the monitoring of DOC and ditch methane emissions from afforested and restored peatlands.**

## 1. Can default Tier 1 IPCC emission factors be applied?

1.1. The 2013 IPCC Supplement to the 2006 Guidelines: Wetlands includes default emission factors for the net exchange of $CO_2$, $CH_4$, $N_2O$, and DOC from various types of wetlands, including afforested and rewetted areas, for the purpose of calculating total greenhouse gas emissions from the land use sector for the National Inventory Report. Emissions from near-natural peatlands (unmanaged land) do not have to be accounted for in national Inventories. At present, all UK land is assumed to be managed.

1.2. The IPCC advocates using higher level emissions factors in national calculations, if the land use category of interest makes up a significant proportion. As this is the case for the UK, development of higher level approaches is advocated, although in the interim Tier 1 approaches may need to be used for some land use categories.

1.3. IPCC default emission factors for forest land only report on soil-based emissions as the carbon held in the timber biomass is calculated separately. The default emission factors from all other categories, however, include the above-ground component, and hence represent the net carbon losses from the ecosystem. Therefore, the figures cannot be directly compared without an estimate of the carbon held in the tree biomass. However, using Tier 1 method calculations, the amount of biomass carbon stored in the timber would have to exceed 10. t $CO_2$e $ha^{-1}$ $y^{-1}$ in afforested peatlands in order to cause the same net emissions as rewetted peatlands (Table 1), which is higher than the FC estimate range of growth yields on deep peat. This crude net balance, however, is at odds with current UK model outputs (see Section 2).

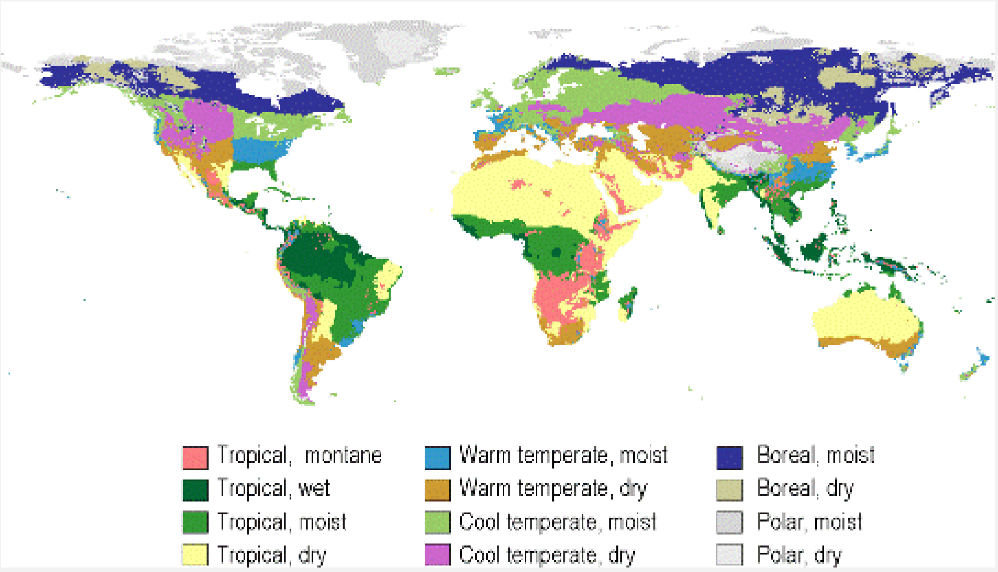
**Table 1.** Comparison of full soil-based emissions based on a worked example using the equations and Tier 1 emission factors presented in the IPCC 2013 Wetlands Supplement (all values recalculated to t $CO_2$e $ha^{-1}$ $y^{-1}$). Positive values represent an emission to the atmosphere i.e. globally warming

| Land use category | Soil $CO_2$ emissions (includes $CO_2$ from DOC as per eq. 2.2, Chapter 2, IPCC 2013 Supplement) | Soil $CH_4$ emissions (includes emissions from site and ditches) | Soil $N_2O$ emissions | **Total soil-based emissions, inclusive of GWP conversion for $CH_4$ and $N_2O$** |
|---|---|---|---|---|
| Forest Land, drained | 10.64 | 0.20 | 1.31 | **12.1 = ΔC-SO** |
| Cropland, drained | 30.06 | 1.46 | 6.08 | **37.6 = ΔC-LU** |
| Grassland, drained, nutrient-poor | 20.53 | 0.70 (assuming EF for shallow-drained grasslands) | 2.01 | **23.2 = ΔC-LU** |
| Peatland managed for extraction | 11.36 | 0.82 | 0.14 | **12.3 = ΔC-LU** |
| Rewetted organic soil | 0.004 | 1.72 | Assumed negligible | **1.7 = ΔC-LU** |

