^{14}C in British Soils

Results from a new survey of British soils conducted by the NERC Macronutrient Cycles Programme 'LTLS Project'

www.ltls.org.uk

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Project aim: To analyse and simulate the Long-Term / Large-Scale interactions of carbon, nitrogen and phosphorus in UK land, freshwater and atmosphere.

Using computer modelling to look at the temporal dynamics of C, N and P cycling through the Holocene at a UK scale.
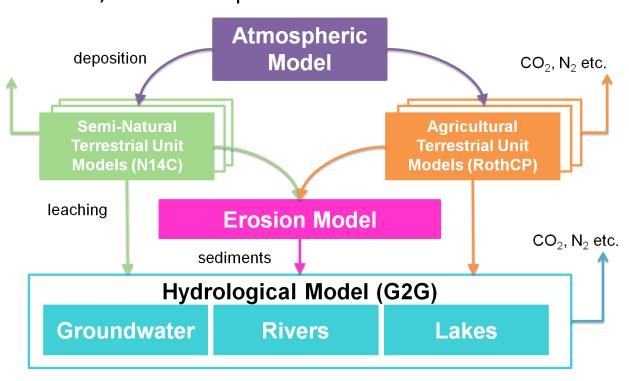
Particular focus upon:

➤ How have long-term soil stores of C, N and P responded to nutrient enrichment over the past 200 years?

➤ How has this affected C, N and P transfers from land to the atmosphere and water?

➤ How has biodiversity responded?

deposition

Atmospheric Model

CO_2, N_2 etc.

Semi-Natural Terrestrial Unit Models (N14C)

Agricultural Terrestrial Unit Models (RothCP)

leaching

Erosion Model

sediments

CO_2, N_2 etc.

Hydrological Model (G2G)

Groundwater   **Rivers**   **Lakes**

Previous ^{14}C soil survey studies

➢ Most soil ^{14}C studies = detailed studies at single sites

➢ Previous survey work includes :

- soils under single vegetation types (Tipping *et al.* 2010; Froberg *et al.* 2011; Harrison *et al.* 2000)

- alpine altitudinal sequence (Leifeld *et al.* 2009)

- US climatic transect (Frank *et al.* 2012) - *mineral soil only*

- zonal soils of Russia (Brovkin *et al.* 2008) - *^{14}C content of isolated humic acid*

- bulk soil ^{14}C (0 - 15 cm) from 133 UK semi-natural sites (Mills *et al.* 2014)

The LTLS Soil Survey

Aim: Obtain new comparable data for C, N & P pools and ^{14}C derived C residency times of UK soils to:

➤ test predictions from the LTLS model

➤ **provide most comprehensive survey of UK bulk soil ^{14}C values to date:**

• complete suite of UK of habitats - both semi-natural & agricultural sites

• wide range of soil C contents

• surface & sub-surface soil

• combining ^{14}C analysis with data on other soil parameters

• soils collected within one season and by same methods.

Survey sites:

80 sites

Located in Macronutrient Programme catchments (Ribble, Wiltshire Avon, Conwy) & Scottish Dee:

• Ribble - range of agricultural & industrial intensity
• Conwy - low agricultural & industrial intensity
• Avon - southerly climate
• Dee – northerly climate & atmospheric deposition

The LTLS Soil Survey: site classification

Site classification:

LTLS model broad veg types (herbs, shrubs, trees) & presence/absence of inorganic fertilisation:

	Site class	Definition
Not inorganically fertilised	**Unimproved grassland: a). Acid; b). Calcareous**	Grassland with no inorganic fertiliser additions: a). Acidic soil; b). Calcareous soil
	Heathland	Shrubs dominant; no inorganic fertilisation; not ombro bog
	Ancient woodland	Woodland since at least 1600s
	Montane	High altitude (> 700m)
	Ombrotrophic bog	Receiving water as precipitation only; peat accumulation
Inorganically fertilised &/or planted	**Improved grassland**	Inorganic fertilised grassland; often also re-seeded
	Arable	Inorganically fertilised crops
	Tree plantation	Forestry plantations

No. of sites for each class based on proportional UK coverage from Countryside Survey 2007

LTLS Soil Survey: Soil sampling methods

➢ 6 (agricultural) or 10 (all other sites) cores from representative 100m² at each site.

