Scenario modelling of ecosystem service provision with a new soil model (MOSES)

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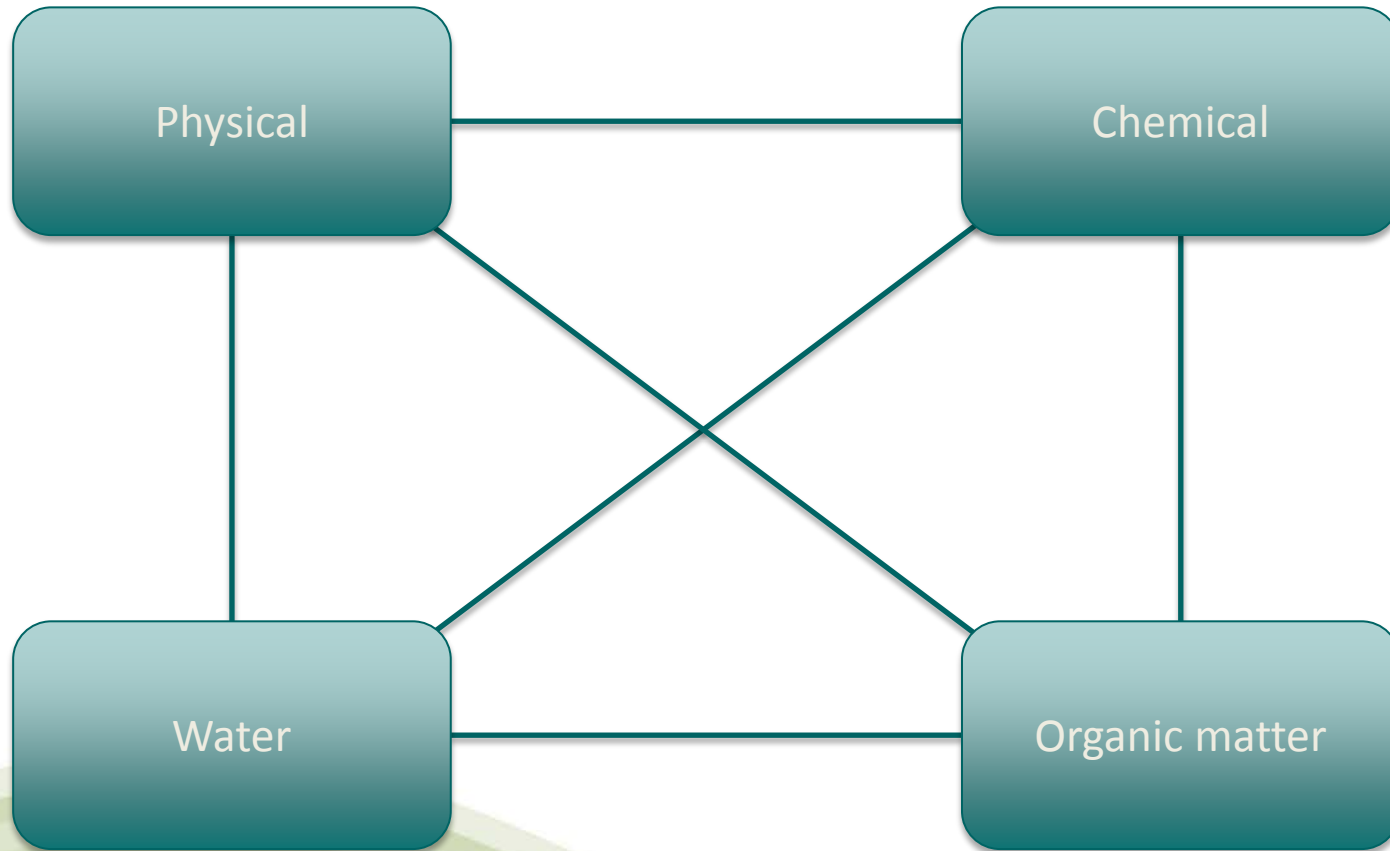University of Reading