ΔC-SO: soil-based emissions; ΔC-LU: net emissions from the land use category

1.4. In the case of afforested organic soils, the IPCC Tier 1 emissions factors are split into boreal and temperate categories as well as a category of forest land that may not fulfil criteria for forest cover. On closer inspection, a significant number of the research studies that have been included in the boreal category were conducted on sites that would technically fall within the temperate zones as per the IPCC definition (Plate 1). A recalculation of the Tier 1 forest land emissions factors, by recategorising studies according to the IPCC climatic zone definition as reproduced in Plate 1 would result in slightly different values (ongoing work in Defra project ' Carbon metrics for the UK Peatland Code') although they fall within the same overall range and are therefore unlikely to be significantly different.

**Plate 1. Climatic zones as per IPCC classification (IPCC, 2006)**




1.5. Regardless of the appropriate calculations of the Tier 1 emissions factor, there are only a small number of research studies of net GHG emissions that have thus far been conducted on afforested peatland. The majority of the published studies are from Scandinavia, where the forestry practices differ markedly to the UK, in that the sites generally already had some natural, stunted, forest cover and drainage was applied to encourage tree growth in such areas. In the UK, the vast majority of afforested peatlands were originally treeless bogs, where substantial drainage, ploughing, fertilisation and reprofiling were applied prior to active tree planting. This has resulted in greater peat soil disturbance and drainage combined with a much denser forest cover in the UK, with generally no or very little understorey and practically no peat forming vegetation. In Scandinavia, there is generally still significant cover of peatland vegetation under the forest canopy, which is contributing both to overall carbon fixation and retention of stored carbon.

1.6. Crucial differences in management practice may determine the net GHG balance of afforested sites. There is currently only a single published UK study of the GHG fluxes of afforested peatlands (Yamulki et al, 2013), which has received a critique on the calculations of the net balances (Artz et al, 2013) resulting in an amendment by the authors (Yamulki et al, 2013b). Other ongoing UK studies are not yet published. Studies of a site in central Finland that had been previously used for agriculture for nearly 30 years and then planted for forestry (i.e. somewhat more akin to UK management practices) suggested that this actively planted former agricultural site was losing soil carbon. Most reports of C balances from sites that had simply been drained to improve timber growth appear to continue to sequester soil carbon. However, this is not a common management scenario in the UK.

1.7. On the basis of the scarcity of direct UK observations of GHG emissions from plantation forestry on deep peat, further research effort is required to understand the net carbon consequences of afforestation of peat soils in a UK context.

1.8. The default GHG emission factors from all other land use categories are similarly derived from mostly Scandinavian or central European studies, where management differs quite markedly from UK scenarios. However, there are a number of ongoing monitoring studies of restoration sites, which may be able to contribute to the development of higher level emission factors in the coming years (see Section 3). There are marked differences in the net GHG budget of sites with different trophic status, as fen habitats or bogs with significant sedge cover tend to have higher methane emissions. Tier 1 emission factor calculations for restored bogs drew on data from both restored and near natural sites as the IPCC authors concluded there to be no significant differences. This may or may not prove to be appropriate in the future, as more data become available.

## 2. Currently used models to calculate GHG emissions from afforested or restored peatlands for national reporting

2.1. At present, the UK National Inventory already applies a Tier 3 based methodology to calculate net emissions from the forest sector, although Tier 1 or Tier 2 methods are used for most of the other land use sectors on organic soils. The current GHG emissions estimates for the forestry sector are supplied by Forestry Commission using their in-house CARBINE model. The model estimates the soil-based emissions for carbon dioxide, methane and nitrous oxide, as well as timber biomass carbon and avoided emissions in harvested wood products. The technical details of how this model functions are not yet available to the wider public, however, a technical report is in preparation by CEH Inventory compilers and FR staff.

2.2. Currently published, modelled, carbon balances of afforested deep peat (using the 3PGN model rather than CARBINE) suggest that a positive GHG balance can be reached even on second rotation sites, with growth rates as low as yield class 8 (sitka spruce) or yield class 6 (lodgepole pine) assuming higher levels of disturbance (data shown at meeting by Mike Perks, FR; Plate 3). However, after the second rotation, total ecosystem carbon under forestry was predicted to be lower than if the site was under native peatland vegetation cover (Minnuno et al, 2010). It is worth noting that these results have not been validated independently to date due to a lack of ecosystem carbon budgets from UK forestry plantations on peat.

