Modelling upland peat carbon: past present and future

“Thinking big, working small and modelling in between”

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Currently, we cannot adequately predict peatland soil C stocks and C dynamics. Most current models lack:

- Holocene peat accumulation
- Total peat column decomposition
- Peat depth dynamics
- Dynamic water table
- Vegetation feedbacks
- Topography effects

→ Lacking a pedogenesis concept
Feedback implications

So, how much can we trust current model SOC - climate feedbacks (CO$_2$ & CH$_4$)?
MILLENNIA peat model

Cohort model
Basic climate
Long-term spin-up
Dynamic water table
Dynamic vegetation
Litter quality

C-Soil
C-Root

Vegetation Layer

Tree
Woody
Herb
Grass
Rush
Sedge
Moss
Sphag

Acrotelm
C-Root
Catotelm
C-Soil

Water Table
Roots
Cohort
MILLENNIA: current C stocks

*Climate Research, 2010*

The MILLENNIA peat cohort model: predicting past, present and future soil carbon budgets and fluxes under changing climates in peatlands

Andreas Heinemeyer, Simon Croft, Mark H. Garnett, Emanuel Gloor, Joseph Holden, Mark R. Lomas, Phil Ineson
Modelled column age

Measured column age

Peat C increment

Time (yrs; 0 = Today)

Peat depth (cm)

C increment (gC yr$^{-1}$)
### Terrain information

<table>
<thead>
<tr>
<th>Elevation (m)</th>
<th>Slope (°)</th>
<th>Aspect (°)</th>
<th>SOC (kgC m$^{-2}$)</th>
<th>SOC (kgC m$^{-2}$)</th>
<th>Peat Depth (cm)</th>
<th>Peat Depth (cm)</th>
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</thead>
<tbody>
<tr>
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</tbody>
</table>

### Model vs. Site data

- **Temperature**: 1
- **Runoff**: 2
- **Erosion**: 3
MILLENNIA: future C dynamics

Temperature rise (+2 or +4 °C)
Precipitation change (±25 % mm)
Model inter-comparison: Migneint

Climate Research, 2010

Model inter-comparison between statistical and dynamic model assessments of the long-term stability of blanket peat in Great Britain (1940–2099)


Temperature! = to 20 cm peat/year!
Major UK Soil Types

Rendzinas  Brown Earths  Gleys  Podsols  Peats

Requires dynamic changes in both, percentage and amount of texture
Future modelling: pedogenesis

Mineral -------------- > Peat

Pedogenesis:
Mull – Moder - Mor

New SDGVM CENTURY-type soils module
Thank you!

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Mark Garnett, UKPopNet staff,
Simon Croft, Pippa Gillingham,
Project students and many others...!
Collar insertion and ‘lost’ root flux

Forest ~10%

Moorland ~40%

Grassland ~20%

European Journal of Soil Science, 2010
Soil respiration: implications of the plant-soil continuum and respiration chamber collar-insertion depth on measurement and modelling of soil CO₂ efflux
Breaking down flux components

- CO$_2$ flux (µmol m$^{-2}$ s$^{-1}$)

Graph showing daily carbon uptake and release scenarios.

- Day-time C uptake
- Night-time C release

Flux tower 1
Flux tower 2
Chamber
Dark respiration
Soil respiration
Scaling up from plot to landscape

CO₂ flux (µmol m⁻² s⁻¹)

-22 -18 -14 -10 -6 -2 2

Chamber
Flux Tower
Air craft

25/08 12:00 25/08 13:12 25/08 14:24 25/08 15:36 25/08 16:48 25/08 18:00 25/08 19:12