

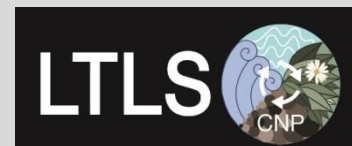


# Modelling semi-natural terrestrial ecosystems

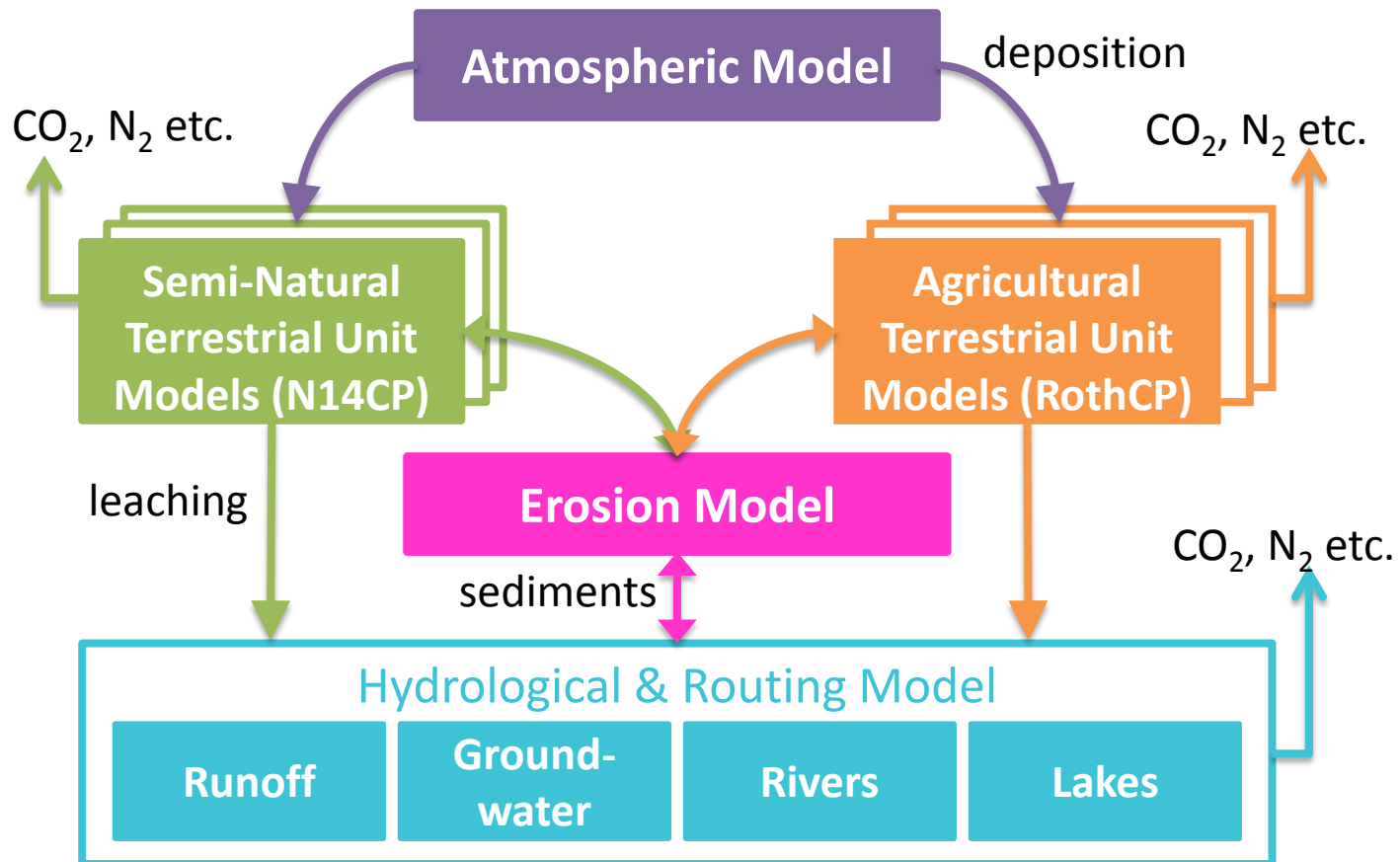


Jess Davies<sup>1</sup>, Ed Tipping<sup>2</sup> & John Quinton<sup>1</sup>

