The SoilC&N model: simulating short- and long-term soil nitrogen supply to crops

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This talk

- Introduction
- Why SoilC&N?
- Model structure: C and N cycle
- Applications:
  - Short-term
  - Long-term
- Conclusions

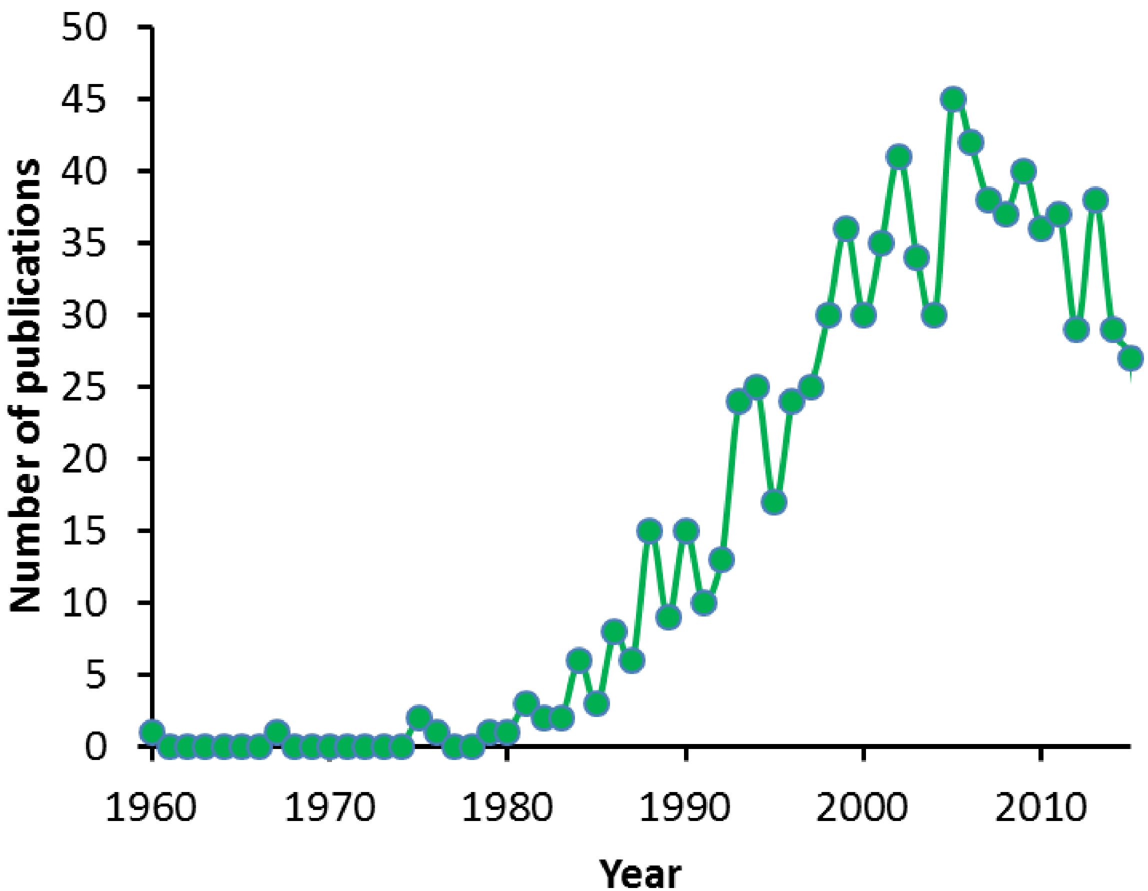
Introduction

- Importance of understanding the N immobilization-mineralization process in ecosystems
  - Linked to the decomposition of plant residues and SOM (C cycle)
  - Short-term dynamics: N fertilizer recommendations, organic resource management
  - Long-term dynamics: soil C sequestration, response of soil C and N to global change

Introduction

- A multitude of soil C and N (decomposition) models to describe and quantify N immobilization-mineralization
  - About 250 models (Manzoni and Porporato, 2009)
  - Since the 1940s: from simple exponential decay functions (Henin & Dupuis, 1945)
  - to a wide range of complex, process-based models (multi-compartment SOM pools) including effects of external factors
    - Examples: CENTURY, Roth-C, Van Veen and Frissel, Ladd et al., NCSOIL,….

