A model approach to assess the sustainability of the soil nitrogen balance of short rotation Eucalyptus in south-western Australia

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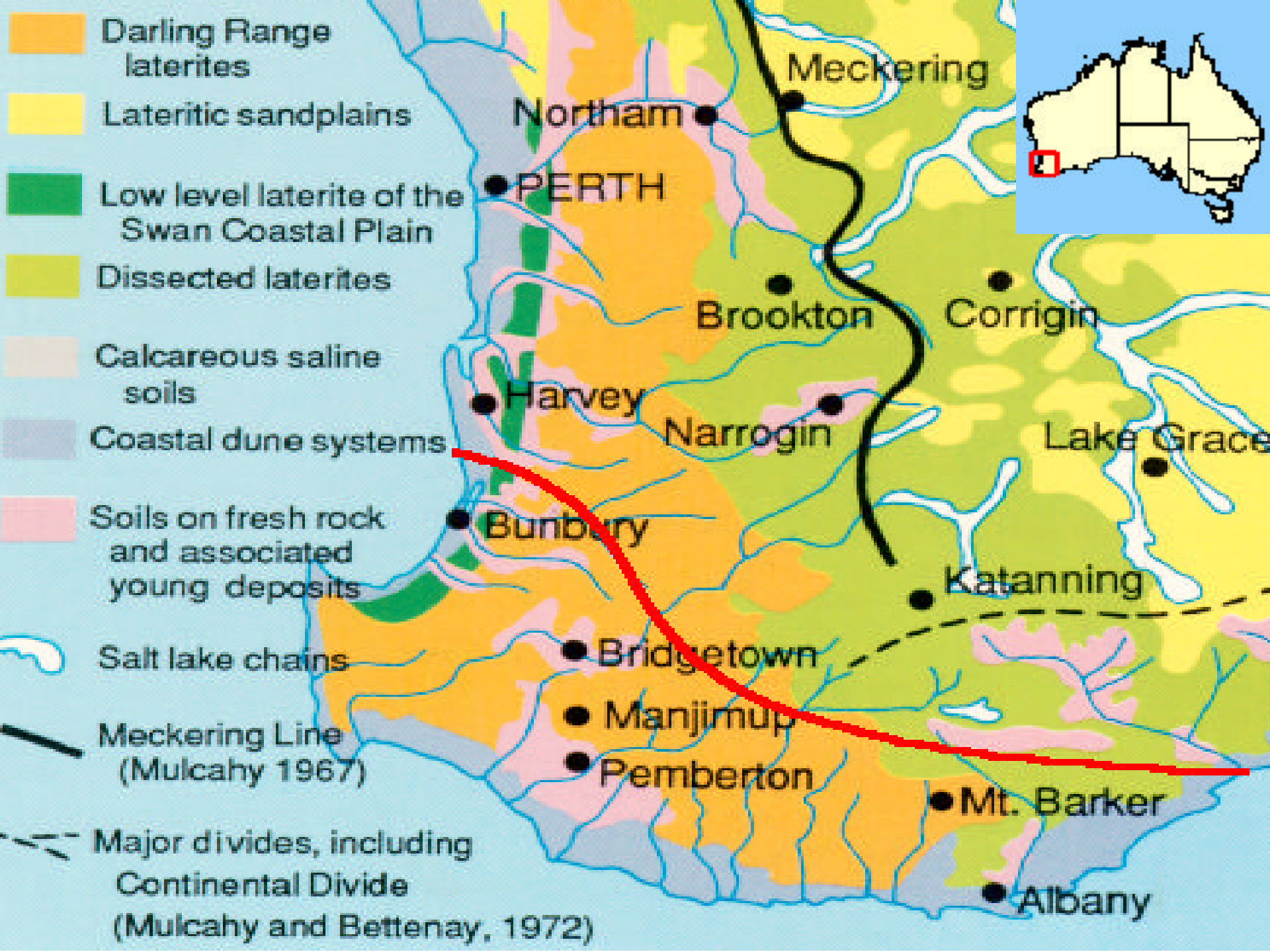
Introduction

- 200 000 ha of short rotation (10 yr) *Eucalyptus globulus* plantations in SW Australia
- on farmland with a past history of annual fertilizer inputs and legume-based pasture systems
- sustaining plantation productivity depends on maintaining the current levels of soil fertility
- management of harvest residues is one option for manipulating site fertility
- impact of site management on soil N supply is key issue


Darling Range laterites
Lateritic sandplains
Low level laterite of the Swan Coastal Plain
Dissected laterites
Calcareous saline soils
Coastal dune systems
Soils on fresh rock and associated young deposits
Salt lake chains
Meckering Line (Mulcahy 1967)
Major divides, including Continental Divide (Mulcahy and Bettenay, 1972)
Meckering
Northam
PERTH
Brookton
Corrigin
Harvey
Narrogin
Lake Grace
Bunbury
Katanning
Bridgetown
Manjimup
Pemberton
Mt. Barker
Albany

Objective: Evaluate the impact of harvest residue management practices on soil N supply rates

Outline:

- Description of the structure and calibration of a generalised decomposition model for plantations
- Validation of this model (C and N dynamics) against an independent dataset
- Link decomposition model with a forest growth model (G'DAY) and parameterise for *Eucalypt globulus* plantations
- Evaluate whole-system model predictions of tree growth and soil N dynamics
- Scenario analysis: simulate impact of alternative harvest residue management options on N supply