2.3. The precise workings of the CARBINE model are not in the public domain at present. Although CARBINE was parameterised with UK-specific data for some parts of the model, there are not as yet sufficient UK monitoring data available to validate the projected GHG emissions on deep peat. There is ongoing monitoring work (see Section 3) which will produce some of these validation data in the next few years. The additional emissions classes proposed by the IPCC Wetlands Supplement, such as methane emissions from ditches, or DOC/POC losses, are unlikely to be included adequately in the CARBINE model at present. Hence, further discussions with the team of researchers developing CARBINE would be useful. The Tier 1 emission factor for DOC converted to $CO_2$ from forest land (drained, temperate) suggests emissions in the range of 1.1 t $CO_2$ $ha^{-1}$ $yr^{-}$

[1] alone. On sites with very poor timber growth, even after 20 years, carbon accumulation rates into timber biomass are in the region of 3.5-4.2 t $CO_2$ $ha^{-1}$ $yr^{-1}$ (Mike Perks, pers comm, calculated example of timber biomass for an example type 10b Sphagnum bog with existing 20 year old stand of sitka spruce/lodgepole pine using the ESC model). At the upper end of timber growth on peatlands, FR estimates are for a net ecosystem productivity of ca. 9.9 t $CO_2$ $ha^{-1}$ $yr^{-1}$ (data shown by Mike Perks at meeting).

2.4. Almost all other peatland areas are currently accounted for under the grassland category in the annual National Inventory Report. At present, the emissions are accounted for using Tier 1 methodology but Tier 2 methods have been proposed. It will need to be assessed whether these take into account the additional GHG emissions categories introduced in the IPCC 2013 Wetlands supplement.

2.5. As the inclusion of rewetted land in the National Inventory Report only applies to 2013 onwards, there is as yet no mechanism for reporting of restoration activity. The most recently submitted NIR (2014) presented data up to 2012, so this will be required to be decided on within the next year. At present, it looks most likely that LULUCF emissions will be likely accounted for using Tier 1 methodology in the first instance. It is unclear as to how to account for a site that has been restored and returns to a near natural status in accounting terms (i.e. when it becomes unmanaged land). At present, no UK land is deemed unmanaged and so all emissions are included for the time being. Whether rewetted land can be reported for KP reporting under the new, elective, category of ‘wetland drainage and rewetting’ will depend on the starting category, as there is a hierarchical approach to KP reporting. This can, in some cases such as in formerly afforested sites, lead to counter-intuitive emissions reporting. UK guidance on this is expected to be produced this autumn in a new DECC project.

## 3. Research gaps and current research activities

3.1. At present, the only published report of GHG emissions from an afforested deep peat site applicable to a UK context is from Flanders Moss (Yamulki et al, 2013). However, some of the budget calculations were indirect, and the net effect of the plantation was not considered over the entire life cycle.

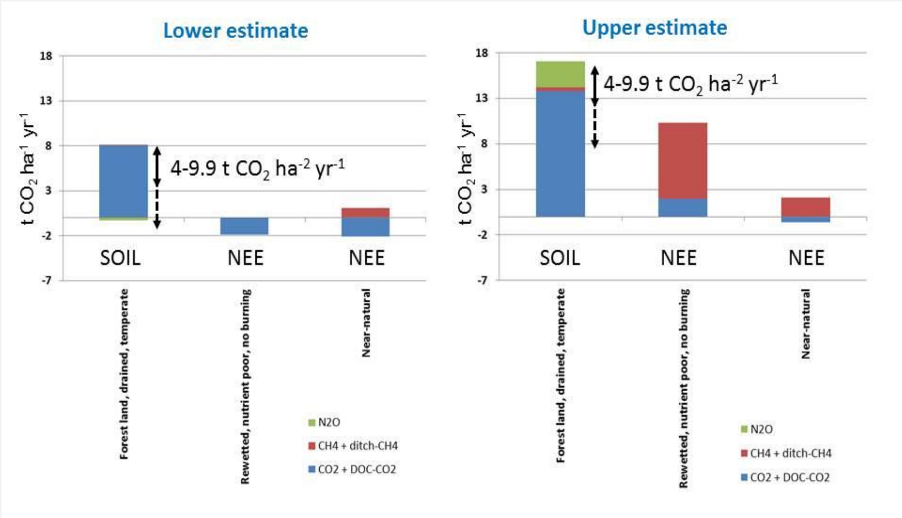
3.2. Ongoing research efforts in the UK and Ireland include measurements of various GHG fluxes at Forsinard (from 2014), Cloosh (from 2011) and Lullymore forests (from 2001). These will provide validation for future modelled GHG balances.