Introduction



Why SoilC&N?

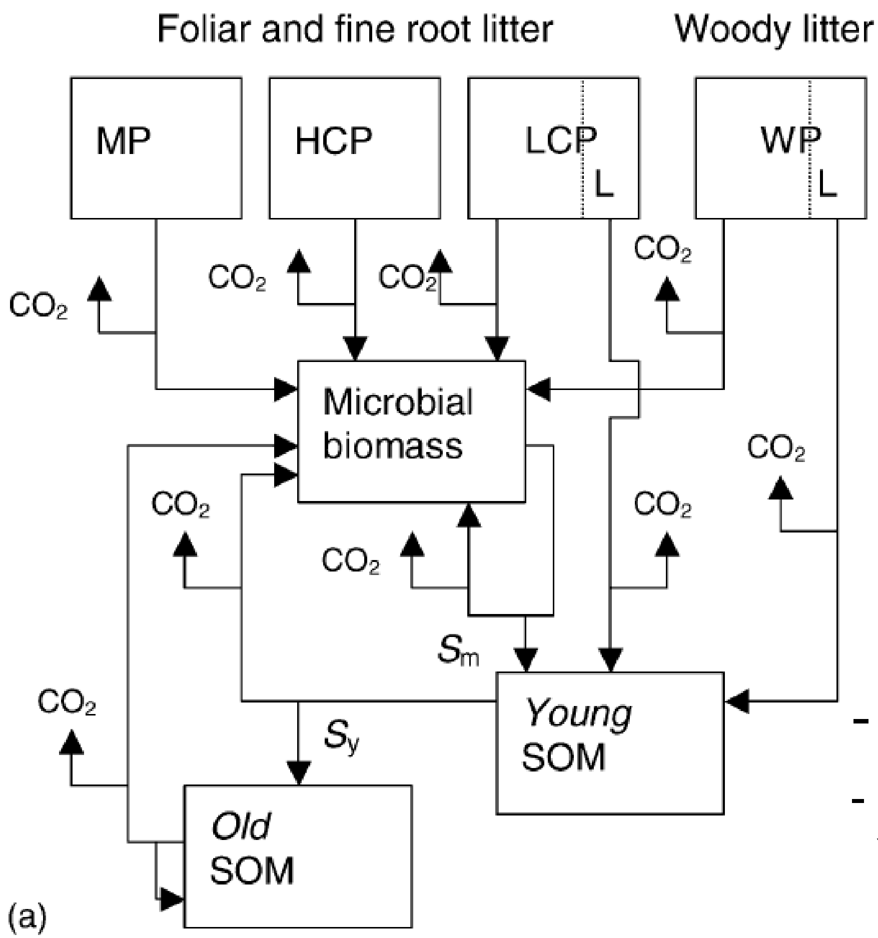
- Based on Century (Parton et al., 1987) and modified from model described in Corbeels et al. (2005)

- Why modified structure?
  - Problems with Century in adequately simulating soil N dynamics (Parton et al., 1994; Moorhead et al., 1999)
  - Need for finer resolution of the relationship between C and N dynamics during decomposition