Decomposition model: structure

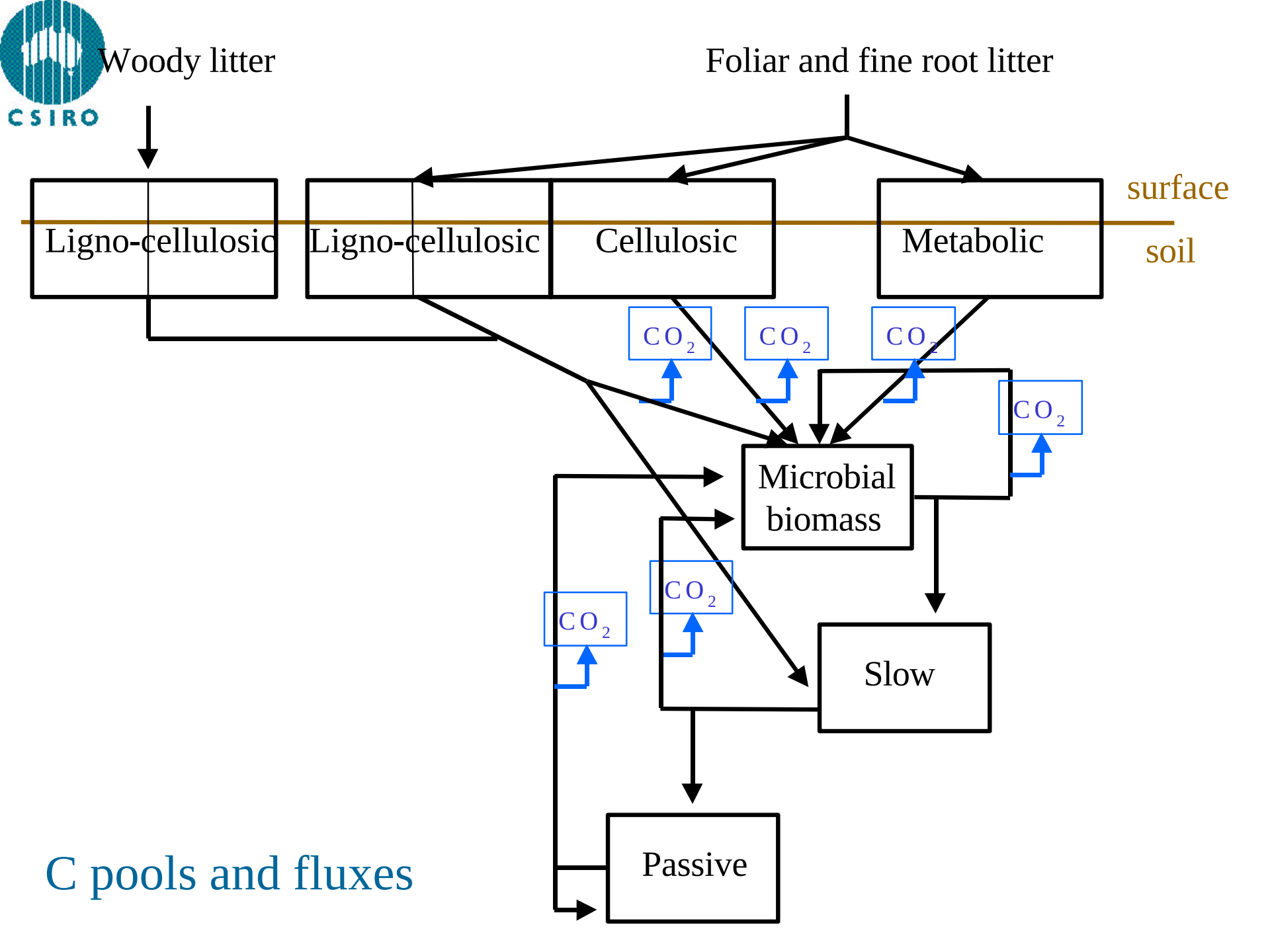
- Based on structure of decomposition submodel of CENTURY

- Why modified structure?

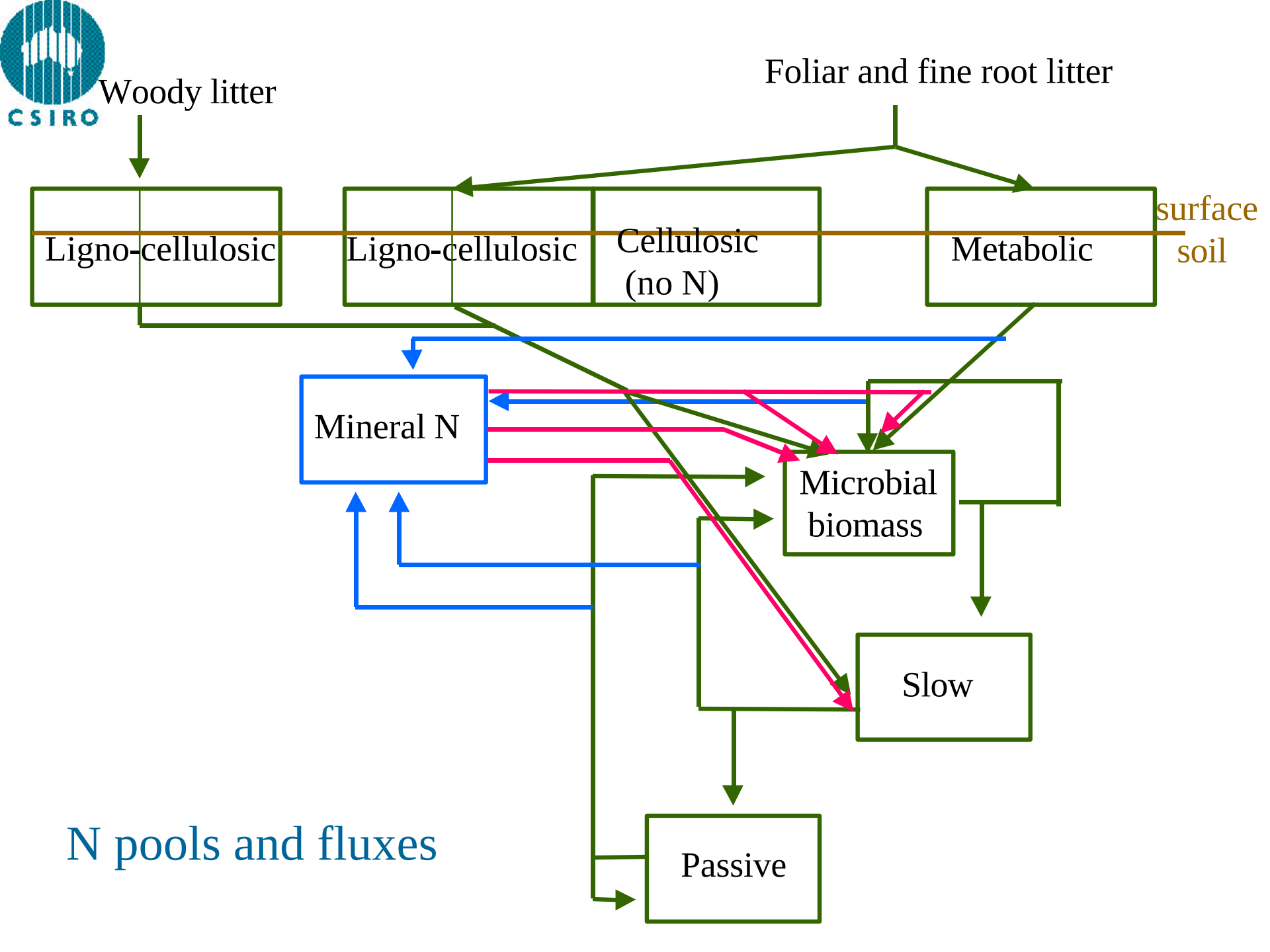
  1) CENTURY failed to describe mass loss and MIT turnover from decomposing plantation litter