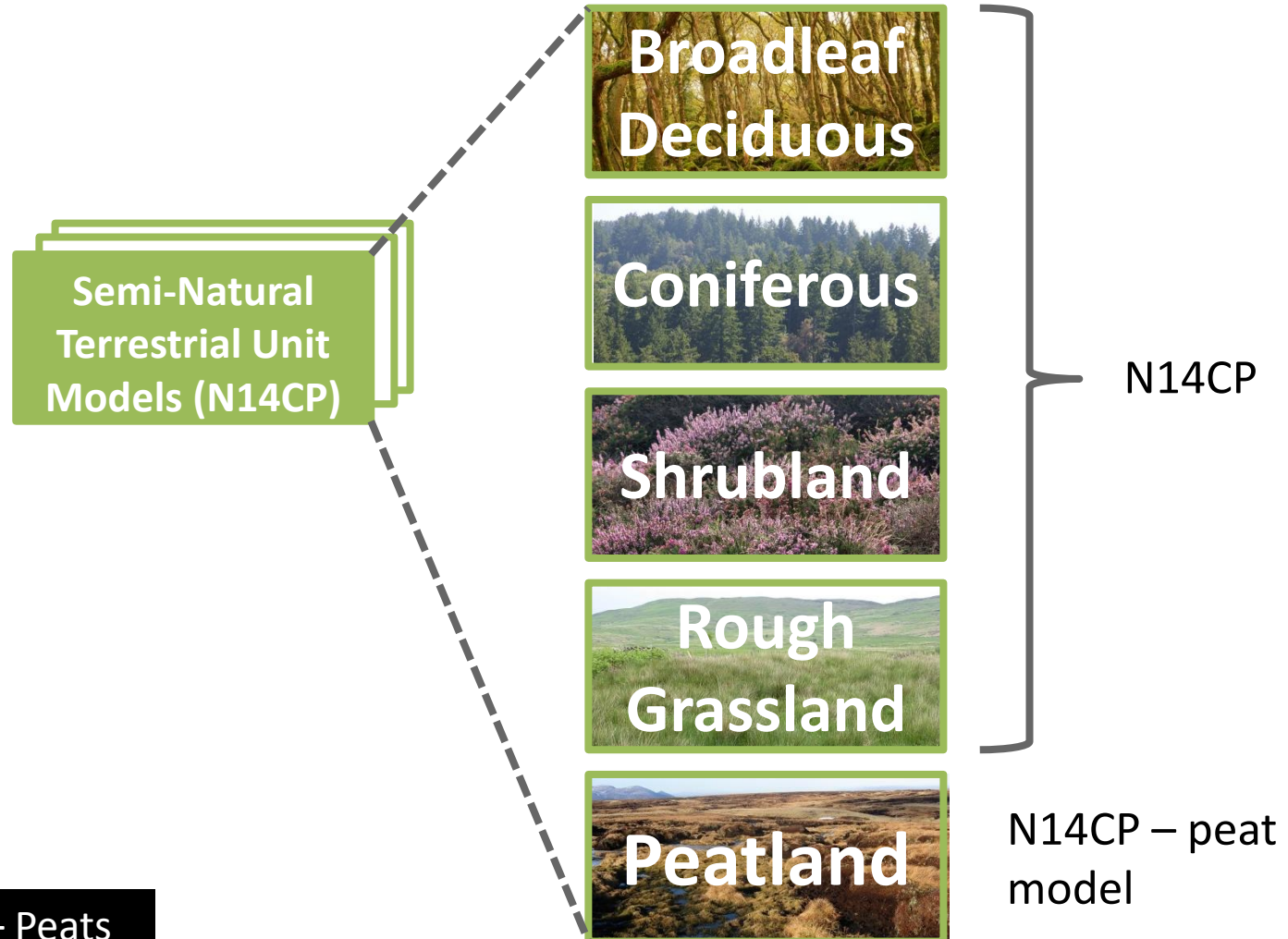
<sup>1</sup>Lancaster University, <sup>2</sup>Centre for Ecology & Hydrology Lancaster



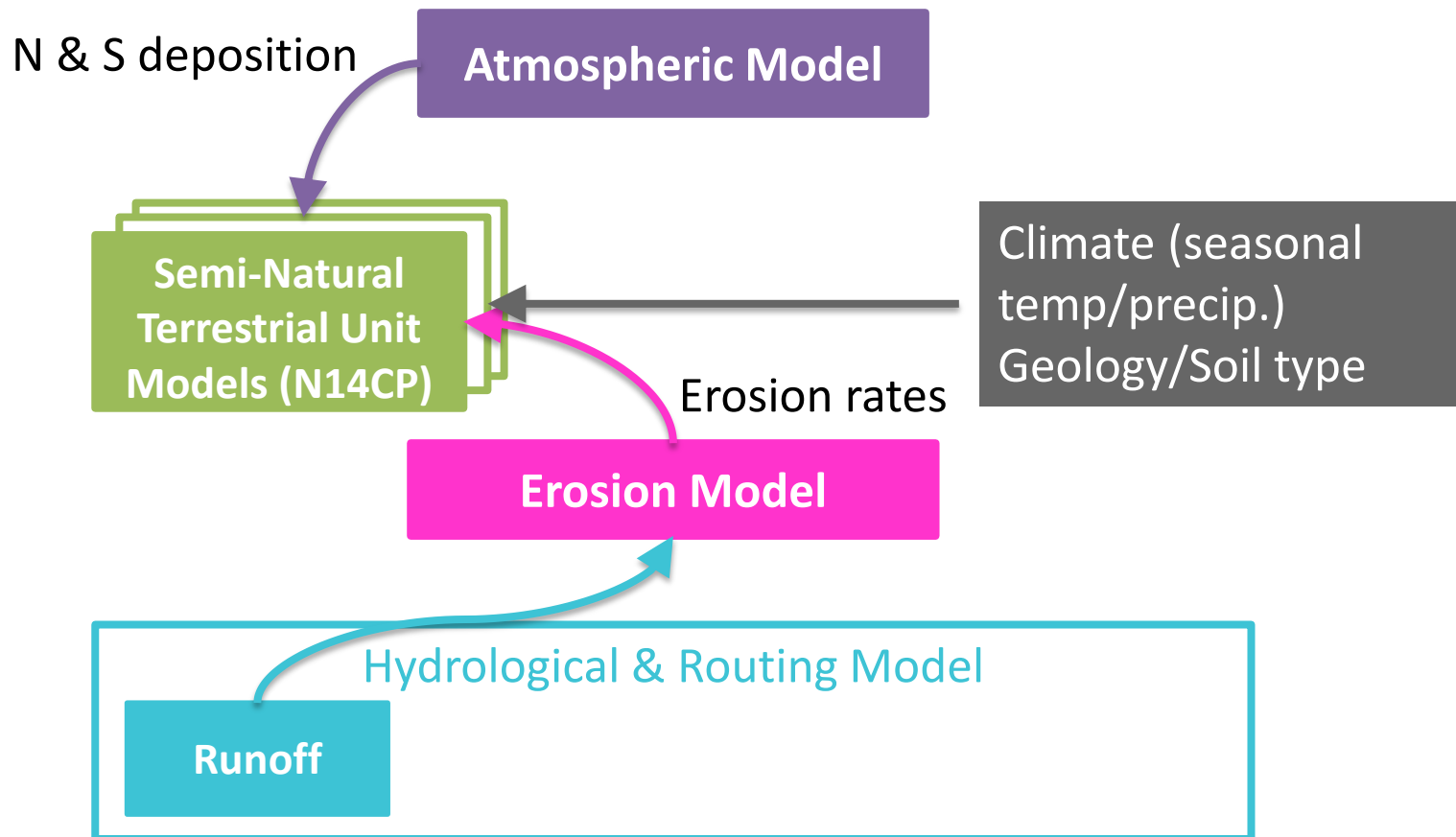
# Semi-Natural Terrestrial Modelling in the integrated model