UK Environmental Change Network
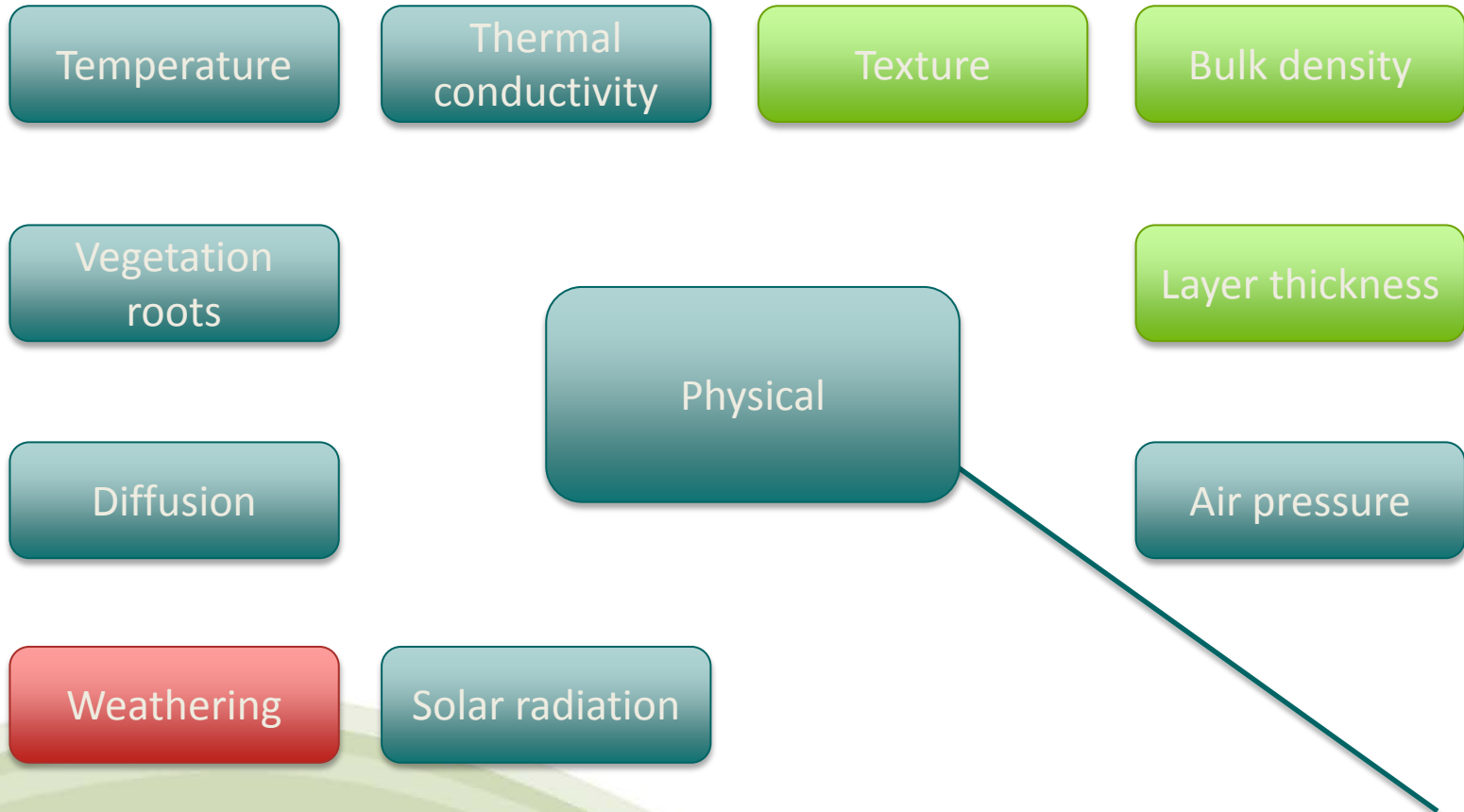
The MOSES model