  2) more mechanistic approach of MIT turnover process

  3) different objective: CENTURY for regional and global studies (time step: 1 month)



C pools and fluxes



N pools and fluxes

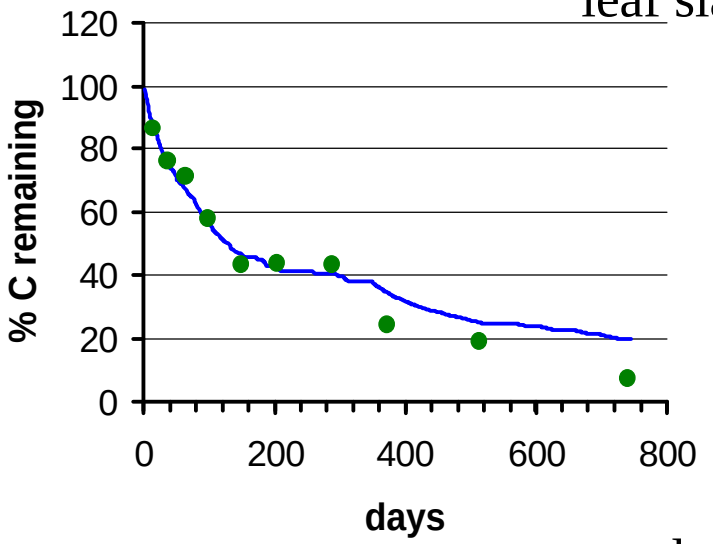
- key differences in model structure :
  - 1) leaf/fine root litter is divided in three biochemical pools (with specific decay rates)
  - 2) microbial biomass succession incorporated in the model
  - 3) microbial biomass C:N = f(litter quality)
  - 4) woody litter is explicitly treated

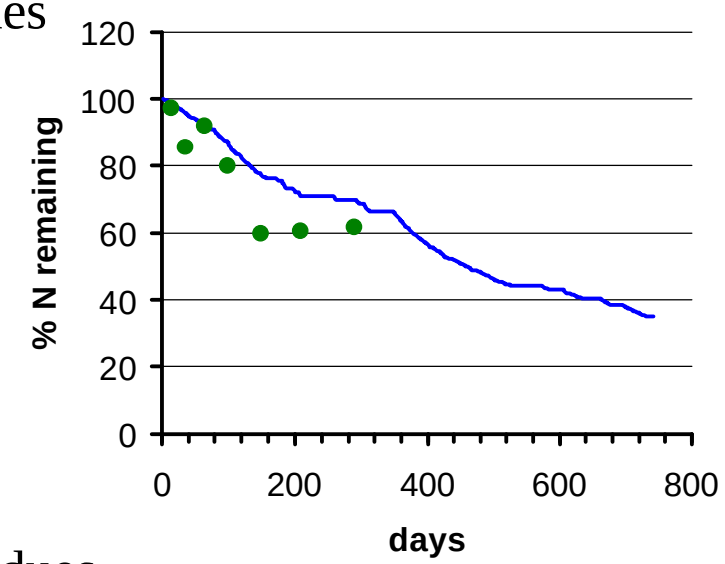
Calibration of decomposition model

- aim:
  - ensure model reasonably simulates C and N dynamics of residue decomposition over time
  - to explore finer details of model behaviour
- experimental data:
  - mass loss and N content data from litterbag decomposition studies with:
    - leaf slash residues
    - woody slash residues

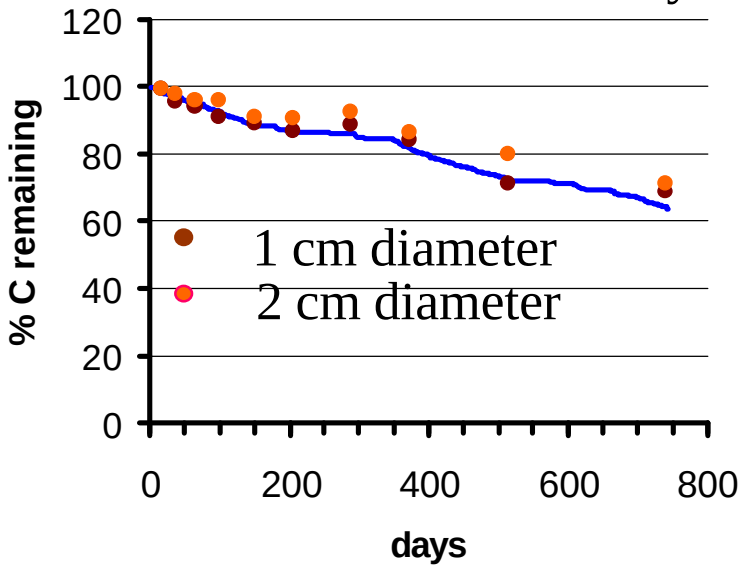
Model calibration: C and N dynamics of *E. globulus*