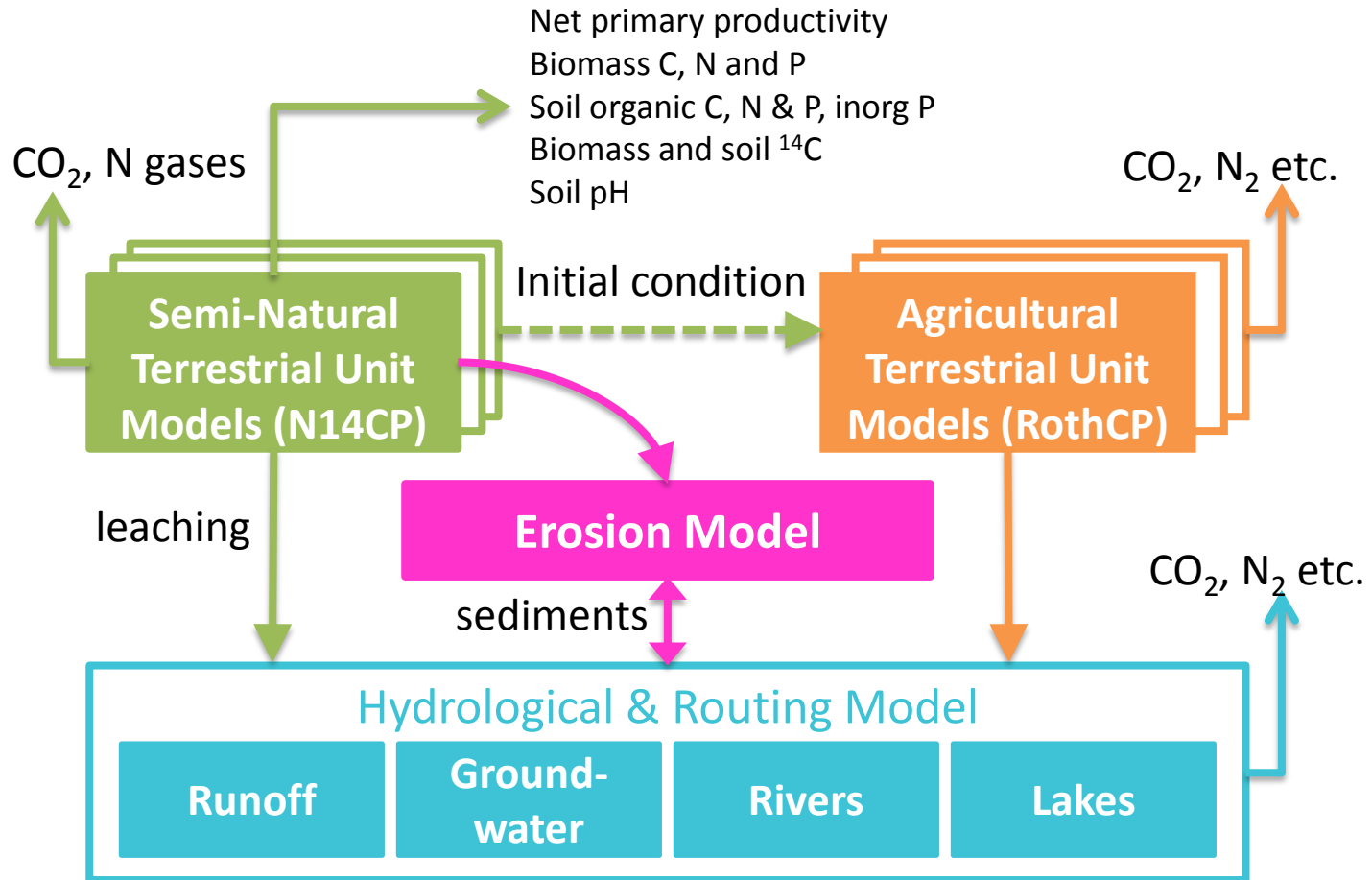
# Semi-Natural Terrestrial Modelling: Simulated habitats



# Semi-Natural Terrestrial Modelling: Input drivers



# Semi-Natural Terrestrial Modelling: Outputs





# Semi-Natural terrestrial ecosystem model: N14CP

Integrated P cycling into the N14C model:

- P weathering
- N fixation linked to P availability
- P limitation - law of the minimum
- Stoichiometrically linked biomass & soil organic matter pools of P
- Inorganic P pools, sorption/desorption

## Global Biogeochemical Cycles


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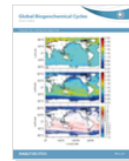
Research Article

### Long-term P weathering and recent N deposition control contemporary plant-soil C, N, and P

J. A. C. Davies , E. Tipping, E. C. Rowe, J. F. Boyle, E. Graf Pannatier, V. Martinsen

First published: 20 February 2016 [Full publication history](#)

DOI: 10.1002/2015GB005167 [View/save citation](#)



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Volume 30, Issue 2  
February 2016  
Pages 231-249