- Modelling Of Soil Ecosystem Services

    - Simulates multiple processes

    - Allows quantification of ecosystem services

    - Allows scenario simulation of land use/climate change

- Process-based point soil profile model

- 1 minute timestep, 1 cm layer
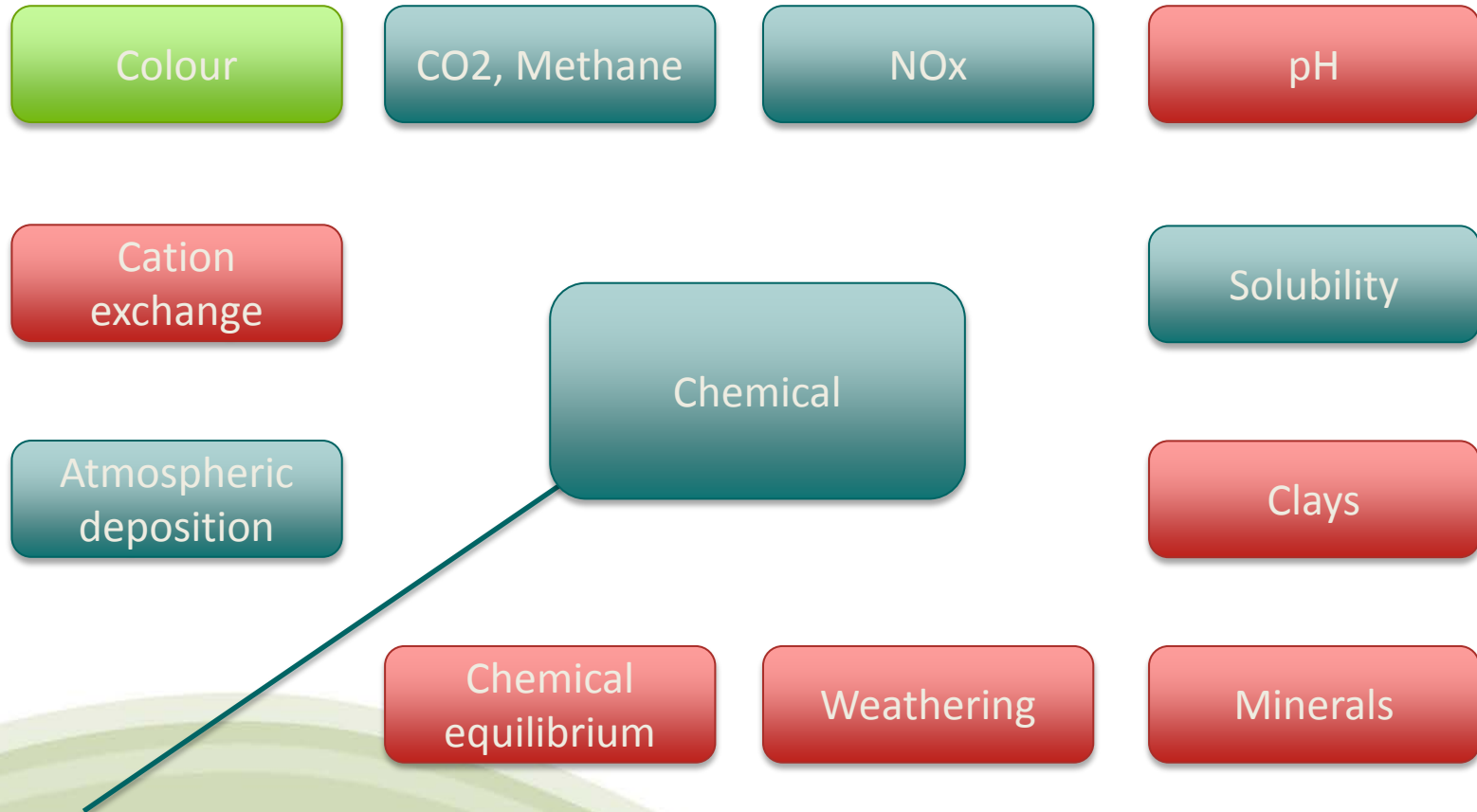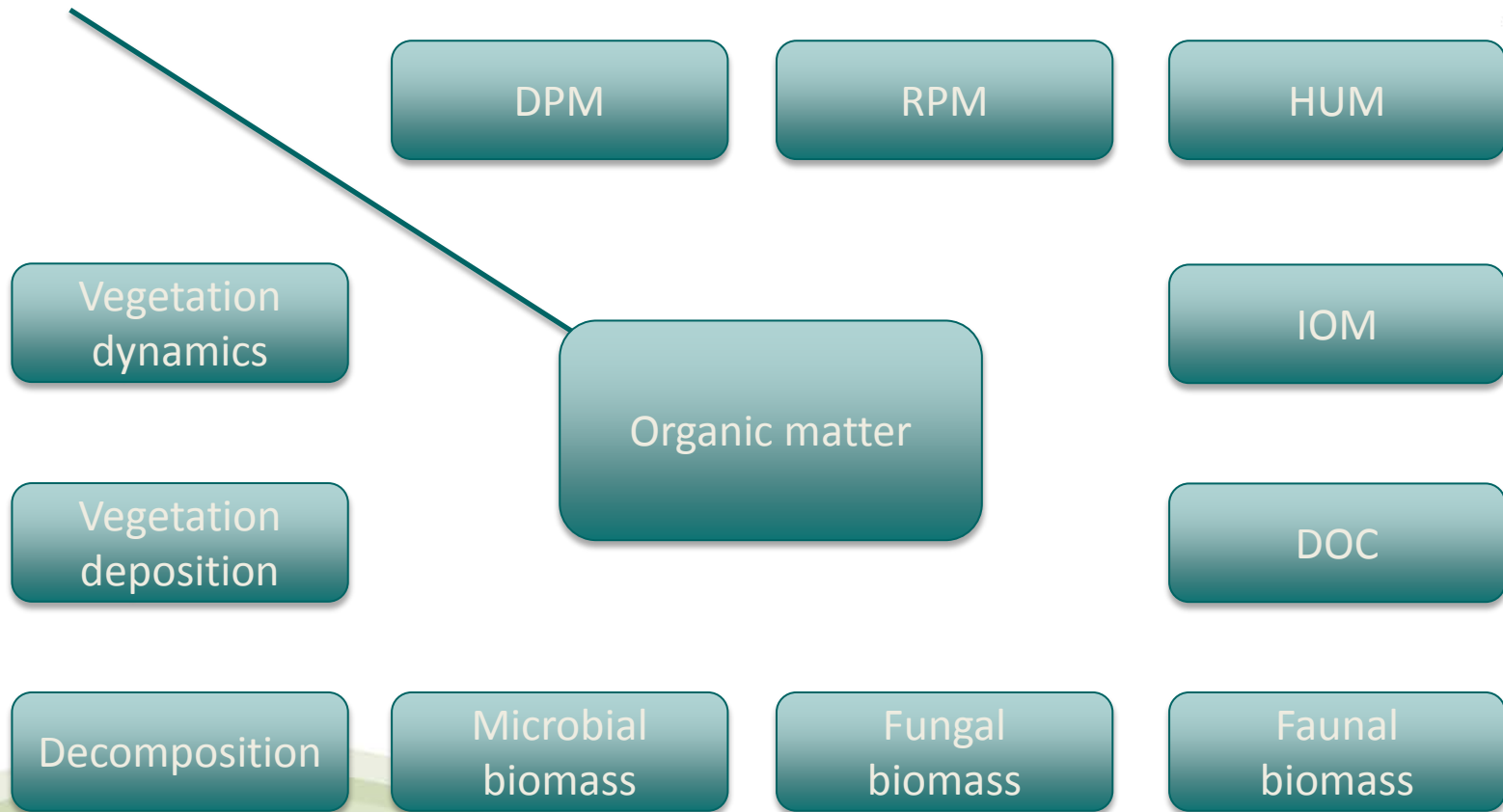
- Outputs saved every 12 hours (optional)

