# 19. Soil carbon and peat extraction in Northern Ireland (WP 2.16)

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## *19.1 Soil Carbon survey on 5 km grid for Northern Ireland – identification of changes in soil C since last survey*

The first systematic survey of the soils of Northern Ireland was carried out during the period 1988-97 and involved the mapping and classification of soils at a scale of 1:50,000. As part of this survey, on predominantly agricultural soils, sites were sampled down to parent material, by horizon, from survey pits located on a near regular 5km grid. In winter 2004-05 (Dec'04-Feb'05), the soils of Northern Ireland were re-sampled on the same 5km grid but extended to include soils from all regions of the Province viz. agricultural, semi-natural, upland and urban. Two sample depths were used in the re-survey viz. 75mm (for agronomic purposes) and to the A-horizon (for comparison with the previous survey). Sample locations were identified using GPS. In all, 582 soils were sampled in 2004-05 (an additional 103 samples compared with the 1988-97 survey) and subjected to physical and chemical analysis including total Carbon (%C). The complete dataset of %C results for the re-survey became available in February 2007.

A statistical summary of the results is given in Table 19-1 (for all records) by land use class. The distribution of soil-C across Northern Ireland is shown in Figure 19-1 using graduated dots to represent %C concentrations in classes <5, 5-10, 10-20, 20-40 and >40%C.

Table 19-1: Average soil % carbon values (with standard deviations in brackets) by land use class for all 582 soils sampled across Northern Ireland on a 5km grid during Winter 2004-05.

| Land Use | No. of records | %C (top 75mm) | %C (A-horizon) |
|---|---|---|---|
| Arable | 24 | 4.18 (2.36) | 3.90 (1.75) |
| Conifer Forest | 27 | 44.82 (14.11) | 44.79 (15.94) |
| Deciduous Forest | 5 | 9.67 (5.23) | 10.57 (7.62) |
| Extensive Grazing | 59 | 45.91 (12.37) | 46.61 (14.32) |
| Grazing | 367 | 8.38 (5.51) | 7.03 (5.45) |
| Silage | 35 | 6.23 (2.29) | 5.15 (1.85) |
| Rough Grazing | 28 | 15.86 (8.88) | 15.36 (10.09) |
| Semi-natural | 10 | 44.54 (11.91) | 43.87 (15.71) |
| Urban Amenity | 8 | 5.94 (3.37) | 5.09 (3.28) |
| Others (mixed use) | 19 | 12.54 (12.85) | 11.19 (13.73) |