Distinctive features of SoilC&N

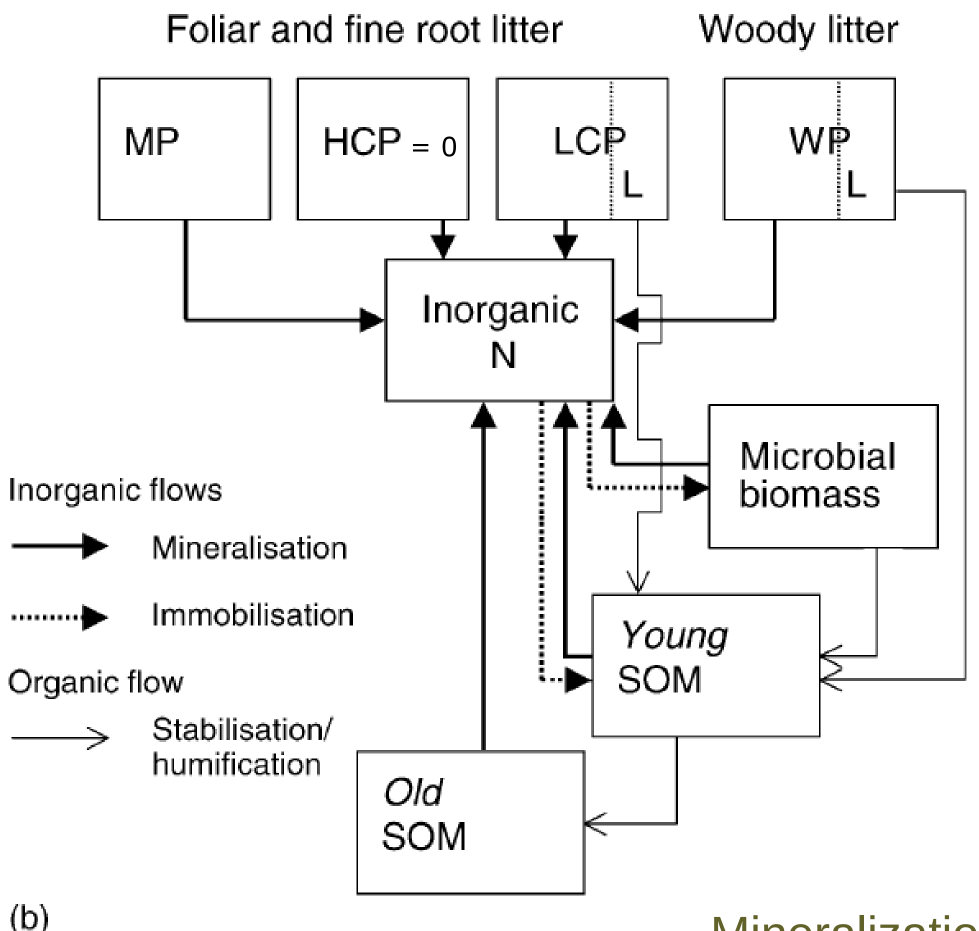
1) growth of microbial biomass is the process that drives N immobilization-mineralization, and microbial succession is simulated; (but is not limiting *per se*)
2) decomposition of plant residues may be N-limited, depending on soil inorganic N availability relative to N requirements for microbial growth;
3) N:C ratio of microbial biomass active in decomposing plant residues is a function of residue quality and soil inorganic N availability
4) C:N ratios of SOM pools are not prescribed but are instead simulated model output variables
5) 'quality' of plant residues is expressed in terms of measurable biochemical fractions

Model structure: C cycle



- simple first-order rate kinetics
- Microbial biomass: 0.01-0.5 yrs
  Young SOM: 2-20 yrs
  Old SOM: 300->600 yrs