Weatherable P is an important long-term control on contemporary soil C and N

Calibrated and tested at 88 natural sites in northern Europe

# Semi-Natural terrestrial ecosystem model: N14CP further testing



Science of The Total Environment

Available online 21 March 2016

In Press, Corrected Proof — Note to users



## 150 years of macronutrient change in unfertilized UK ecosystems: Observations vs simulations

J.A.C. Davies<sup>a</sup>, E. Tipping<sup>b</sup>, A.P. Whitmore<sup>c</sup>

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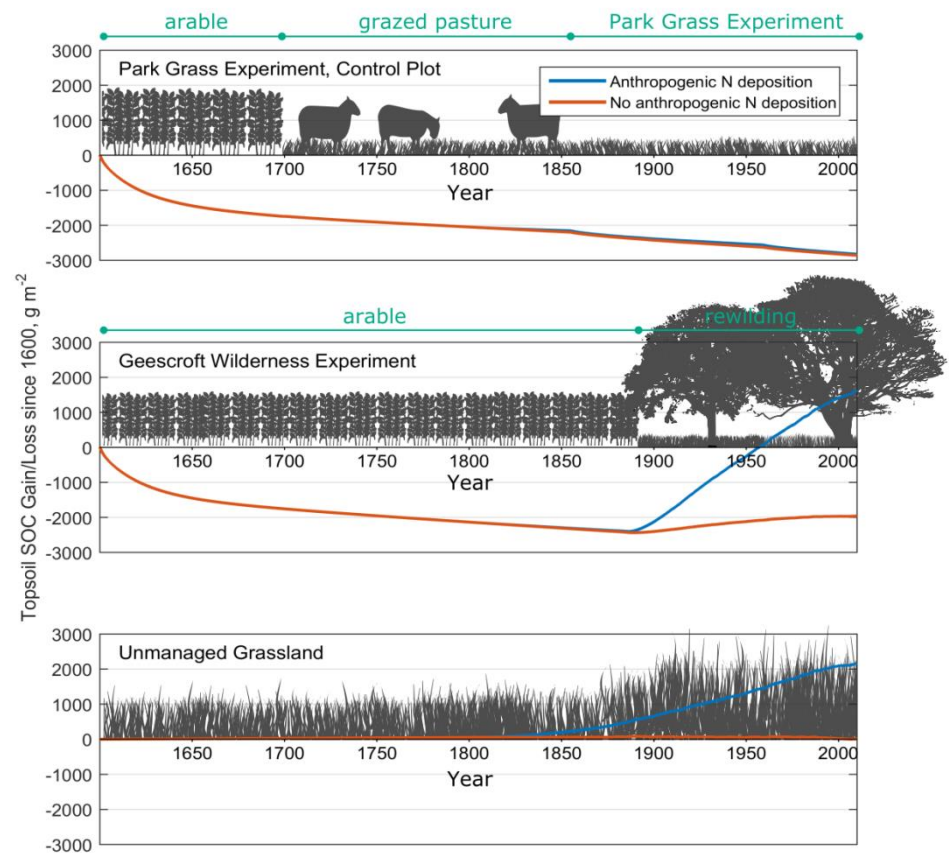
doi:10.1016/j.scitotenv.2016.03.055

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Uncoupling N deposition and land use change/management effects



# Semi-Natural terrestrial ecosystem model: Results (in brief)

Land use change

Woodland expansion

N deposition increases

N deposition reduction

Related posters – Scenarios

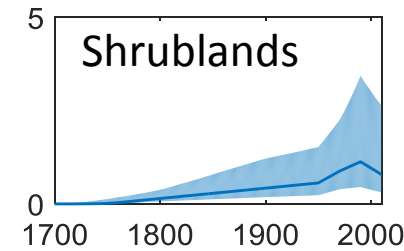
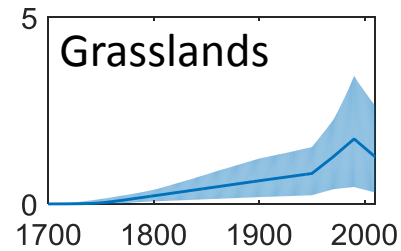
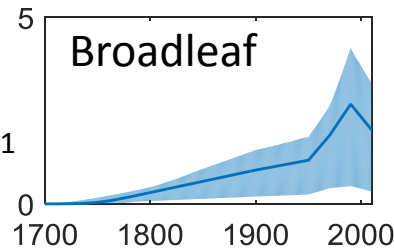




# Past semi-natural terrestrial ecosystems change: Carbon

Increased atmospheric N deposition

N dep.,  
 $\text{g-N m}^{-2} \text{yr}^{-1}$

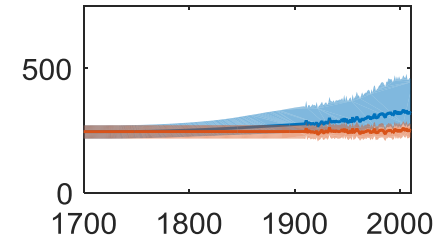
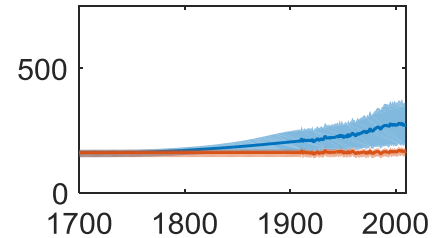
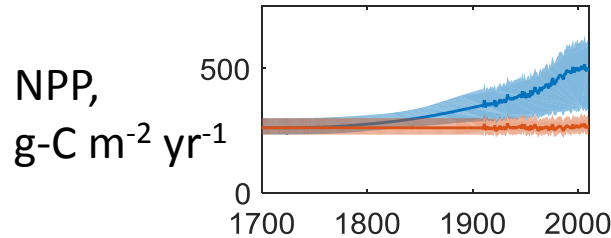
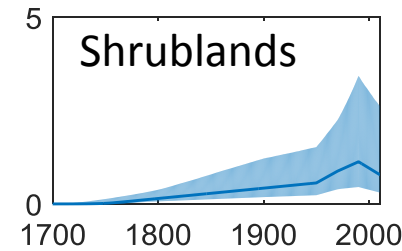
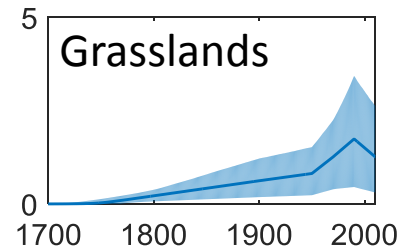
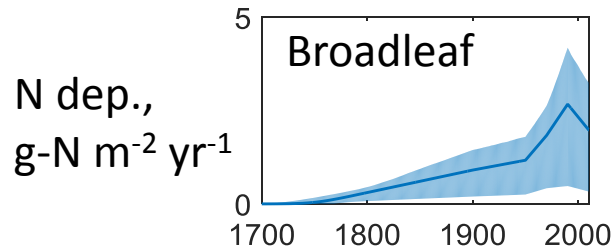