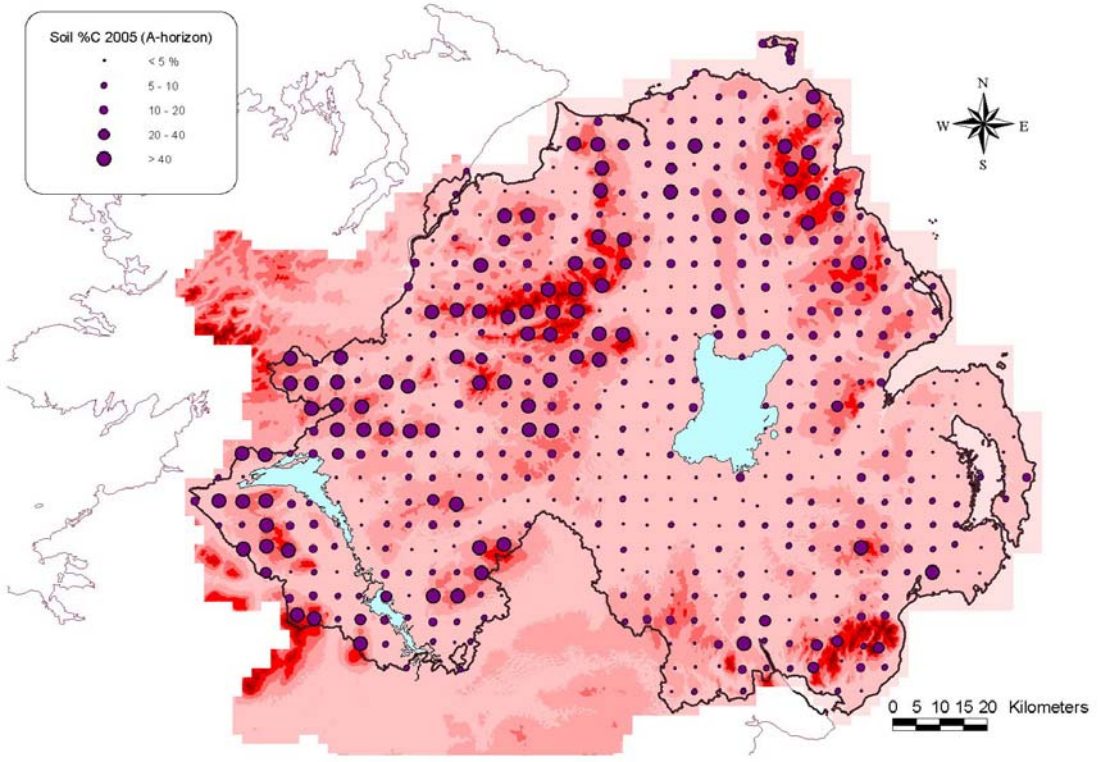


Figure 19-1: The distribution of soil C concentrations (%) on a near regular 5km grid for soils sampled in winter 2004-05 (A-horizon), superimposed on a digital elevation model for Northern Ireland (higher altitude = darker pink/red).

In order to estimate the degree of change in soil C concentrations between the two surveys, the datasets (possible for A-horizon samples only) from the 2 periods were matched using a Geographic Information System (viz. ESRI's ArcGIS). Exact matches could not be made because of the different systems used to identify the coordinates of the sample points (approximate map references used in 1988-97 vs. GPS readout for 2004-05) but it was possible to match sample points in close proximity (median positional difference 123m, with 95% of samples within 500m of each another). For brevity, from here on, the 1988-97 survey will be referred to as the '1995 survey'.

A statistical comparison of the matched records from the 2005 vs. 1995 datasets is summarised in Table 19-2 and the % change in the mean %C value from 1995 evaluated for each of the 5 main land uses represented in the matched dataset. Also included in Table 19-2 are the linear regression parameters for the lines of best fit for %C 2005 (y-axis) vs %C 1995 (x-axis) for each class together with their respective regression coefficient (as $R^2$).

Table 19-2: A statistical comparison of the matched 2005 vs. 1995 soil carbon dataset summarised by land use together with the regression lines for %C 2005 (y-axis) vs. %C 1995 (x-axis) by land use.

| | %C 2005 | %C 1995 | %C 2005 | %C 1995 | %C 2005 | %C 1995 | %C 2005 | %C 1995 | %C 2005 | %C 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Arable** | | **Coniferous Forest** | | **Extensive/Semi-natural** | | **Managed Grassland** | | **Rough Grazing** | |
| Count | 17 | 17 | 16 | 16 | 51 | 51 | 318 | 318 | 19 | 19 |
| Minimum | 1.33 | 1.62 | 10.40 | 7.29 | 4.24 | 3.51 | 1.96 | 0.77 | 4.07 | 3.96 |
| Mean | 3.73 | 3.85 | 47.01 | 39.39 | 46.03 | 35.64 | 6.80 | 6.21 | 15.77 | 13.14 |
| Median | 3.38 | 3.54 | 53.55 | 42.80 | 52.70 | 45.40 | 5.64 | 4.67 | 12.90 | 8.57 |
| Maximum | 7.68 | 7.67 | 54.60 | 51.80 | 56.50 | 52.50 | 51.10 | 49.80 | 35.80 | 51.30 |
| 1st Quartile | 2.06 | 2.46 | 50.10 | 37.05 | 50.75 | 19.80 | 4.14 | 3.73 | 8.62 | 5.76 |
| 3rd Quartile | 4.82 | 4.84 | 53.78 | 46.03 | 53.80 | 48.17 | 7.81 | 6.42 | 21.00 | 15.65 |
| Interquartile Range | 2.76 | 2.38 | 3.68 | 8.98 | 3.05 | 28.37 | 3.68 | 2.69 | 12.38 | 9.89 |
| **%change vs. 1995** | **96.8** | | **119.4** | | **129.2** | | **109.6** | | **120.0** | |
| | | | | | | | | | | |
| **Regression line (thro' origin)[a]:** | | | | | | | | | | |
| | | | | | | | **%C2005>=%C1995** | **%C2005<%C1995** | | |
| No of matched records | 17 | | 16 | | | | 105[a] (from 221) | 61[a] (from 97) | | |
| **slope** | **0.965** | | **1.183** | | | | **1.123** | **0.862** | | |
| $R^2$ | 0.853 | | 0.881 | | ns[b] | | 0.969 | 0.951 | ns[b] | |

[a] For the managed grassland classes, the soil dataset was split in two, one part for those records where %C2005>=%C1995 and a second set where %C2005<%C1995. In order to see the underlying trend, poorly matched points ('outliers') were identified and removed from the comparison for the grassland subsets if the soil %C in 2005 was 30% higher, or 30% lower, than the matched soil %C value for 1995 (i.e. 0.7 * %C1995 > %C2005 >1.3 * %C1995).

[b] ns = not significant.