Model structure: N cycle

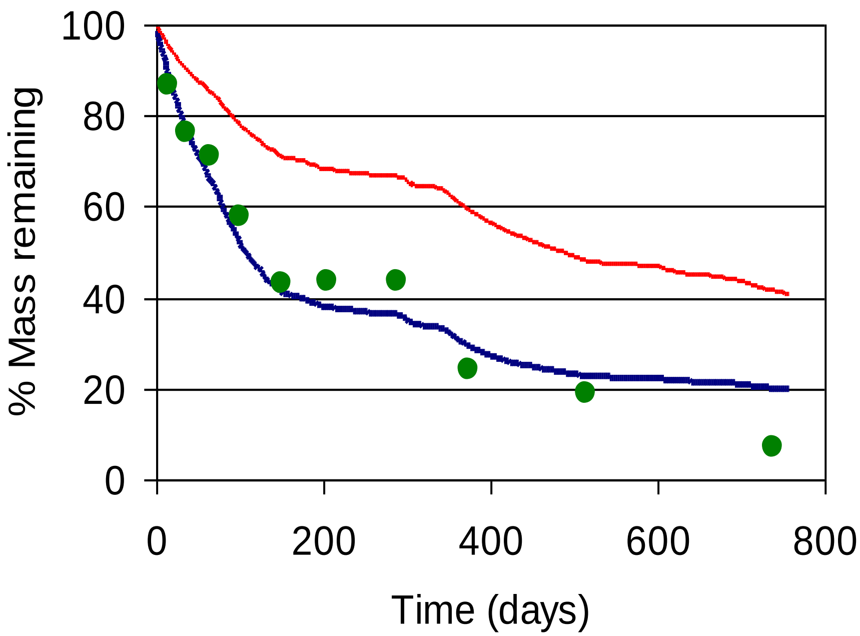


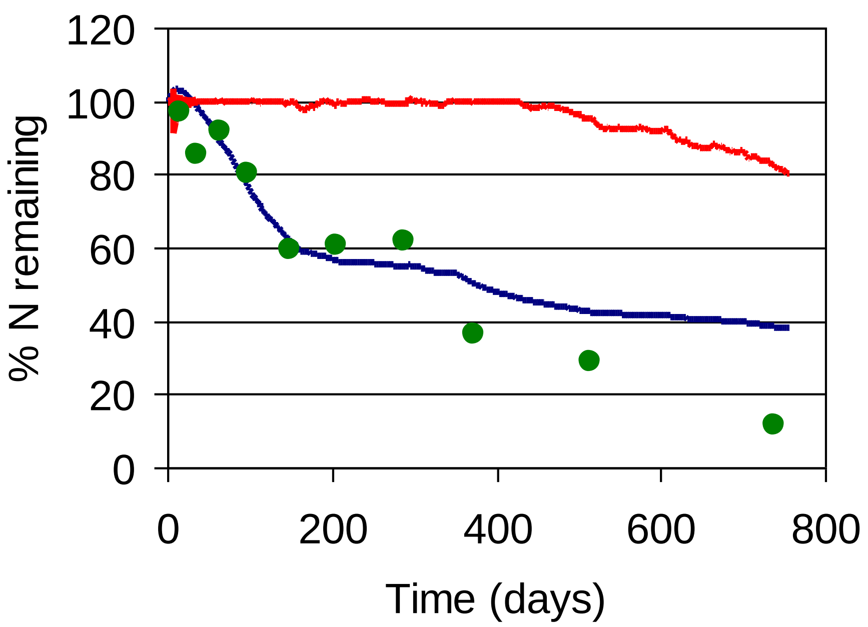
- Mineralization-immobilization turnover hypothesis

C and N weight loss from *E. globulus* leaves

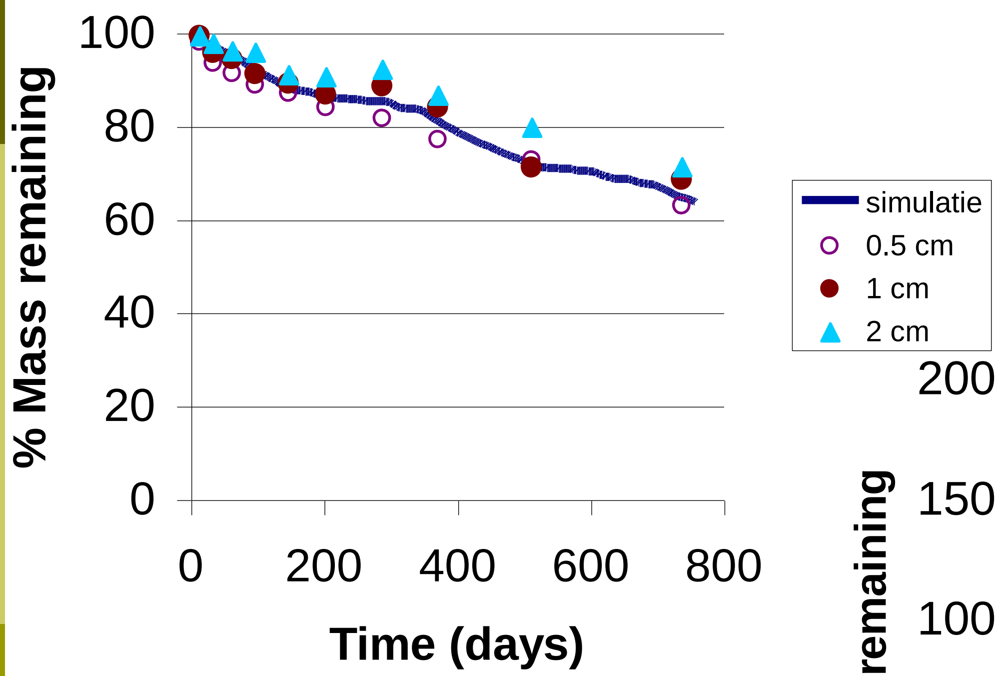
-Litterbag study under field conditions in Western Australia (data from Shammas et al, 2003) - 1500 mm rainfall; 15.2°C, sandy soil

