QUERCC
QUantifying Ecosystem Roles in the Carbon Cycle

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QUERCC: QUantifying Ecosystem Roles in the Carbon Cycle

Overall objective: - NERC-speak.

To quantify the contemporary terrestrial carbon cycle using new combinations of data and models.

This will be achieved through 4 work packages

Overall objective: - reality?.

Change/replace TRIFFID components to include a nitrogen cycle, a wider range of functional types and more ecologically realistic sub-grid scale dynamics.
TRIFFID

Schematic showing TRIFFID carbon flows for each vegetation type. Processes above the dotted line are fluxes calculated in the MOSES2 land surface scheme every atmospheric model time step (≈ 30 minutes).

In dynamic mode, TRIFFID updates the vegetation and soil carbon every 10 days using time-averages of these fluxes.
TRIFFID and GCM coupling.

Changes in the distribution and structure of five functional types feedback to climate via two routes.

1. Vegetation determines the biophysical parameters which affect fluxes of heat, water and momentum.
2. Changes in the carbon stored in vegetation and soil (NEP) also change atmospheric CO$_2$ and climate.

Nitrogen deposition is also shown as a driver for vegetation change, but this version of TRIFFID does not include an interactive nitrogen cycle.
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Work package objectives

WP1. Develop new calibrated models of soil chemistry and nutrients that influence the carbon cycle, with particular emphasis on the N cycle.

WP2. Develop, expand and validate descriptions of plant function.

WP3. Create model(s) to capture sub-grid scale dynamics of vegetation behaviour.

WP4. Combine the above models into the JULES structure and apply globally.
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- **WP2**: Functional types (FTs)
- **WP3**: Sub-grid cell dynamics
- **WP4**: Input to JULES
- **WP1**: Soil N,P
- **WP4**
- **CEH/Exeter**
- **Simulations data base**
- **Aberdeen**
- **Leeds**
- **Observational data base**
Work Package 1

How to represent nutrient availability in models

1. Temporal compartmentalisation of soil C cycling.

2. Identify the role of soil nutrient availability (N and P) on rapid and slow cycling.
Work Package 1

Hypothesis -
Organic matter pool turnover regulated by nutrient driven feedbacks in the short and long term

Wardle et al. (2004) Science
The Nitrogen cycle

Atmosphere

1. **Organic matter**
   - N₂ fixation
   - Photosynthesis
   - N₂O

2. **NH₄⁺**
   - Nitrification
   - Denitrification
   - N₂O

3. **NO₂**
   - NO₃

4. **N₂**

**Aerobic conditions**

**Anaerobic conditions**

Detrital organic matter

After Wollast (1981)
Work Package 2

GLC 2000 vegetation map

Key regions
Wright et al.: Major axis of leaf variation

- Major axis of variation from fast to slow living plants.
- Also correlated:
  - N content,
  - P content
  - Assimilation capacity,
  - Dark respiration
Change in leaf longevity of dominant vegetation (months)

- Black = Outside Climatic range
Work Package 3

Sub-grid scale activity
Work Package 3

TRIFFID/MOSES land surface scheme

- Grid cell divided into tiles.
- Each tile is one PFT
- Size of tile determined by empirical dominance hierarchy
- **Tendency for a single vegetation type to dominate**

- E.g. LPJ (Smith et al 2001)
Work Package 3

Ecosystem Demography Model (ED)

Moorcroft et al. (2001)

“Size and age structured approximation of an individual based model”
Simulating succession in ED

Leaf cost vs. mortality trade off

Cheap leaves
High mortality

Expensive leaves
Low mortality
WP1: N cycle and P response

WP2: Improved characterisation of PFTs

WP3: Sub-grid cell dynamics

WP4: Combine new knowledge into JULES structure

“Newer” processes for land surface modelling
Soil Nutrient regulated Ecosystem Carbon Cycle

Can N and P availability be used as a predictor of Carbon cycling?

Slide from Nick Ostle, CEH Lancaster
Slide from Peter Smith, Aberdeen
Work Package 3

Leaf life span change from fixed per FT to Wright *et al* variable relationship with temperature and precipitation
Soil model evaluation and improved process description

Testing models

Model improvement
Predicted changes in LL/SLA ratio

Log_{10} [LL (months)]

Log_{10} [SLA - (g m^2)]
Wright et al. 2004
Work Package 3

Wright et al. 2004
Work Package 4

JULES modular structure

Unified Model  IMOGEN  Other driving data

Surface exchange
- radiation
- Canopy conductance
- soil
- Dynamic vegetation

- snow
- hydrology

Ocean and sea ice

Other driving data
- phenology

Canopy conductance

radiation

Soil

Dynamic vegetation