In conclusion:

- Most (about two-thirds of) grassland soils in Northern Ireland have been slowly accumulating C at an annual average rate of about 1% of their original value.
- Arable and some managed grassland soils (those with a change in land use since 1995 or having had a recent reseed), in Northern Ireland have been losing C at an average annual rate of about 0.4% and 1.4%, respectively.

These conclusions have important implications for the updating of the soil C inventory values for Northern Ireland. Bulk density measurements (taken from top 50mm; volume 222cm$^3$) for each sample from the 2004-05 survey are nearing completion and should help improve the accuracy of the carbon load estimate in the topsoils of Northern Ireland.

## *19.2 Carbon losses due to Peat Extraction in Northern Ireland*

### 19.2.1 Peat Extraction for Fuel

A sampling network for fuel peat extraction has been derived. Initially a 5% random sample of 1km x 1km grid squares from the Northern Ireland Peatland Database (Cruickshank *et al*., 1993) gave 102 grid squares with lowland peat and 154 squares of blanket peat. Of these squares 19 lowland and 29 blanket had fuel extraction in 1991, which represent around 4% of the incidences of extraction in 1991. Drawing the sample from all grid squares with peat led to the inclusion of the fens of Cos. Down and East Armagh in the lowland sample, and of the Mournes – Slieve Croob and Slieve Gullion in the blanket sample. These are areas in which machine cutting was not found in 1991, nor likely to be found because (a) the fens have no suitable peat left in them (they are fens because centuries of hand cutting has removed the acid peat) and (b) these upland peats are thin and on relatively steep slopes. A 5% random sample excluding these areas gave 85 grid squares with lowland peat and 25 incidences of machine fuel cutting (approx. 6% of incidences). For blanket peat the sample gave 121 grid squares and 52 incidences (approx. 5% of incidences).

The contract for the work came late in the summer (July 2006) so that by the time field survey could begin the cutting season had largely been missed; it was not possible to achieve the first one-third of field sampling. Instead, work on horticultural extraction was moved forward (see below).

#### Complementary evidence of trends in fuel peat extraction

Forest Service (NI) lets turf banks annually. Up to 1987 the number of people to whom turf banks were let is reported in the Forest Service Annual Report; thereafter, with the exception of two years for which there are no data, Forest Service records the number of turf banks let. It is assumed that in the years to 1987 most people would lease only 1 bank. If that is the case, then the 'turf banks let' is at a maximum in 1983, falling rapidly thereafter (Figure 19-2) to less than 4% of the maximum in recent years. The data do not distinguish between hand cutting and machine cutting, but it is notable that machine cutting was introduced into Northern Ireland in 1981. Wet summers reduced harvesting in 1986 and the impact of the oil crises, that in part had stimulated peat cutting in the 1980s, began to lessen in the 1990s. Additionally, national campaigns to reduce peat extraction may have had an effect. It may be that availability of Forest Service turf banks also declined. However, whilst the area of unplantable land in turbary and in turbary rights has declined (Figure 19-2), it has remained fairly constant in recent years (although some data is awaited from Forest Service (NI)) while the lettings have continued to decline steeply. Looking at the number of turf banks per hectare of turbary, this declines from 0.87/ha in 1983 to 0.1/ha in 2002 (the last date for which data are currently available) - this suggests that the decline in the number of turf banks let is the result of a decline in demand rather than availability.

Comparison of Forest Service lettings in 1991 with the number of incidences found across Northern Ireland (Cruickshank *et al.*, 1995) indicates that the Forest Service lettings may have accounted for around 50% of incidences. If that were to be the percentage at present, there could be as few as 150 fuel extraction sites today. However, that assumes that decline in the number of extraction sites has been the same outside Forest Service land as within. Nevertheless, the trends in Forest Service lettings lend support to impressions gained from field observation and discussions with foresters and conservation personnel that fuel extraction has declined - but data on the extent of the decline will come from the field survey.