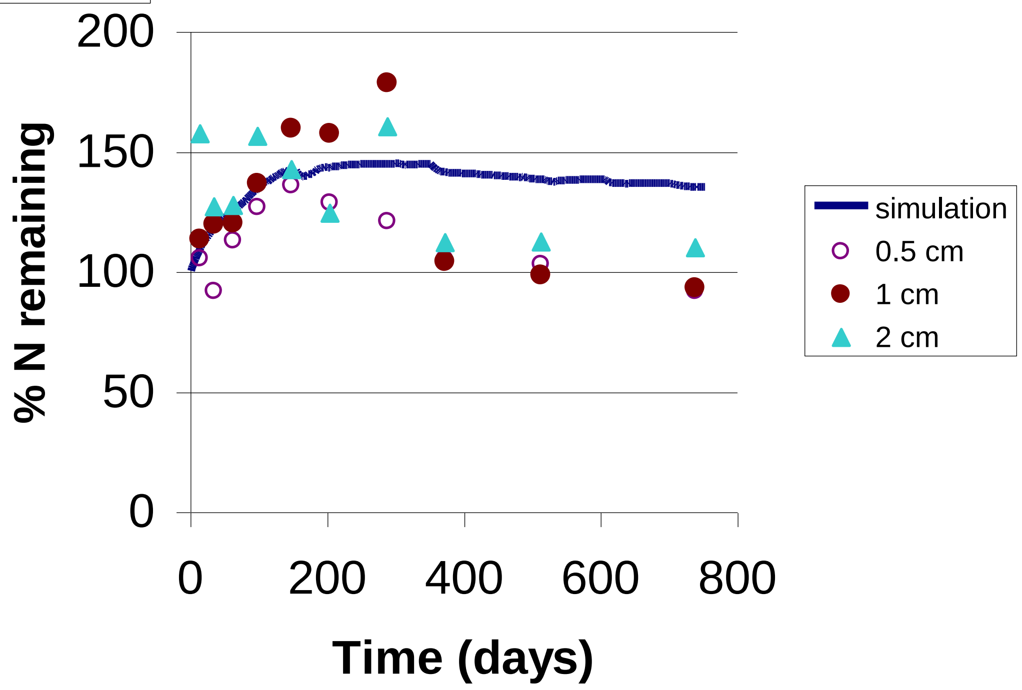
-SoilN&C run with initial biochemical composition of leaves + climate data of site