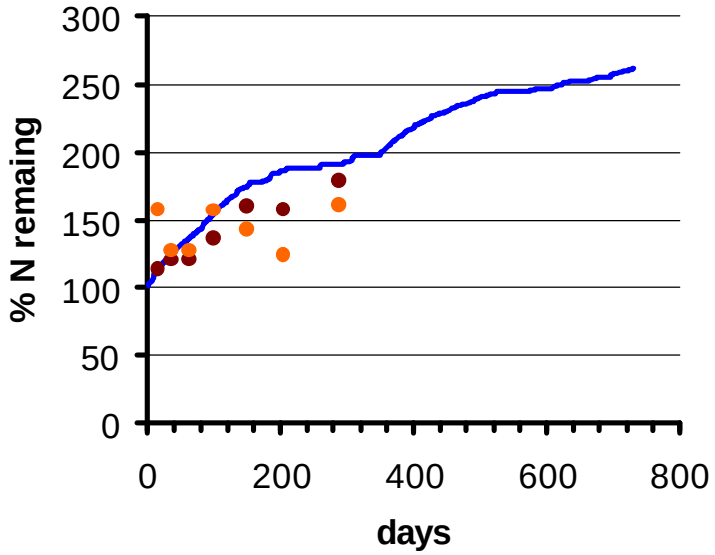
leaf slash residues





woody slash residues



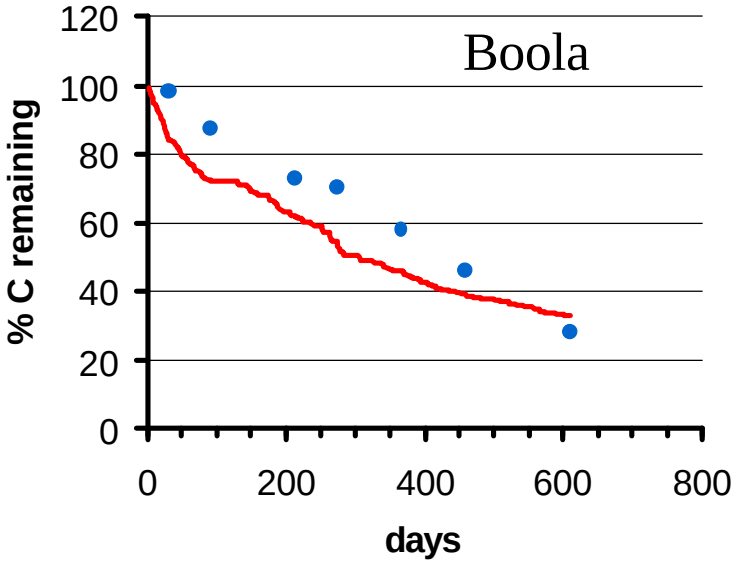


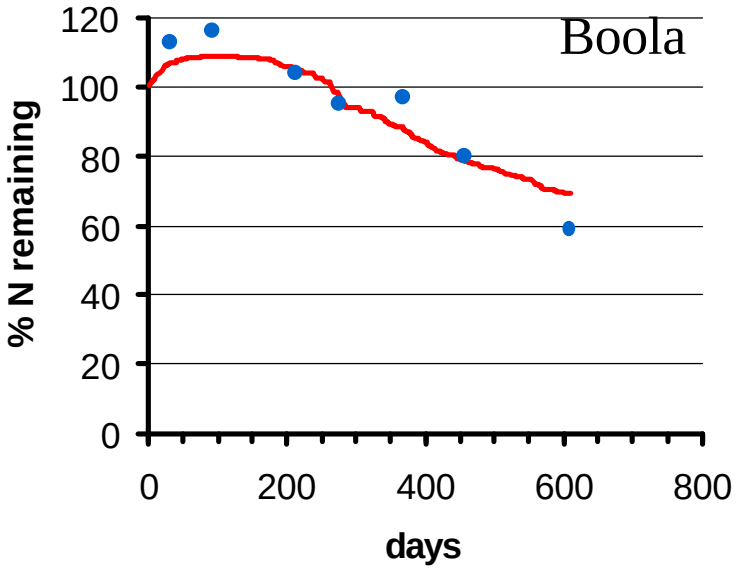
Model validation

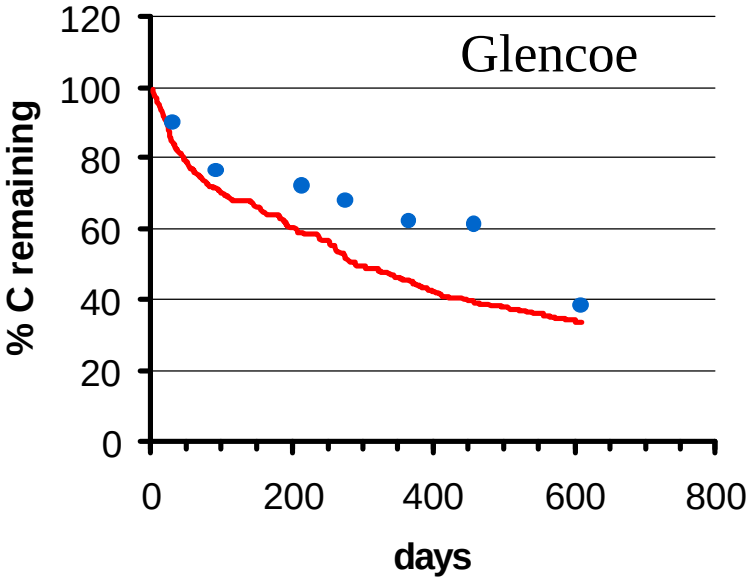
- aim:
  - to test the ability of the model to describe C and N dynamics on an independent dataset
- experimental data:
  - mass loss and N content data from litterbag decomposition study with:
    - leaf litter (2 sites in Gippsland, south-eastern Australia)