# Past semi-natural terrestrial ecosystems change: Carbon

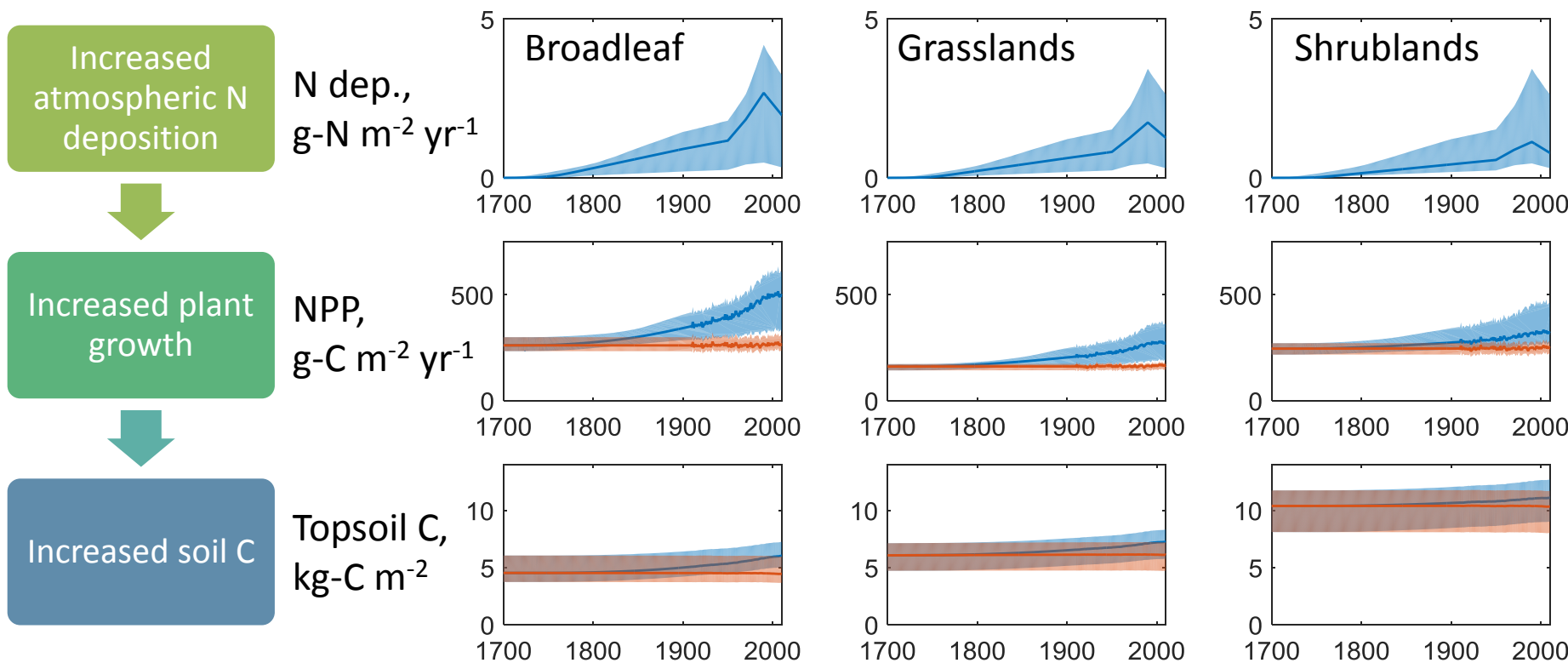
Increased atmospheric N deposition



Increased plant growth



# Past semi-natural terrestrial ecosystems change: Carbon



## Supporting evidence

Topsoil resampling 1959-2010 (mean 27 yrs)

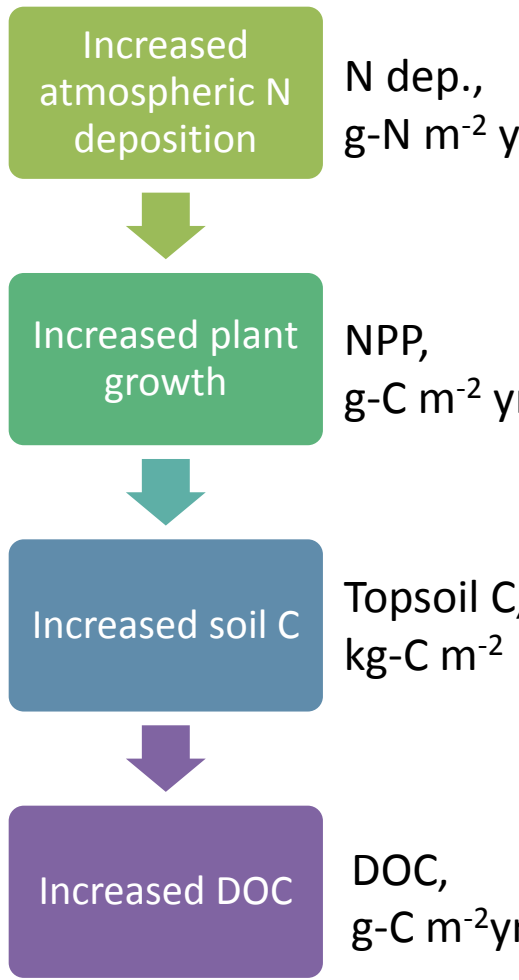
For broadleaf habitats:

Average  $[\text{SOC}]_2 / [\text{SOC}]_1$

Model: 1.05

Obs: 1.05 ( $>1.00$ ,  $p < 0.001$ )