C and N weight loss from *E. globulus* branches



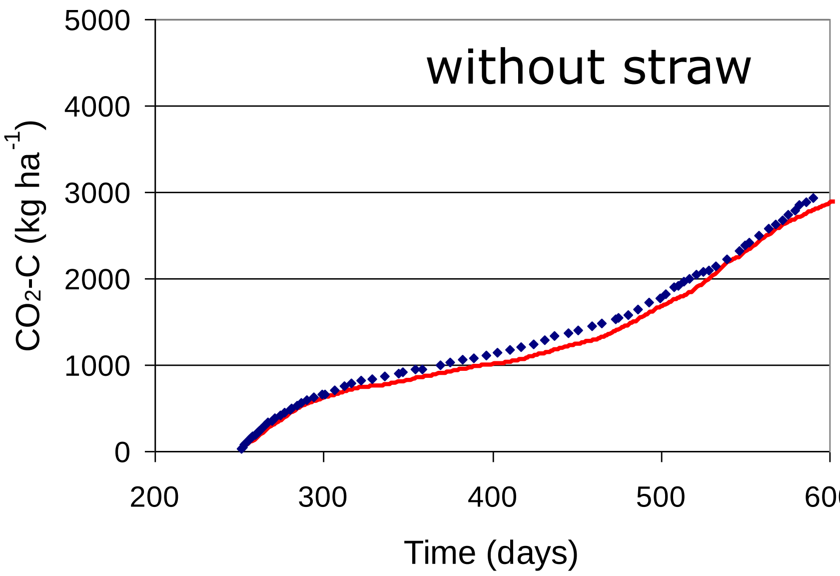


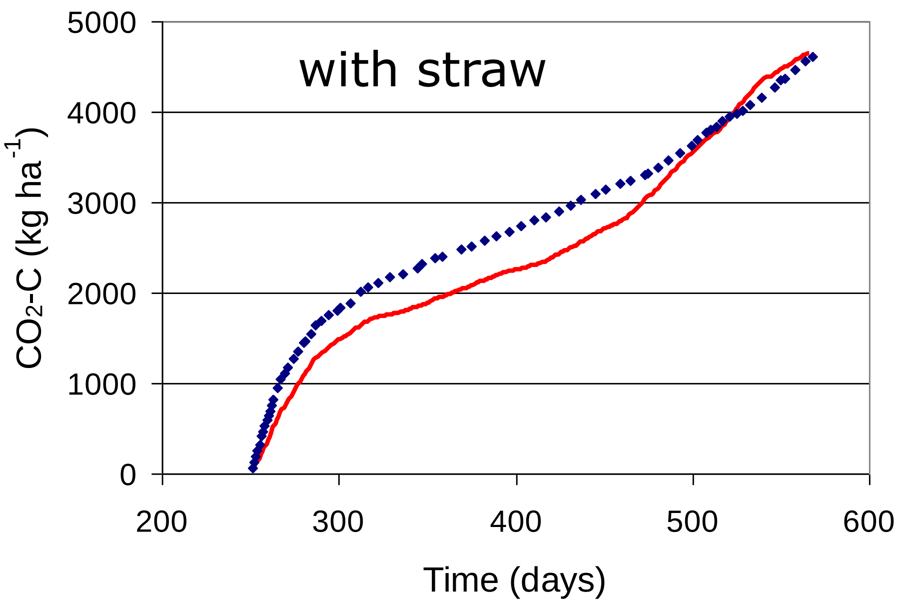
C and N dynamics with and without wheat straw incorporation

-Experiment in Northern France on a deep loam – started in September and ended the next year

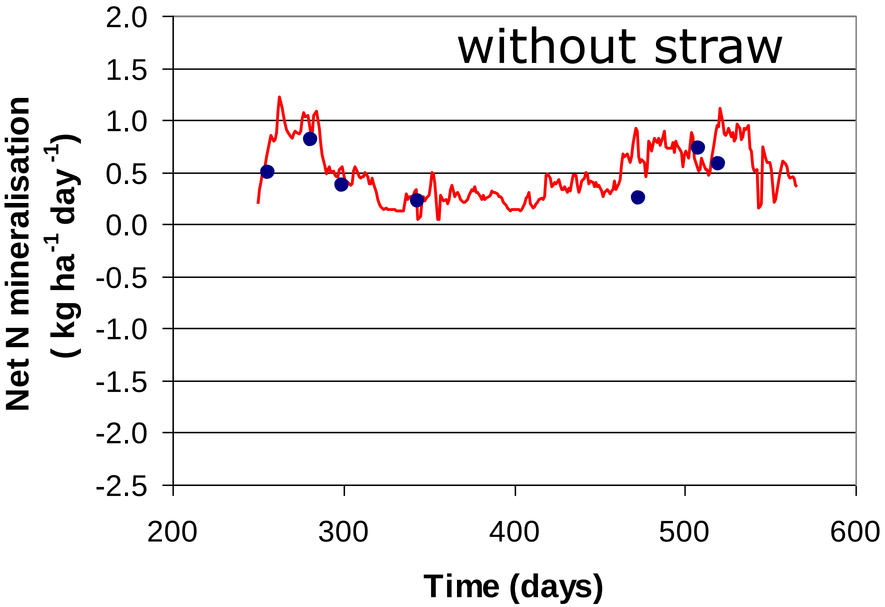
-Without and with 8 ton DM/ha (0-20 cm)