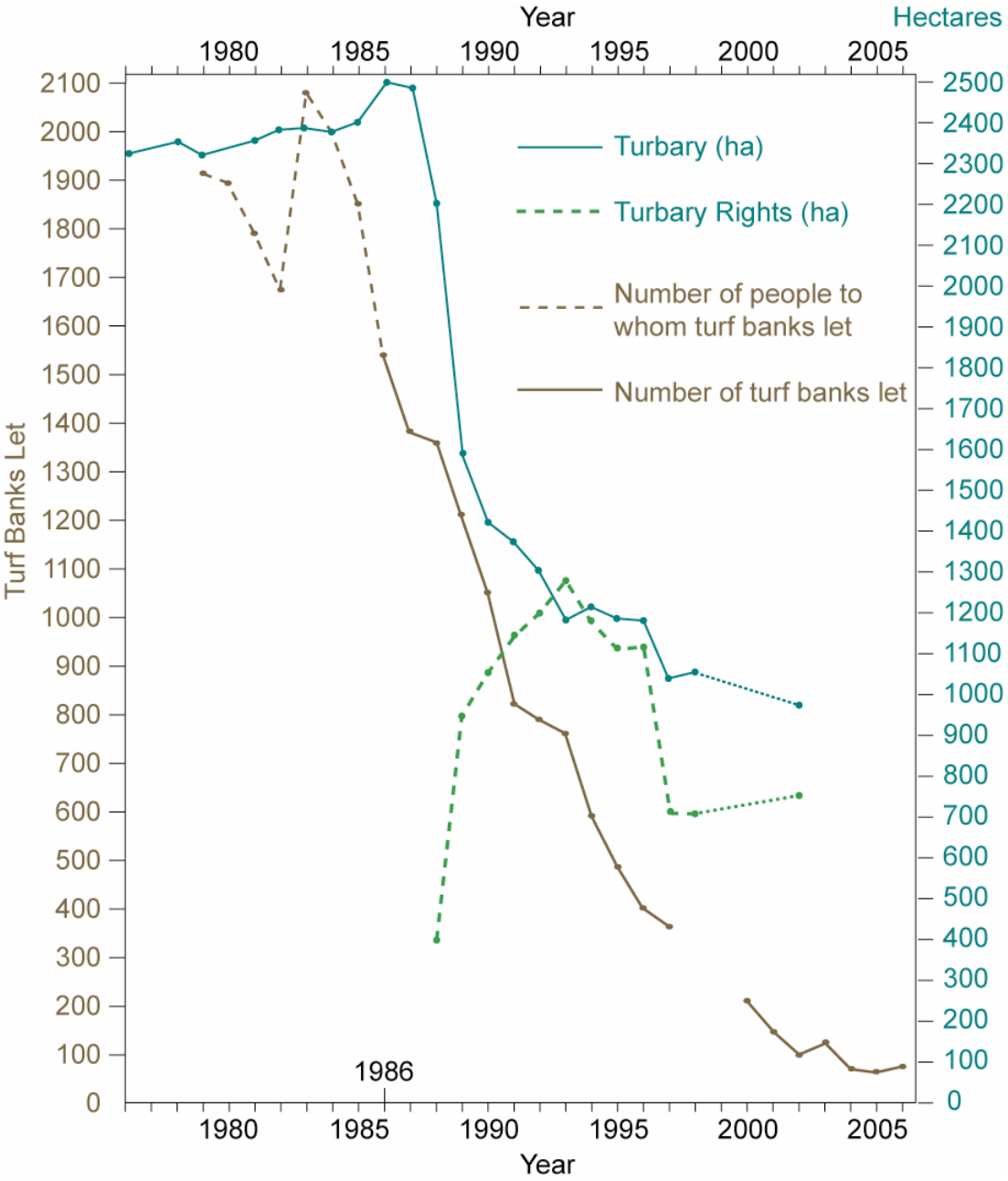


Figure 19-2: Area of turbary, turbary rights and number of lettings for turbary on Forest Service land. (Source: Data from Forest Service (NI) Annual Reports and unpublished data from Forest Service (NI))

## 19.2.2 Peat Extraction for Horticulture

The first stage was to review previous estimates of carbon loss in the early 1990s. In the 1996 Report (Cruickshank *et al.*, 1996) the estimate was based on volumes of peat extracted using information from planning applications. Subsequently, it proved difficult to obtain similar

data; also, because the estimated carbon losses were derived from forecast volumes given in the planning applications they did not necessarily reflect the subsequent productive areas. Using our existing database of peat extraction (identified from satellite images and field visits) which gave areas for each site, and assuming an annual removal of 10cm of peat (from discussion with producers and review of estimated extraction rates in the Republic of Ireland) and a C content of 5.08 kg/100 litres (constant from the 1996 report), the estimated C extraction in 1991 was 38,456 tonnes C. This compares with 31,902 tonnes estimated in the 1996 Report. Note that 10cm of annual removal is a conservative estimate relating to a long-term average that considers variations in seasonal conditions.

Satellite imagery for 2001 has been examined and sites of horticultural extraction identified and measured. (But checking all sites to ensure they were horticulture extraction is not complete). Using the same procedures as for 1991, this has produced an interim C extraction of 37,389 tonnes. The procedures will be repeated for the latest imagery available close to the end of the contract.

It appears that C losses from horticultural peat extraction in 2001 were similar to those in 1991. Bearing in mind changes in methodology (including advances in image interpretation and measurement of sites), and that some sites remain to be confirmed (including changes in type of extraction), C losses from horticultural peat extraction in 2001 are not too dissimilar from those reported in 1996.

## *19.3 References*


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