MOSES interface

Multiple parameters & processes

Physical parameters & processes

Temperature

Thermal conductivity

Texture

Bulk density

Vegetation roots

Layer thickness

Physical

Diffusion

Air pressure

Weathering

Solar radiation

Chemical parameters & processes

Colour

CO2, Methane

NOx

pH

Cation exchange

Solubility

Chemical

Atmospheric deposition

Clays

Chemical equilibrium

Weathering

Minerals

Organic parameters & processes

DPM

RPM

HUM

Vegetation dynamics

IOM

Organic matter

Vegetation deposition

DOC

Decomposition

Microbial biomass

Fungal biomass

Faunal biomass

Water parameters & processes

Rainfall

Matric potential

Hydraulic conductivity

Humidity

Water

Groundwater

Erosion

Chemical transport

Leaching

Freeze/thaw

Vegetation uptake

Thermal movement

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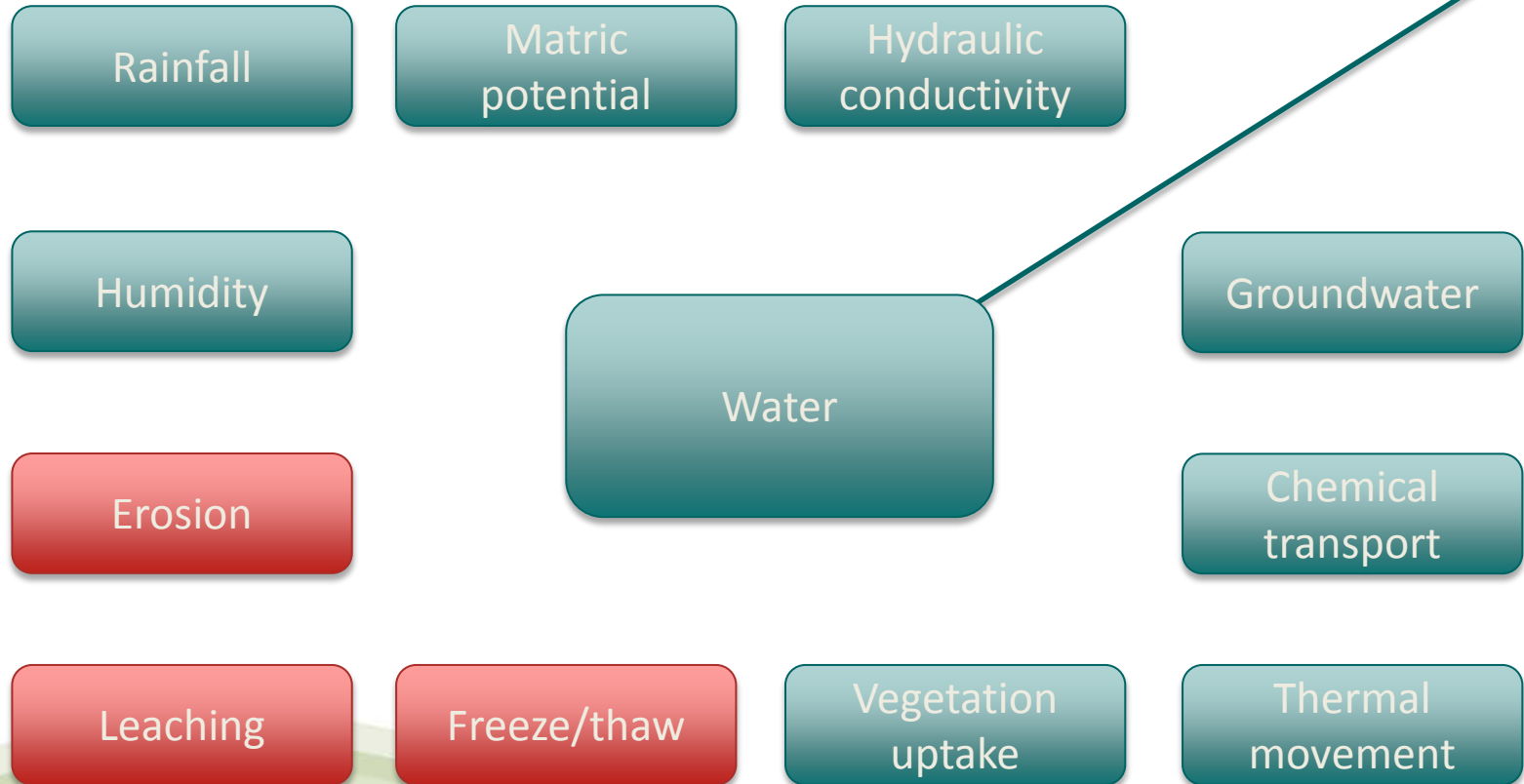
Previous validation work

- Aitkenhead, M.J., Albanito, F., Jones, M.B., 2011. Development and testing of a process-based soil model (MOSES) for ecosystem services. Ecological Modelling 222, 3795-3810.

- Aitkenhead, M.J., 2011. Exploring potential contributions of soil microbes to Martian terraforming through soil simulation. CAREX Conference on Life in Extreme Environments, Dublin, October 2011.
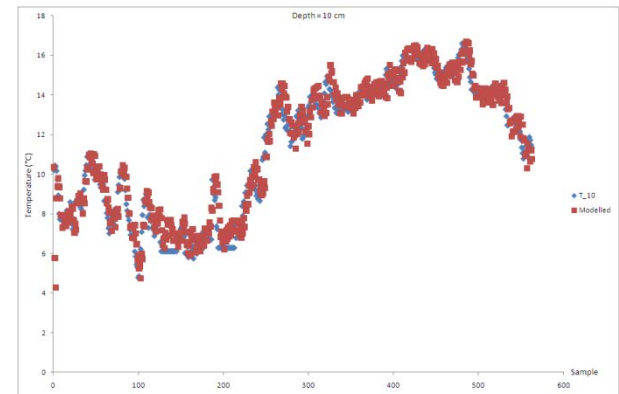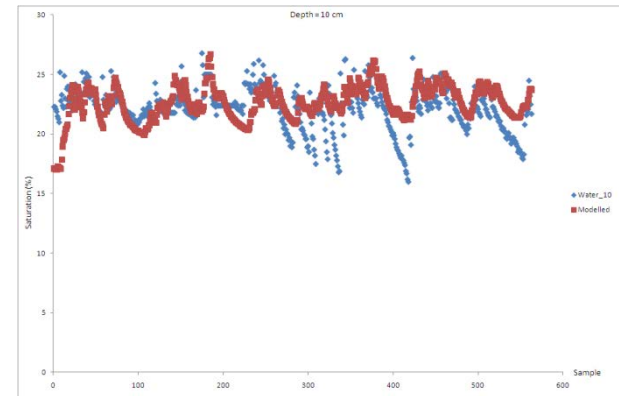
Modelling ecosystem services

- All model parameters automatically output

- Subroutines for integrating selected parameters

  - C sequestration

  - Total void space (not implemented)

  - Water storage

  - Microbial mass x activity (summed over all functional groups) (probably a function, not a service)

- Allows 'bottom to top' analysis of model predictions

- Scope for additional ES implementations in future

Experimental design

- Moor House ECN site, 57° 7' N, 2° 4' W

- 565m elevation, sphagnum peat bog

- Environmental conditions monitored 1991-2003

- Soil matric potential measured

- Clark et al., 2006. Environ. Sci. Technol. 40, 1776-1783

- MOSES model simulated drought conditions and other environmental factors

- 5 scenarios of land cover change from 1st Jan 1991

  - Not always plausible considering the conditions!