-SoilN&C was calibrated for bare soil and run with initial biochemical composition of wheat straw + climate data of site

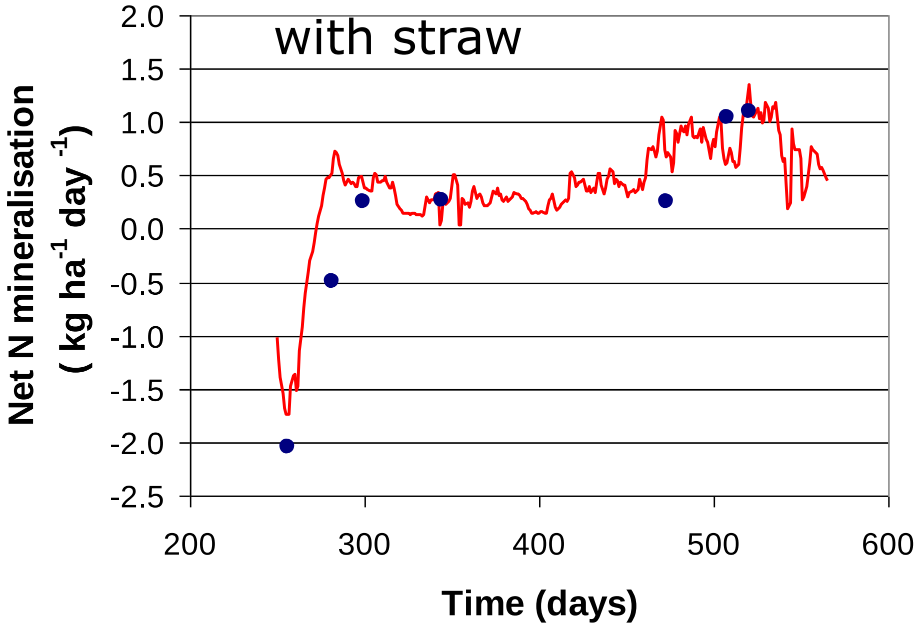




C and N dynamics in a bare soil with and without wheat straw incorporation

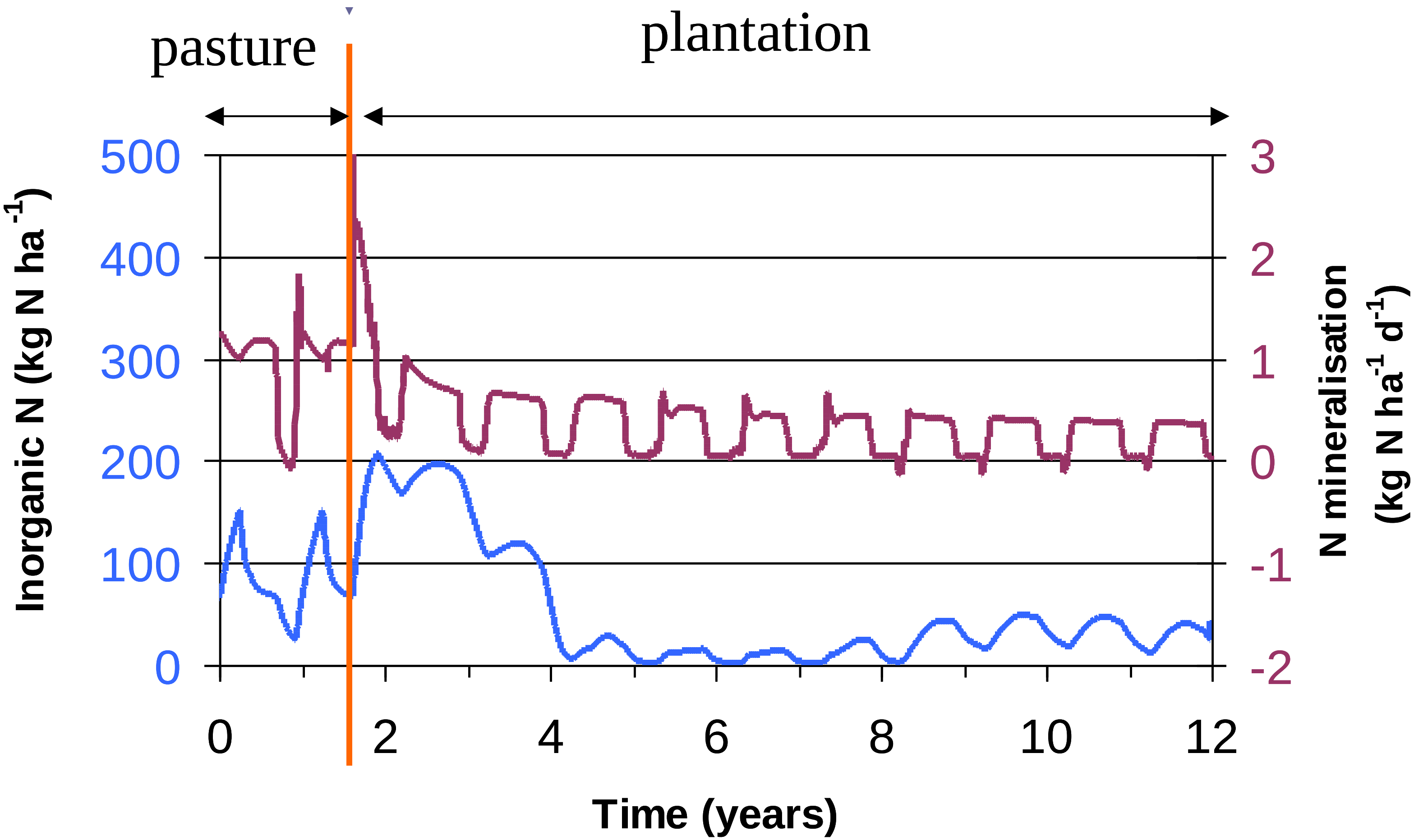


Total N mineralisation (12 months) = 155 kg N/ha



Total N mineralisation = 120 kg N/ha

C and N dynamics with land-use change from pasture to forest plantation – site Molteni, WA



C and N dynamics with land-use change from pasture to forest plantation – site Molteni, WA

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

C and N dynamics with land-use from pasture to forest plantation

Variable	Pasture	Plantation
NPP (Mg C ha^{-1} yr^{-1})	9.6	23.4 (+144 %)
N inputs (kg N ha^{-1} yr^{-1})	125	5.0 (-96 %)
N losses (kg N ha^{-1} yr^{-1})	61	19 (-69 %)
Litter C production (Mg C ha^{-1} yr^{-1})	7.7	7.1 (-8 %)
Litter N production (kg N ha^{-1} yr^{-1})	333	91 (-73 %)
C mineralisation (Mg C ha^{-1} yr^{-1})	7.7	5.7 (-26 %)
N mineralisation (kg N ha^{-1} yr^{-1})	324	97 (-70 %)
Soil C (Mg C ha^{-1})	154	169 (-10 %)
Soil N (Mg N ha^{-1})	9.2	7.6 (-17 %)
Soil C:N	16.8	22.2 (+32 %)

Conclusions

1) SoilC&N is able to simulate short-term (daily) and long-term (several years) rates of decomposition and N mineralization (at field scale) and is relatively simple

2) The level of detail is comparable with the level of detail of a crop growth model such as DSSAT, APSIM,…

3) SoilC&N incorporates a more mechanistic treatment of the role of microbial biomass in the mineralization-immobilization process
   - N limitation feedbacks on C decomposition and on microbial (and SOM) stoichiometry (= important also for global studies!)
   - N:C ratios of SOM pools are simulated output variables (land use change studies!)

Conclusions

4) It can handle a wide range of plant residue types, because it deals explicitly with residue chemistry

5) More testing against new datasets is needed to asses the general predictive ability of this model

6) Need to incorporate soil structural effects (= increased model complexity)? Depends of scale of interest…

Thanks for your attention

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