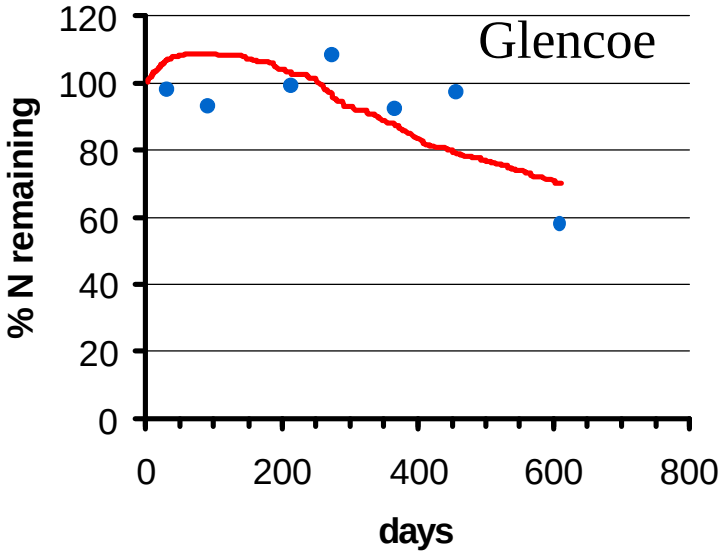
Results of model testing

C and N dynamics of *E. globulus* leaf litter in litterbags







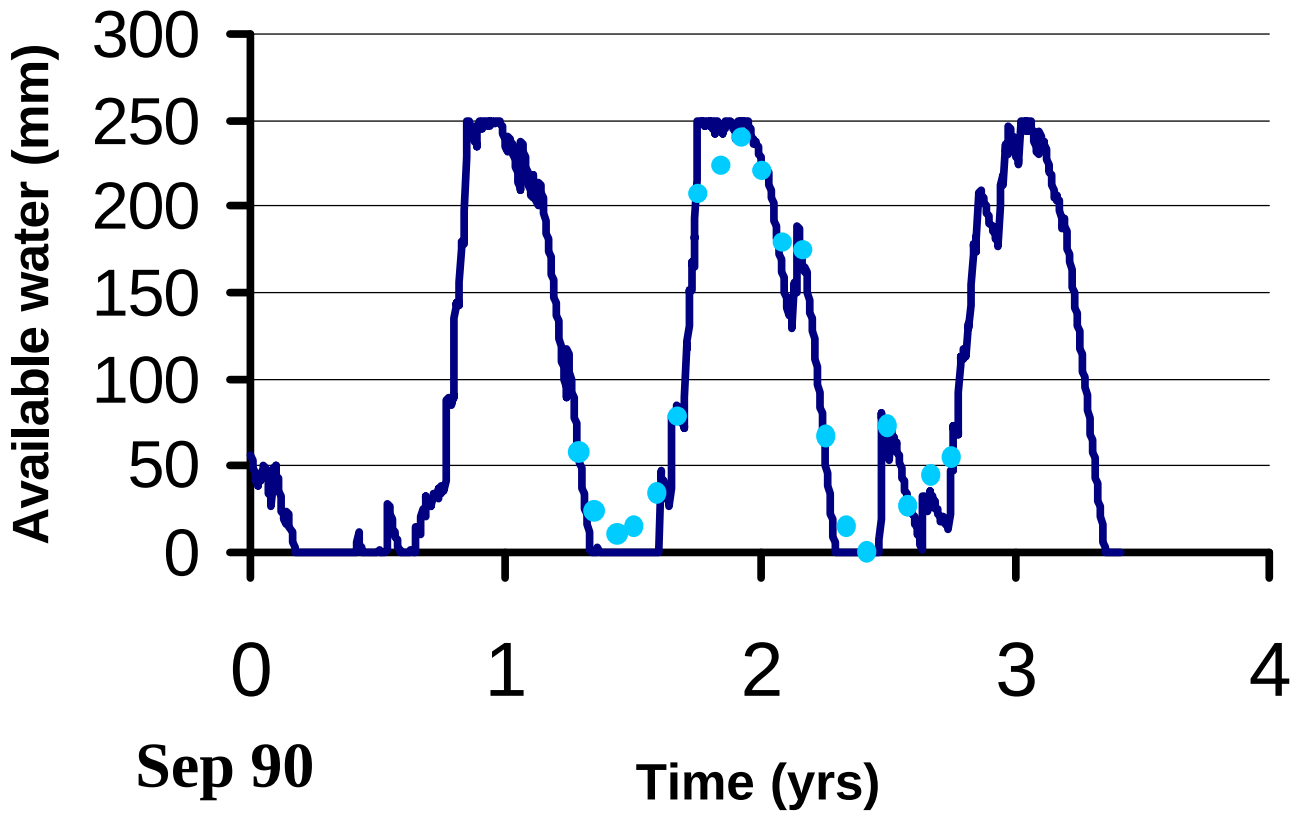


Link with plant growth model

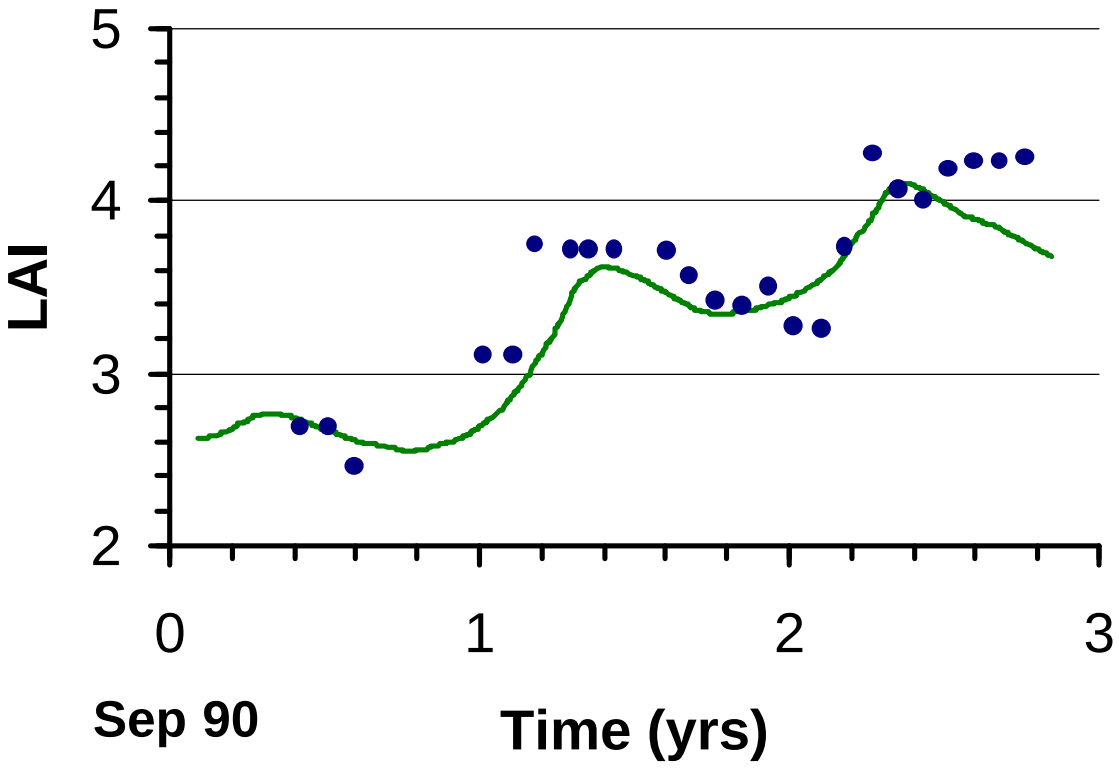
- aim:
  - to examine the links between tree growth, litter inputs and N mineralisation

- G'DAY model: parameterised for growth of *E. globulus*
- Experimental data from plantation at Mumballup in south-western Australia