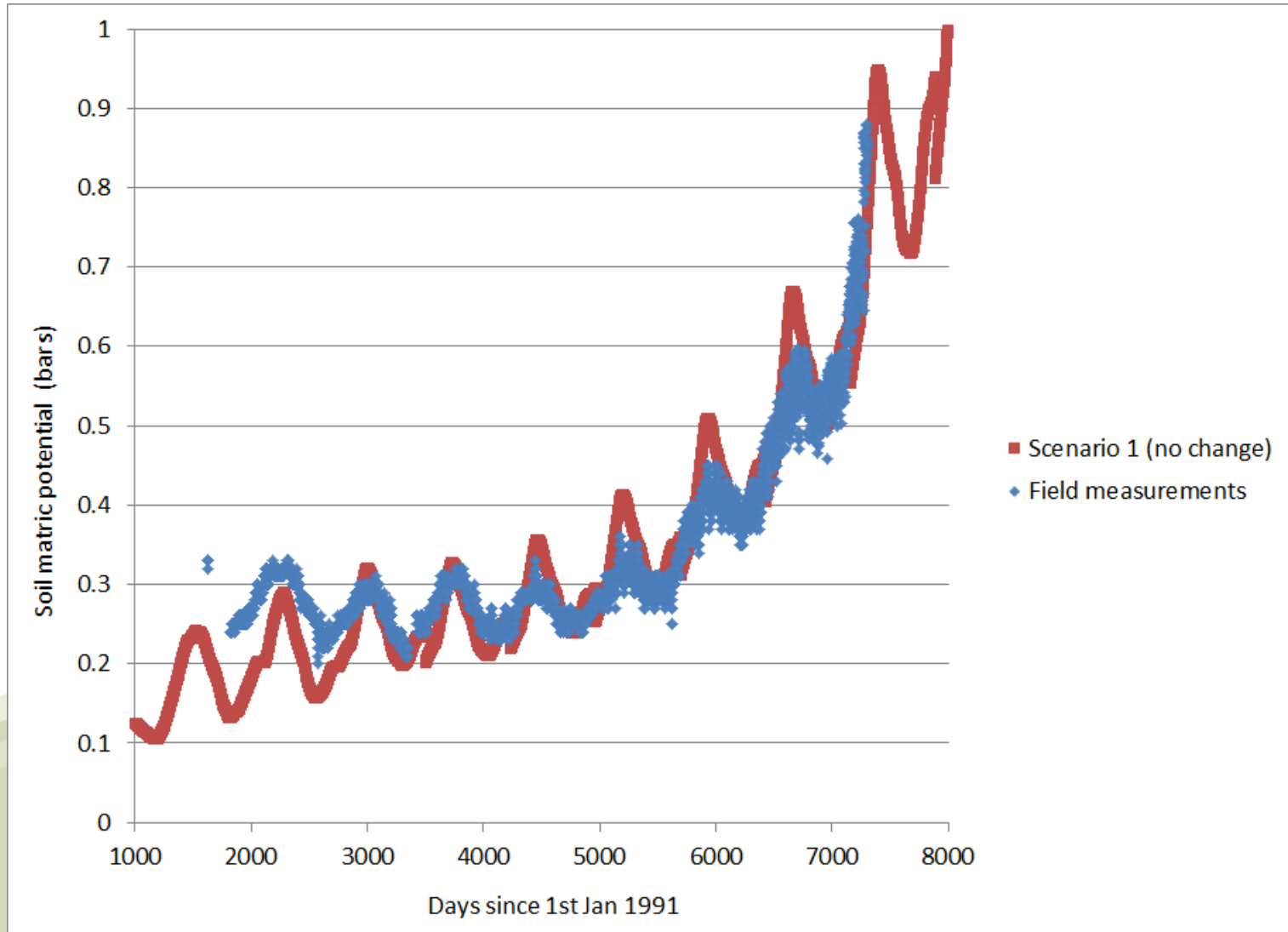**ECN website image of Moor House, ©CEH**
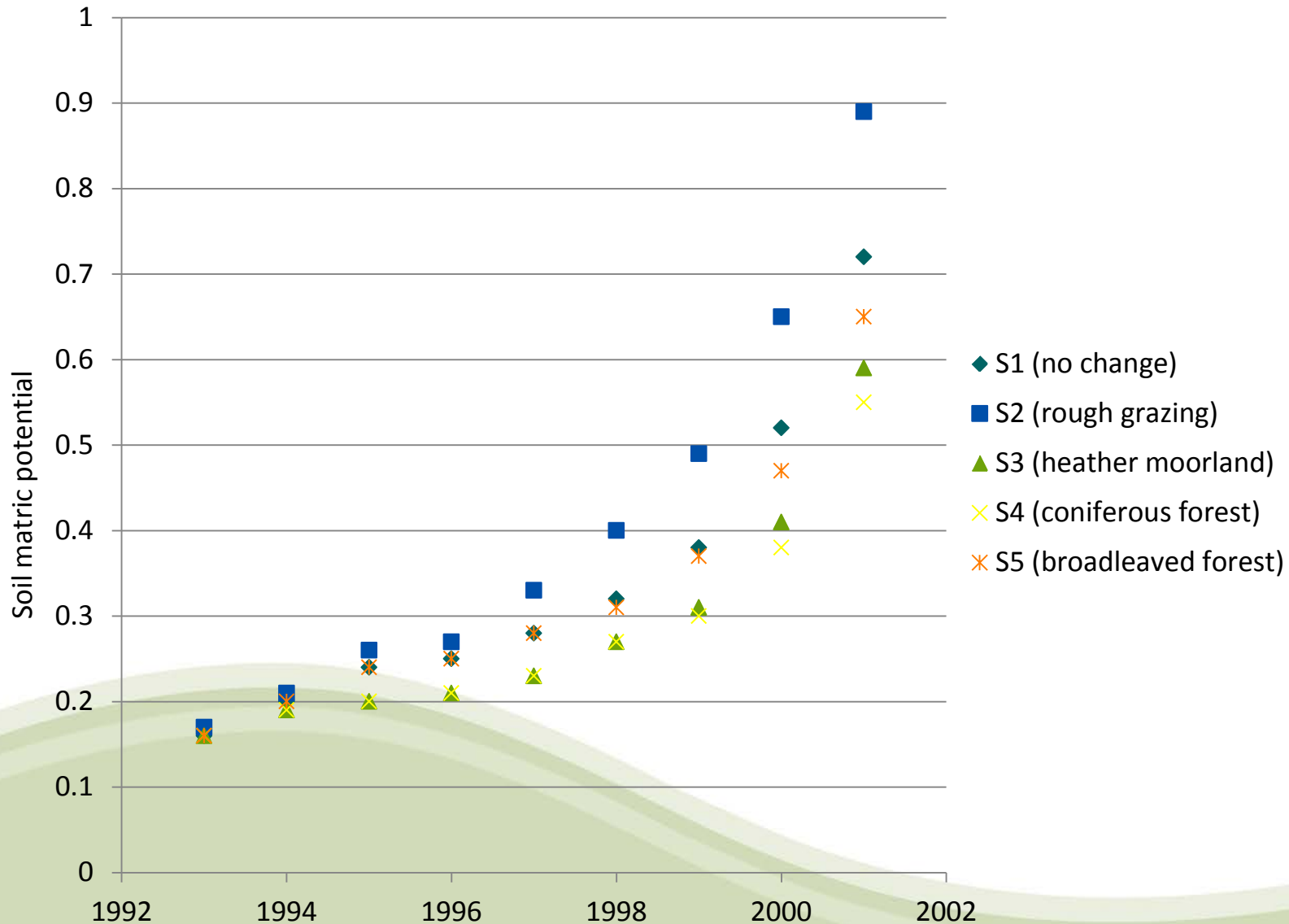
Scenarios explored (I)