➢ Surface (0-15 cm) and sub-surface core sections taken consecutively down same profile.

➢ Sub-surface core sections taken to 40 cm where possible and shallower at sites where impenetrable material hit at < 40 cm depth.

➢ Core sections bulked to give a surface and sub-surface bulked sample for each site.

➢ Soils sieved to 2mm

➢ 2mm fraction analysed for:
- **^{14}C content**
- **Bulk density & particle size**
- **pH**
- **% organic matter**
- **% organic C, total N, total & organic P**

LTLS Soil Survey Results: Depth

➢ Range of bulk soil mean ^{14}C enrichment values:

• 0 -15 cm:

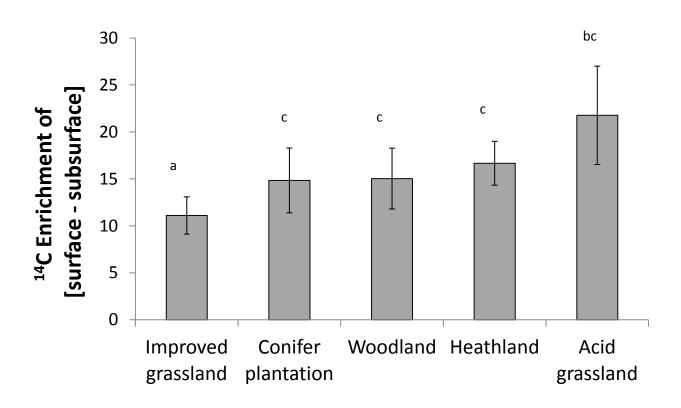   82 abs % modern (~ 1500 yrs BP)   to   114 abs % modern

• 15 - 40 cm:

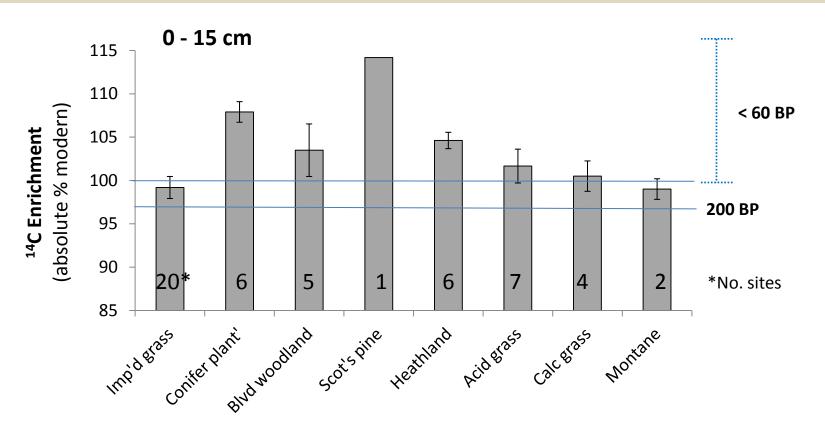   49 abs % modern (~ 5600 yrs BP)   to   102 abs % modern

➢ ^{14}C enrichment of 0-15 cm soil > 15-40 cm at all sites ($P<0.001$);
    i.e. increasing age of soil C with depth.

LTLS Soil Survey Results: Depth

- ➢ Increase in soil C with depth:

- lowest for improved grassland (mixing via ploughing ?)

- highest for acid grassland (water saturation ?)