  - planted in 1988 on a lightly textured soil with a plant-available water capacity of about 250 mm
  - relatively fertile ex-farm site with moderate soil N supply
- Model simulations and experimental data:
  - stem biomass production
  - leaf litter production
  - N mineralisation rate

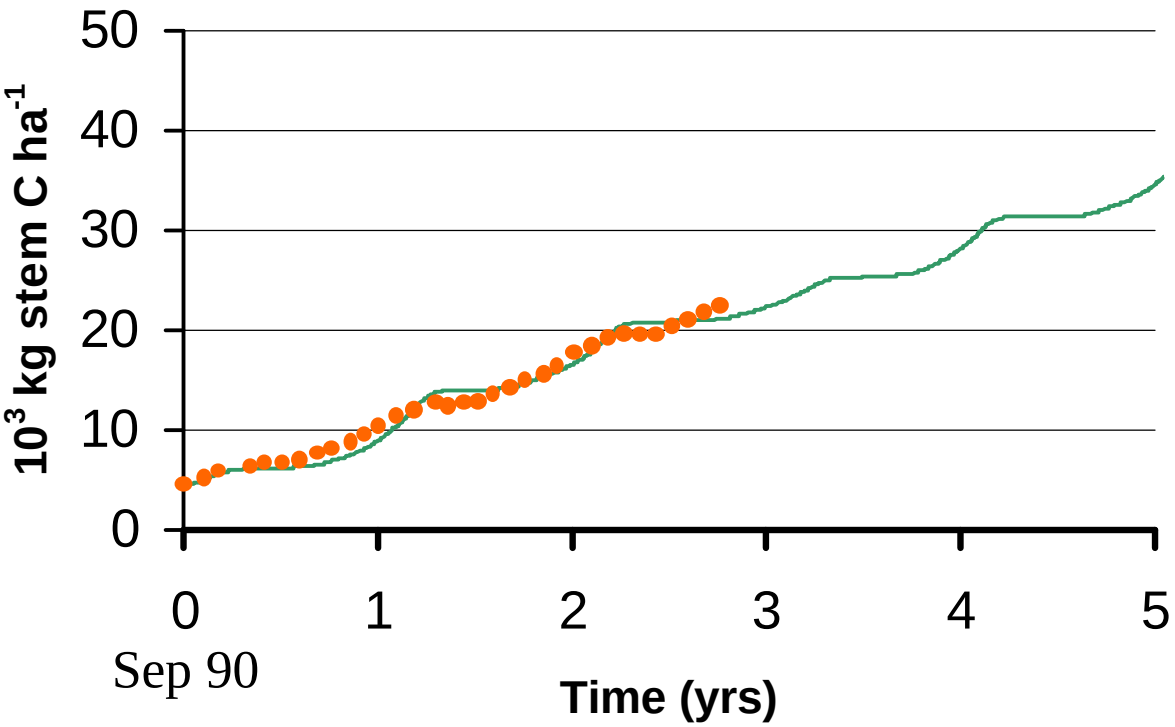
Plant-available soil water content (3 m depth): measured using neutron moisture meter;
and simulated