- Scenario 1 – no change (peatland vegetation)

- Scenario 2 – good rough grazing

- Scenario 3 – heather moorland

- Scenario 4 – coniferous forest

- Scenario 5 – deciduous forest

- In each scenario, vegetation is 'planted' on Jan 1st 1991

- Vegetation submodel controls several growth, littering, ground cover and rooting parameters (parameterised from literature)

Soil matric potential
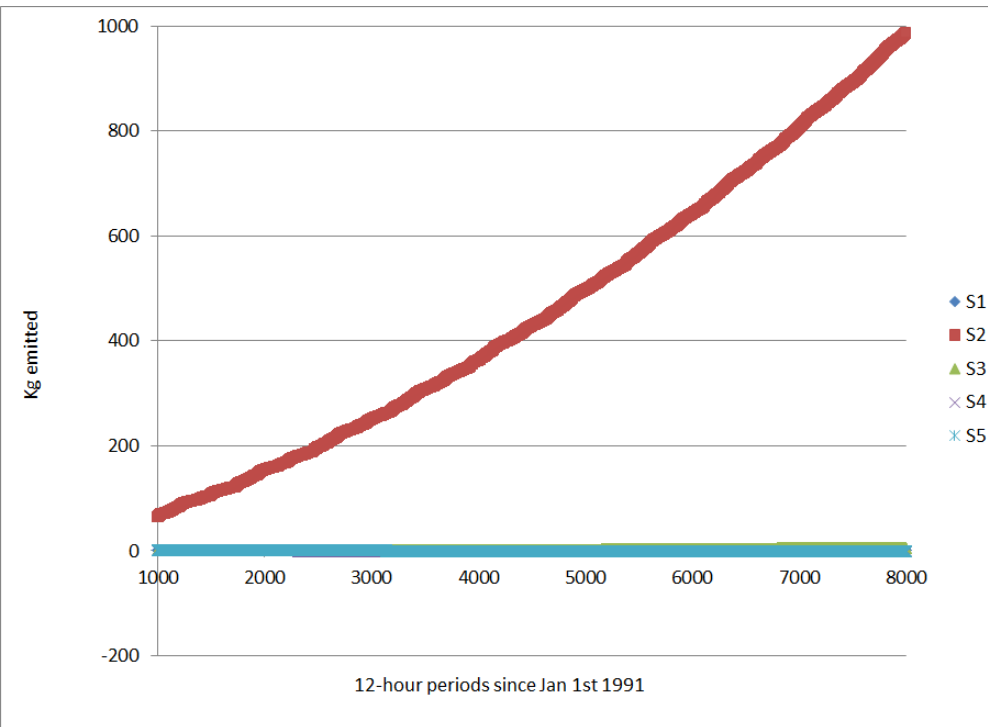
Soil matric potential (annual mean)

Scenarios explored (II)

- Scenario 1 – no change (peatland vegetation)