LTLS Soil Survey Results: LTLS habitat type

- ➢ Improved grass: effects of ploughing and removal of C by intensive grazing
- ➢ Montane: slower C cycling at altitude
- ➢Conifer plantations: recent planting & fast tree growth
- ➢Soil ^{14}C enrichment of semi-natural broadleaved woodland > semi-natural grassland as found by Mills *et al* 2014; but not the case for heathland < 700m a.s.l.
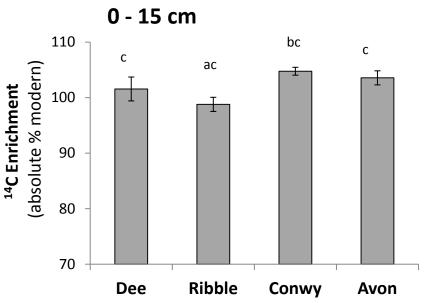
(Arable to be sampled autumn 2014)

LTLS Soil Survey Results: LTLS habitat type

15 - 40 cm

Y-axis: ^{14}C Enrichment (absolute % modern)

Bar labels (No. sites): Imp'd grass 19*, Conifer plant' 6, Blvd woodland 5, Scot's pine 1, Heathland 6, Acid grass 7, Calc grass 1

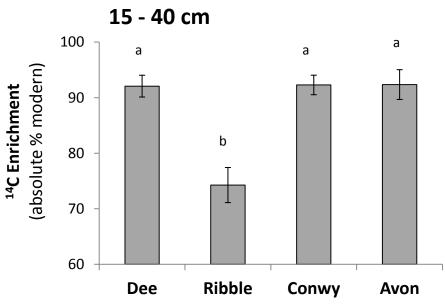700 BP (line at ~90)
1700 BP (line at ~80)

*No. sites

➢Acid grassland oldest subsurface soil C:

low pH & high moisture content – *but why so different from heathlands?*

➢Improved grassland comparable to semi-natural sites:
management for high grazing intensity not markedly affected ^{14}C enrichment of deeper soil.
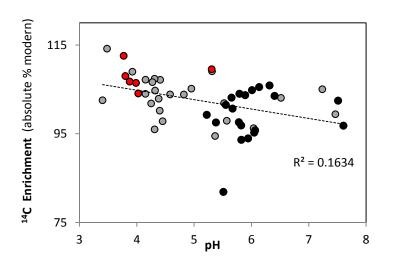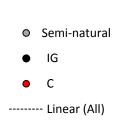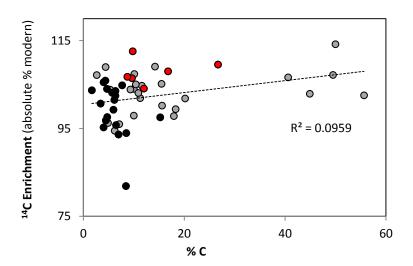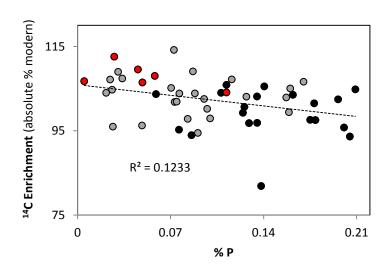
LTLS Soil Survey Results: Catchment

0 - 15 cm

15 - 40 cm

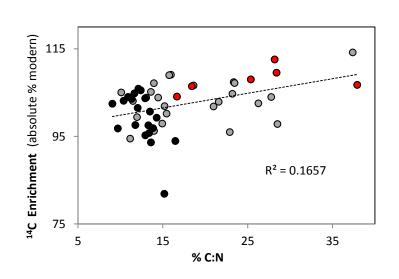# LTLS Soil Survey Results: ^{14}C vs. other soil variables

0 – 15 cm

LTLS Soil Survey Results: Summary

➢ The LTLS soils survey represents the most comprehensive UK survey of bulk soil ^{14}C to date: (semi-natural & agricultural, 0 - 40 cm depth, wide range of soil types)

and combines ^{14}C analysis with data on other bulk soil parameters.

➢ Findings include:

- Soil C at 15 - 40 cm = older than in surface 15 cm; this decline in soil C age less pronounced in improved grassland than semi-natural systems – maybe due to ploughing.

- Differences exist in ^{14}C enrichment amongst habitat types; ploughing, grazing intensity, plantation forestry & altitude amongst potential drivers.

- Soils in the Ribble older than the other catchments - particularly for the subsurface.