# Past semi-natural terrestrial ecosystems change: Carbon



N dep.,  
g-N m<sup>-2</sup> y

NPP,  
g-C m<sup>-2</sup> y

Topsoil C,  
kg-C m<sup>-2</sup>

DOC,  
g-C m<sup>-2</sup>yr<sup>-1</sup>

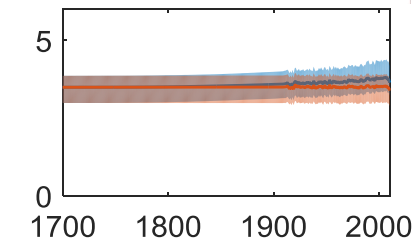
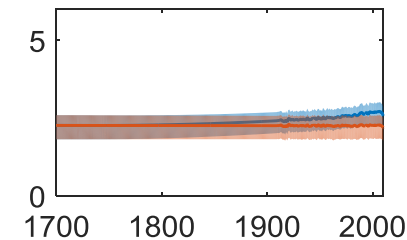
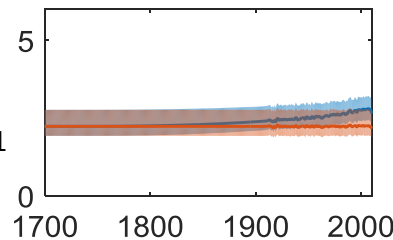
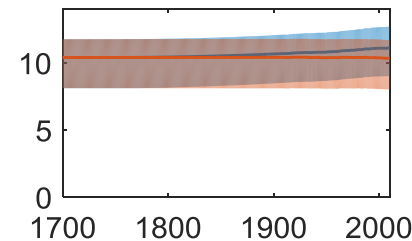
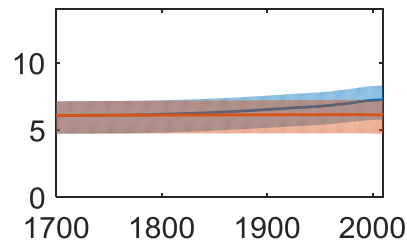
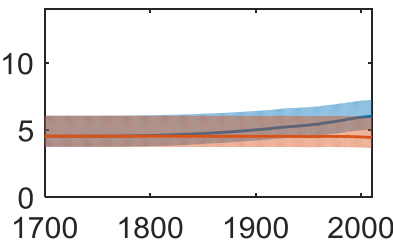
N.B.

There is no pH effect on DOC in the model.

Increases in semi-natural model arise from:

- Increased soil C pool
- Increase in temperature (this is more obvious in the future projections)

A pH effect could be incorporated.