- Scenario 2 – good rough grazing

- Scenario 3 – heather moorland

- Scenario 4 – coniferous forest

- Scenario 5 – deciduous forest

- In each scenario, vegetation is 'planted' on Jan 1st 1991
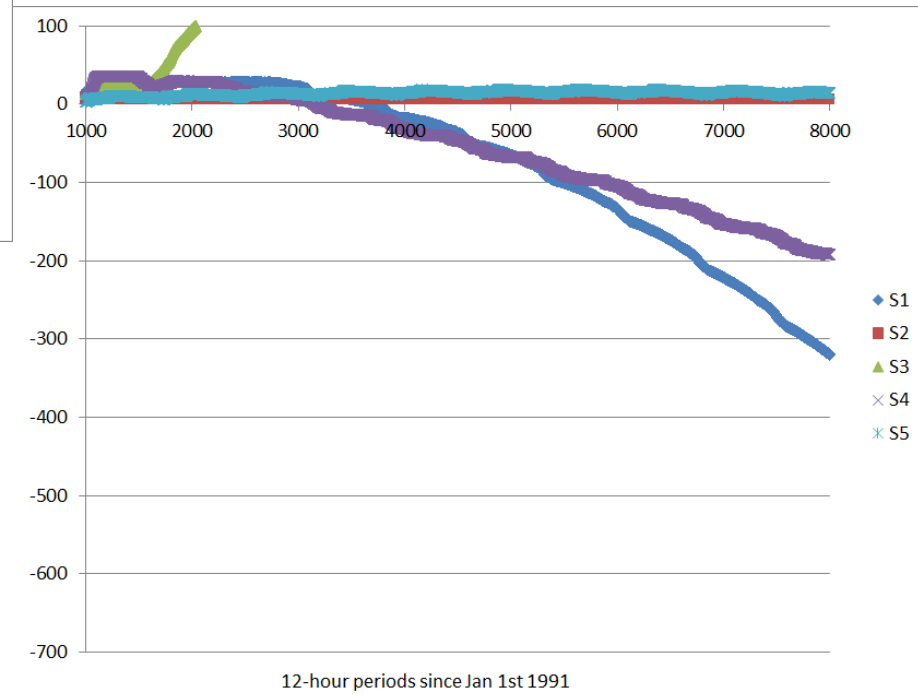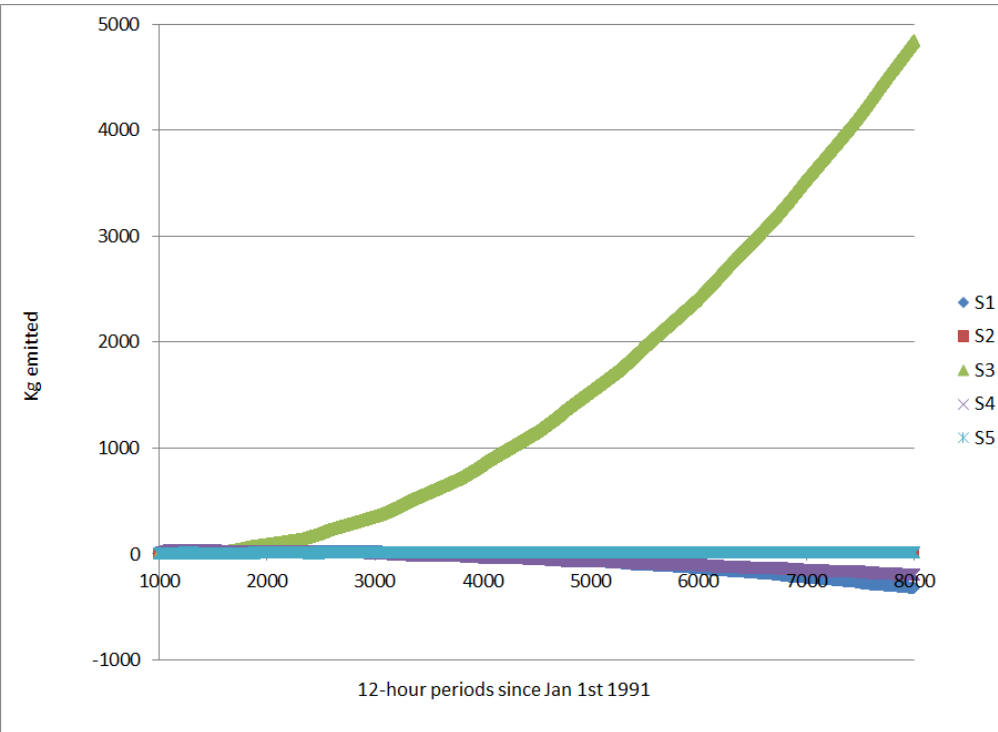
- No droughting, used rainfall pattern from 1991
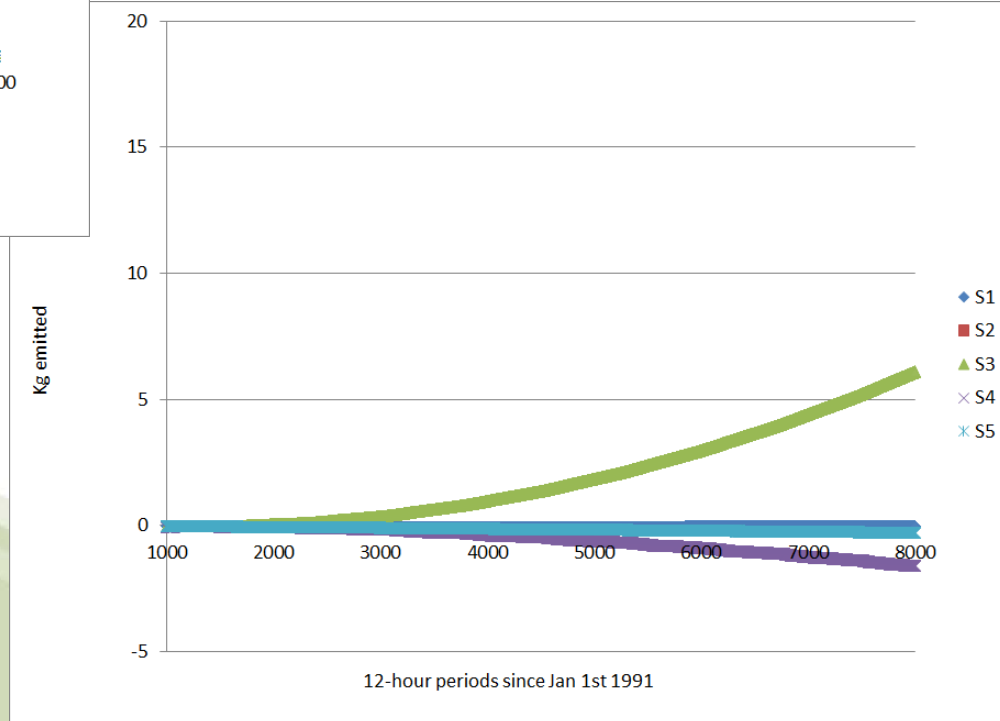
Emissions (methane, kg/ha)