Leaf area index: measured by a light interception; and simulated



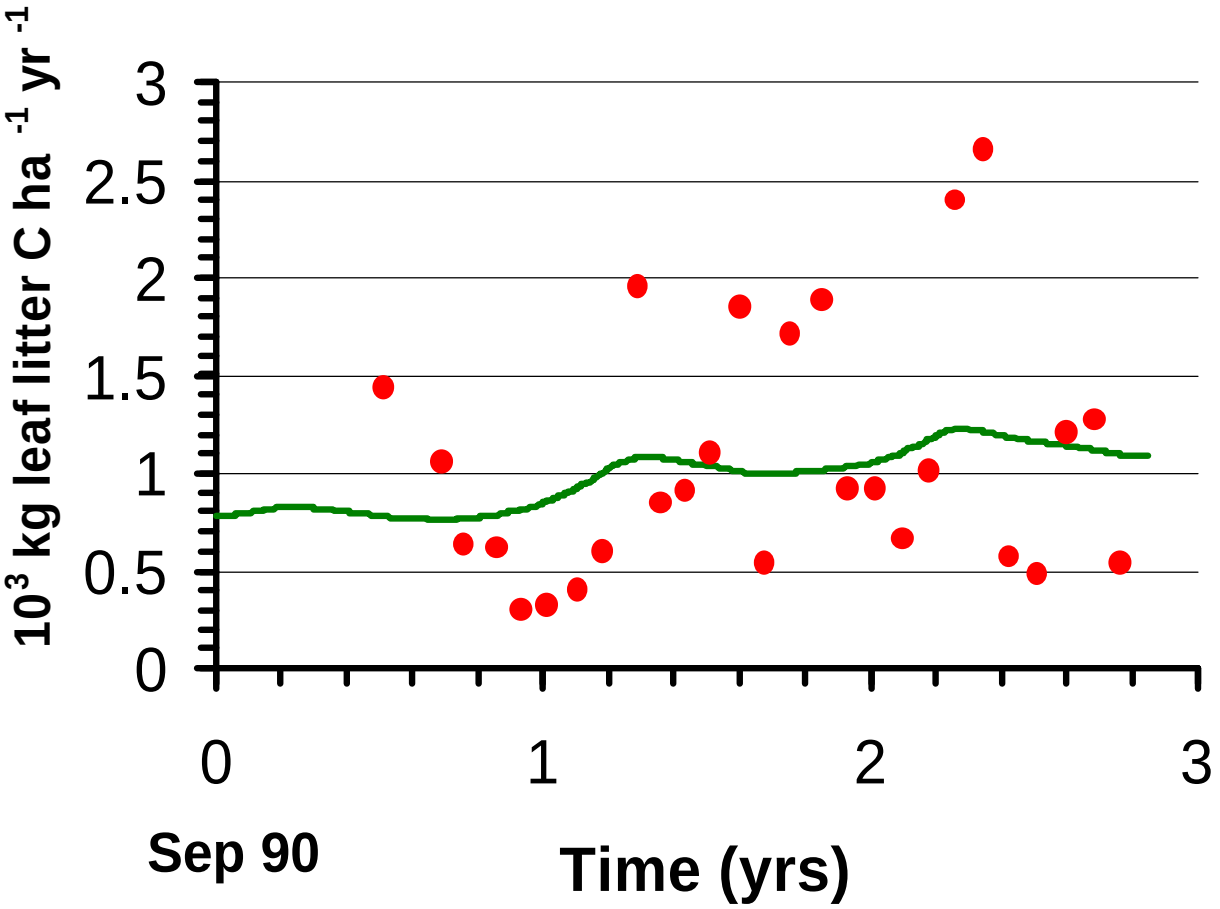
Stem growth: estimated from DBHOB and height; and simulated



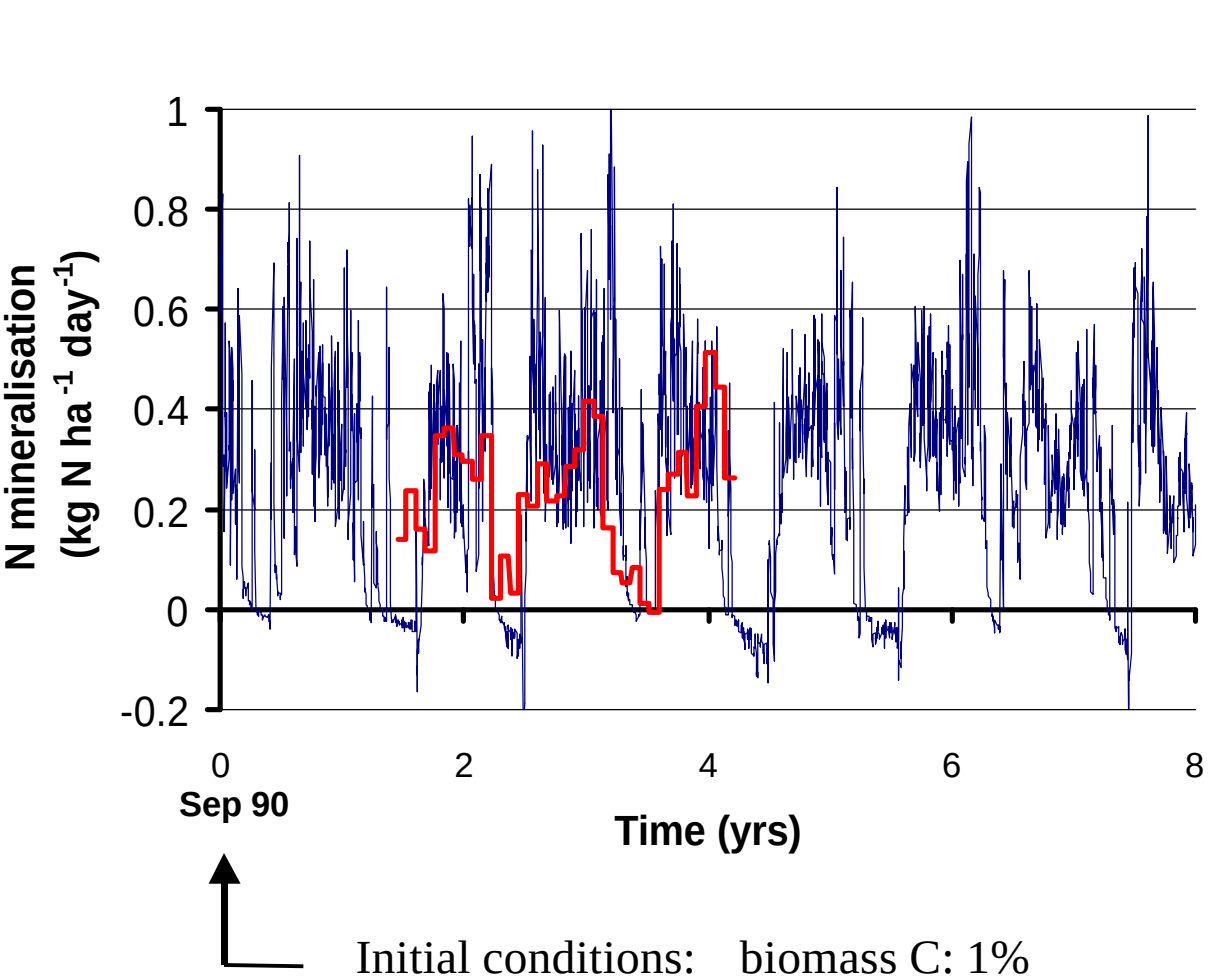
	Allocation coefficient
Stem	53
Branch	10
Leaf	12
Root	25