# Past semi-natural terrestrial ecosystems change: Carbon

Total UK change 1800-2000 per m<sup>2</sup> of semi-natural ecosystems

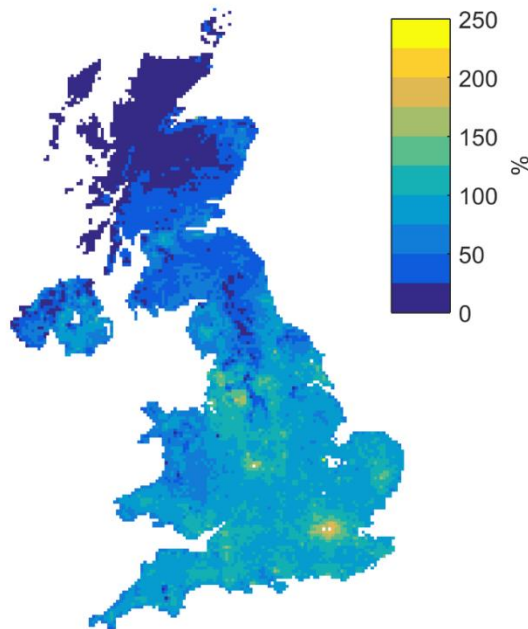
**64% increase  
in NPP**

**17% increase  
in soil C**

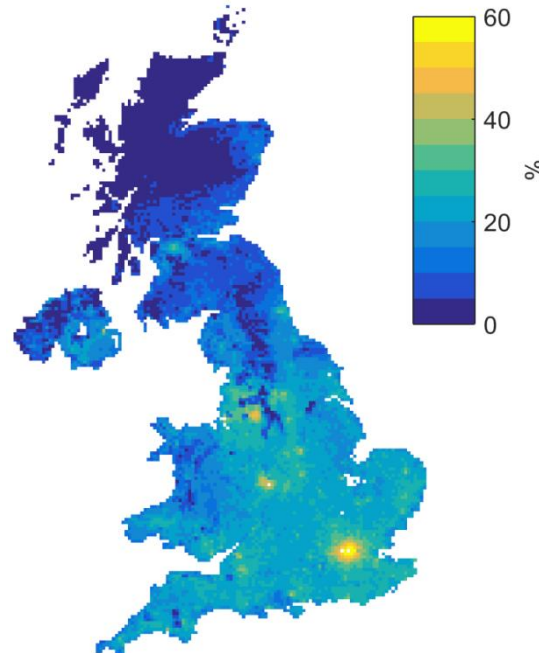
**~17% increase  
in annual DOC**

Mean change in undisturbed semi-natural areas, 1800-2000

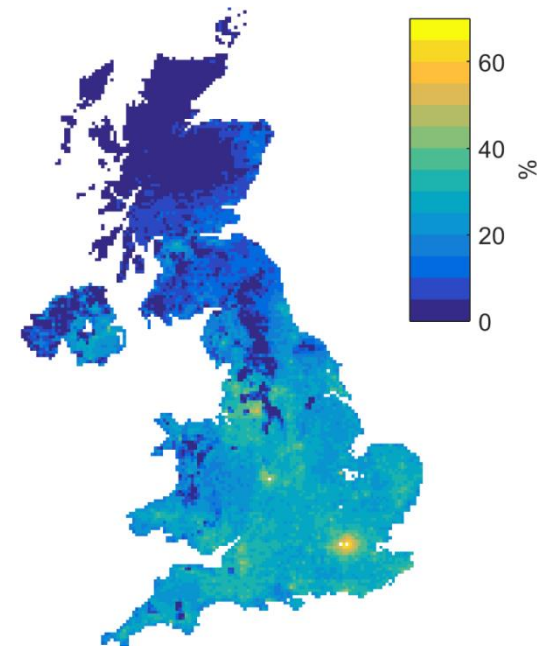
**Net Primary Productivity**



**Soil organic carbon**

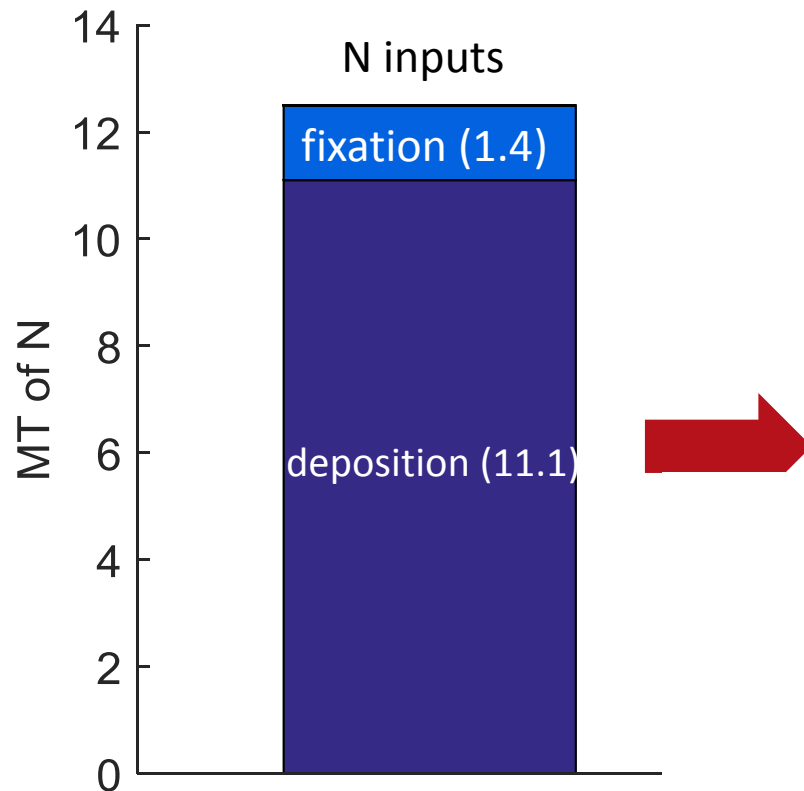


**Dissolved organic carbon**



# Past semi-natural terrestrial ecosystems change: Nitrogen

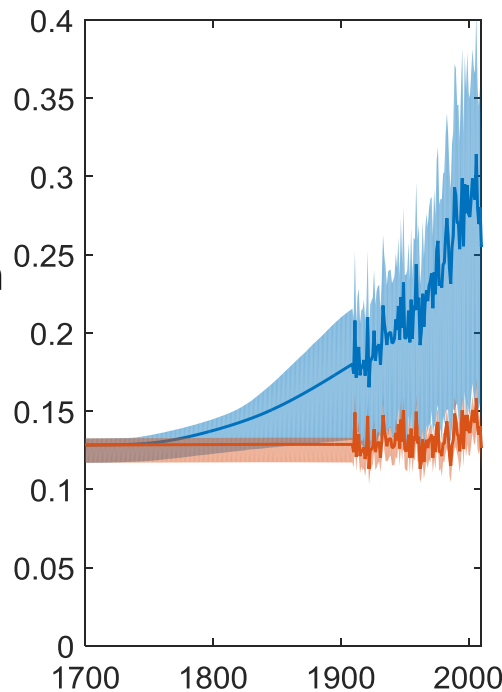
Roughly half of N inputs over 1800 to 2010 remain in the ecosystem



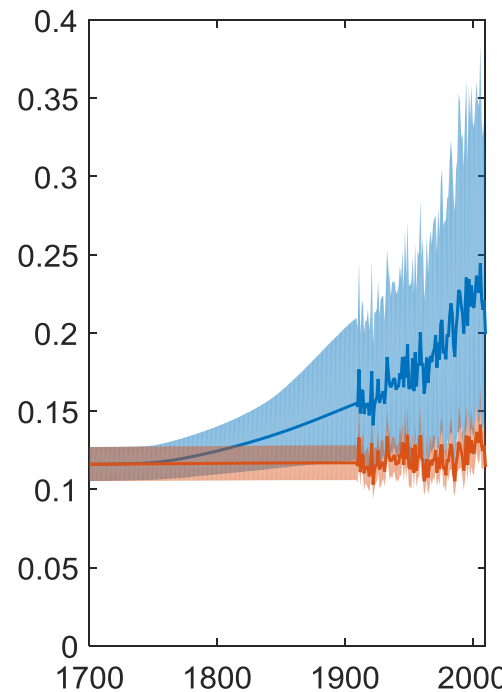
# Past semi-natural terrestrial ecosystems change: Nitrogen