Emissions (CO2, kg/ha)

Emissions (total C, kg/ha)
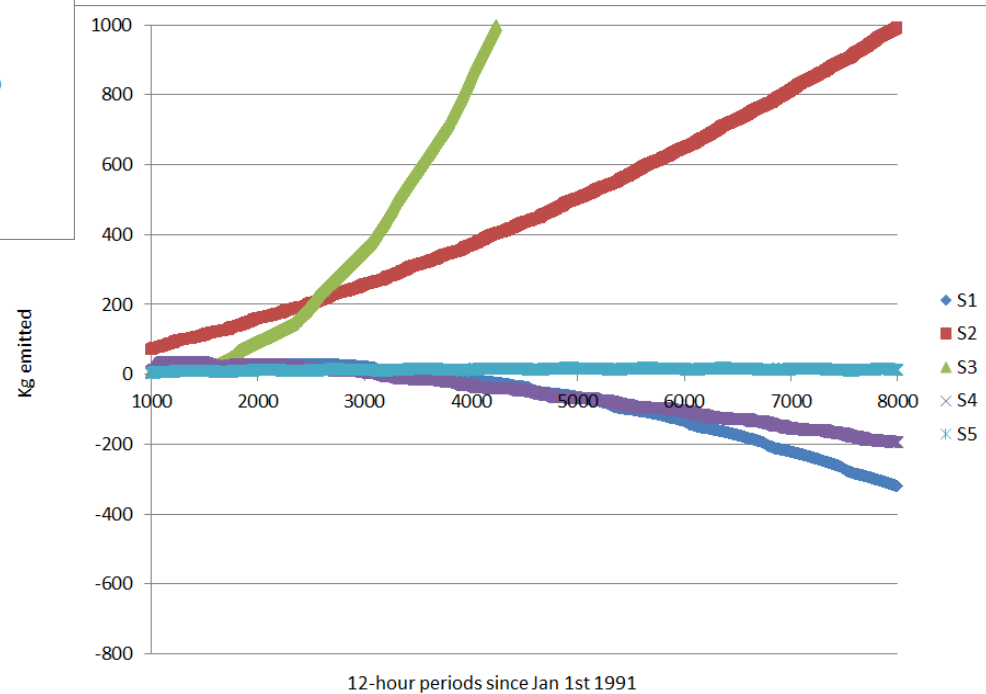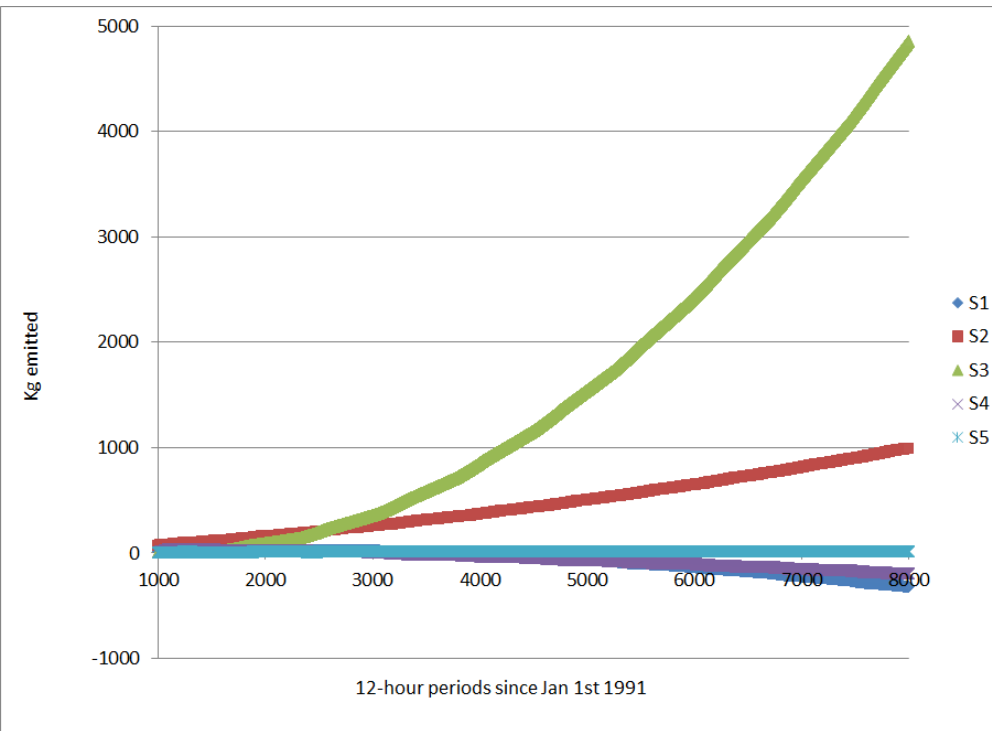
Ecosystem services - changes

	S1	S2	S3	S4	S5
C sequestration	●	⬇	⬇	⬆	⬆
Water storage	●	⬇	↓	⬇	↓
Microbial	●	⬆	↑	↑	↑

⬇ **Decreasing rapidly**

↓ **Decreasing slowly**

● **No change**

↑ **Increasing slowly**

⬆ **Increasing rapidly**

Conclusions

- MOSES can be used to model soil at a range of levels:

    - Processes/parameters

    - Functions

    - Ecosystem services

- Incorporates a wide range of processes/parameters (and is designed to be extendable)

- Useful for scenario modelling

- If anyone would like a postdoc and doesn't need paying, I have 13,000 lines of code that need cleaned up and worked on…