3.3.At present, there is no data available for the GHG consequences of site preparation, or harvesting, although some of the effects of clearfell will be captured by research efforts at Forsinard on a planned restoration site currently still with standing timber.

3.4.There is a much larger publication record from Ireland on the GHG emissions on restored peatland sites, however, these tend to be predominantly from areas restored after peat harvesting. Being at the extreme end of site disturbance, these values will not be representative of the likely fluxes from peatlands restored by, for example, ditch blocking.

3.5. A large number of research activities are already active to produce GHG emissions values from restored peatlands in the UK and Ireland, with notable examples at Forsinard, Thorne Moors, Hatfield Moors, Forest of Bowland and nearby areas, Bleaklow, Manchester Mosses, Bakers Fen, Exmoor National Park, Dartmoor, Migneint, Lake Vyrnwy, Whixall Moss, Turraun, Bellacorick, Blackwater, Glenvar, Scohaboy and Pollagoona. These examples span a wide gradient of starting conditions prior to restoration activities took place, ranging from ex-peat harvesting sites to former forestry plantations. For the most part, these monitor net $CO_2$, $CH_4$ and $N_2O$ emissions, with some notably lower efforts in the monitoring of emissions specifically from e.g blocked ditches and the net loss of DOC from the site.

**Plate 2. Schematic example of GHG fluxes from afforested, restored and near-natural peatlands on the basis of IPCC 2013 Tier 1 calculations**




The IPCC 2013 Tier 1 emissions factors can be used to calculate crude budgets. Note that emissions from forest land do not include net C uptake by biomass, whereas all other land uses do. Using the lower and upper 95% confidence intervals, the likely net budget of afforested peatlands would fall either in the same range as emissions from restored peatlands, if timber biomass C accumulation is assumed at the upper end of 9.9 t $CO_2$ $ha^{-2}$ $yr^{-1}$ or assuming the lower timber C accumulation figures of 4 t $CO_2$ $ha^{-2}$ $yr^{-1}$ would mean emissions from afforested peatlands were substantially higher than under restoration scenario. Data for neat-natural peatlands were calculated from data collected by Artz et al. (2012) and subjected to IPCC Tier 1 calculations (assuming 90% of DOC would be converted to $CO_2$, there are no ditches present to add to the site-based $CH_4$ emissions, and assumed zero emissions from $N_2O$).

***continued***

**Plate 3. Modelled net C stocks (3PGN) of forestry on peat and peaty gley.**

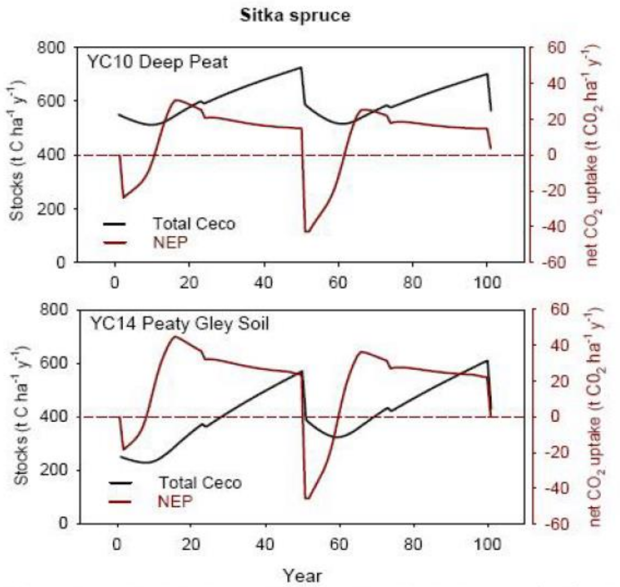



Figure 3.1. Modelled total ecosystem net $CO_2$ uptake (NEP, t $CO_2$ $ha^{-1}$ $y^{-1}$) and total ecosystem C stock changes (Total Ceco, t C $ha^{-1}$ $y^{-1}$) over two rotations of even-aged Sitka spruce. Soil types were deep peat, [top panel] and peaty gley [bottom panel]. Outputs are from the model 3PGN (after Minnuno, 2009).

Data presented at the workshop suggest, on the basis of modelled data, that reasonably productive timber stands on deep peat (> yield class 6 for Sitka spruce and yield class 4 for lodgepole pine 50:50 mix) still provide a net carbon benefit in the second rotation.

After the second rotation, however, the ecosystem carbon content under forestry plantation is lower than if the site had never been planted. A restoration scenario has not yet been considered in modelling terms, but was deemed to have insufficient data availability at present to be used as an alternative scenario to second rotation planting.

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