- Denitrification increased by 53%

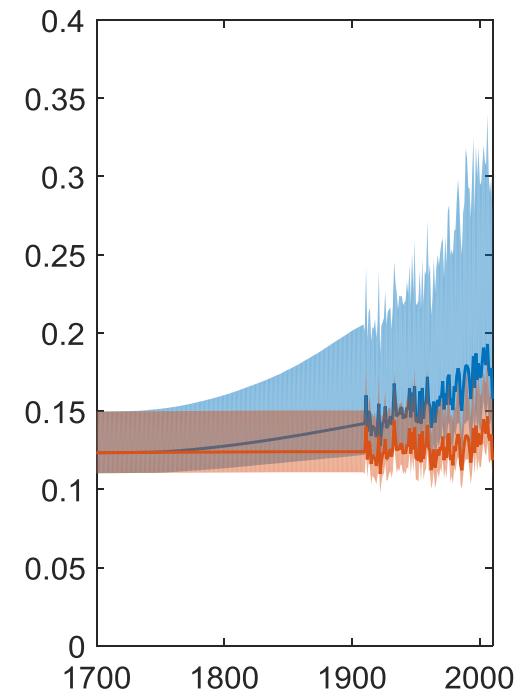
Broadleaf



Grasslands



Shrublands



# Past semi-natural terrestrial ecosystems change: Phosphorus

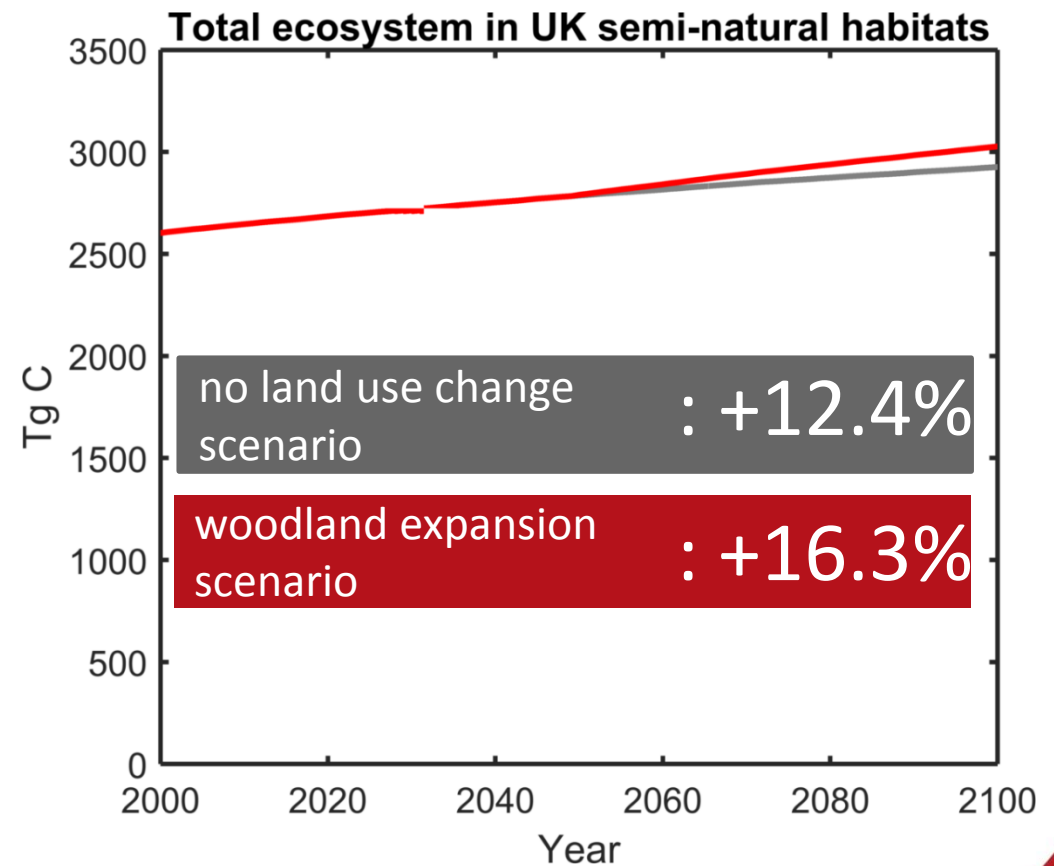
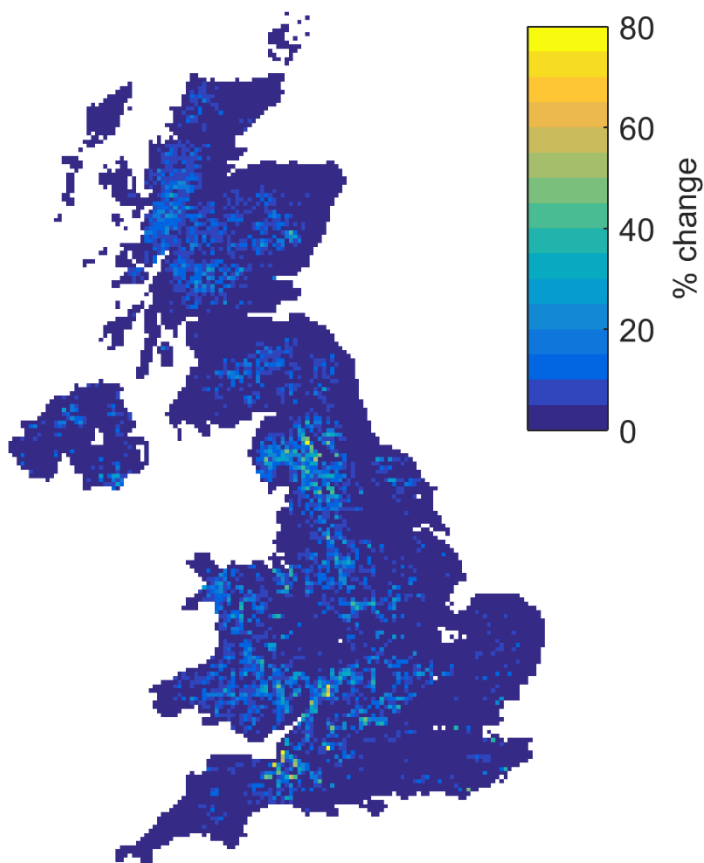
- Whilst C and N inputs increase 1800-2000, P does not
- However, biomass P has increased 40% due to increased NPP
- Resultantly, total topsoil P has decreased 6%





# Future C, N and P change: Woodland expansion scenario

Total ecosystem C change due to woodland expansion 2000-2100



# Summary

In the project we have:

- Developed, calibrated and tested a new model which integrates C, N and P plant-soil cycles for semi-natural ecosystems
- Applied this model to the UK's semi-natural areas
- Connected with the LTLS IM

The model suggests:

- Past increases in NPP, soil C, denitrification and N enrichment as a result of N deposition
- Past redistribution of P within the ecosystem
- ~4% increase in ecosystem C from woodland expansion