Leaf litter production:

measured in littertraps and simulated



N mineralisation rate:
measured by the intact core technique and simulated



	Nmin (kg N ha^{-1} yr^{-1})	
year	observed	simulated
1992	72	78
1993	81	107
1994	81	86

Initial conditions: biomass C: 1%

slow C: 15% of total observed C (65 t C ha^{-1})

Impact of alternative harvest residue management options on soil N dynamics

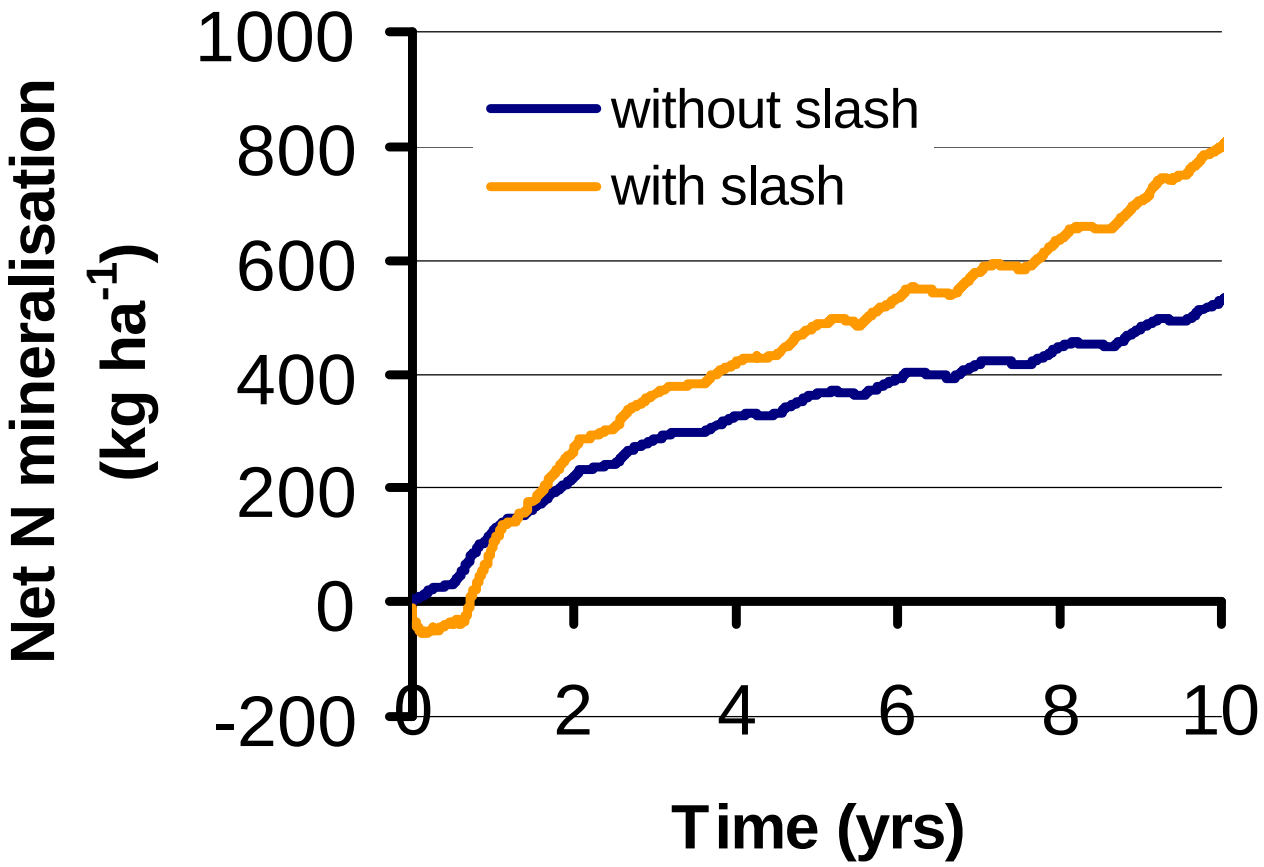
Two scenarios:

- 1) Harvest residues removed
- 2) Harvest residues retained

  8 t C leaves ha^{-1}; C:N = 40

  10 t C wood ha^{-1}; C:N = 150

Effect of slash load on N mineralisation



Conclusions

- Revised decomposition model for plantations
- Good description of C and N dynamics in litterbag studies
- Revised G'DAY for plantation forestry able to describe tree growth and N mineralisation patterns
- Validation on a range of plantation sites is required
- Harvest residues: initial immobilisation then high N release; to be validated against experimental data
- Simulations suggest that retention of residues will favour enhanced soil N supply for the next rotation