THE SIGNIFICANCE OF PLANT-SOIL FEEDBACKS FOR DIVERSIFICATION AND ECOSYSTEM SERVICE DELIVERY IN GRASSLAND

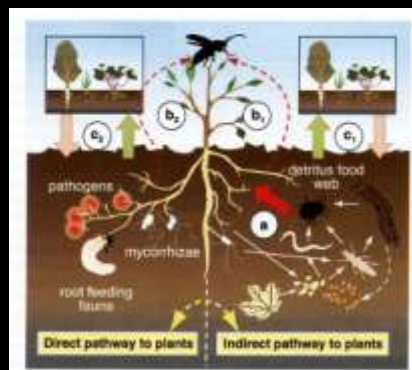
Richard Bardgett







Combined aboveground-belowground approach: functional significance of feedbacks between plant and soil communities



Wardle *et al*. (2004) *Science 304, 1629-1633.*

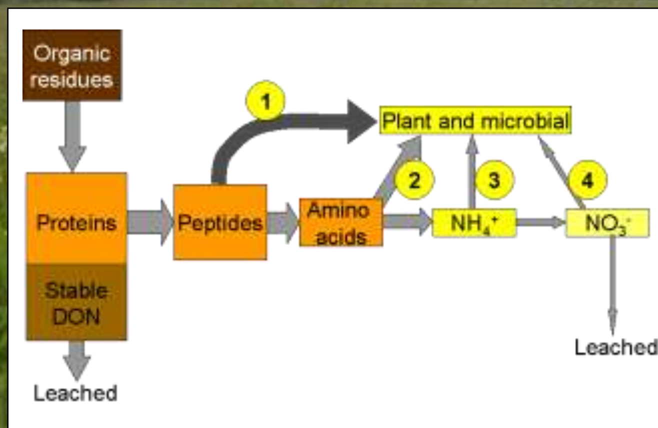
Talk plan

Functional role plant-soil linkages for diversity restoration and delivery of ecosystem services:

(A) Nitrogen cycling – plant-microbial competition for N and mechanisms of efficient N use in species-rich grassland

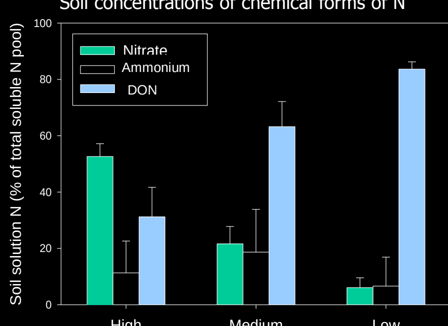
(B) Carbon storage – management of plant-soil relationships for soil carbon storage in grassland

Case 1: Plant-microbial competition for organic N in grassland systems



DON dominates soluble N pool in low input systems

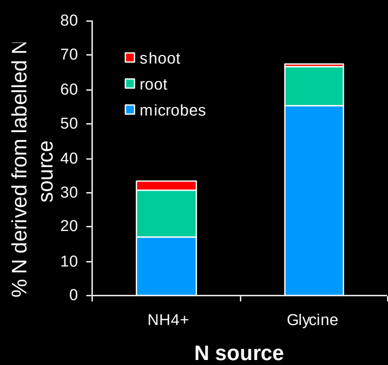
Soil concentrations of chemical forms of N



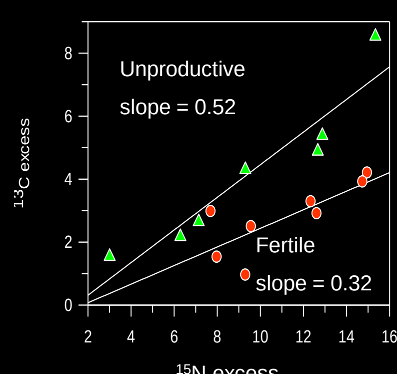
Bardgett et al. 2003 *Ecology*, 84, 1277-1287.

Microbes effective competitors with plants for organic N, especially in low input, species-rich grassland

Short-term ^{15}N addition experiments

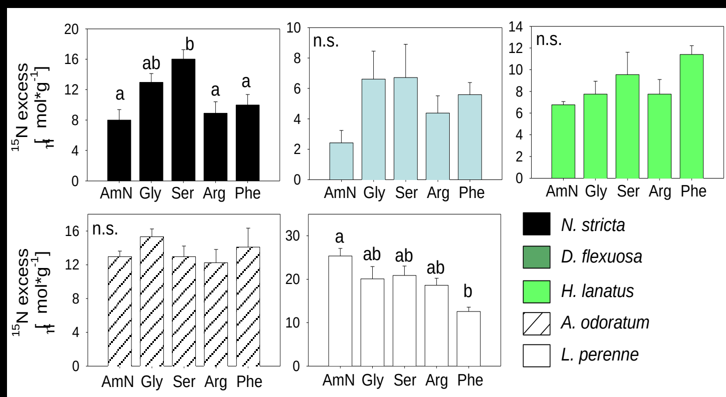


Direct uptake of organic N greatest in low-input, low production grassland



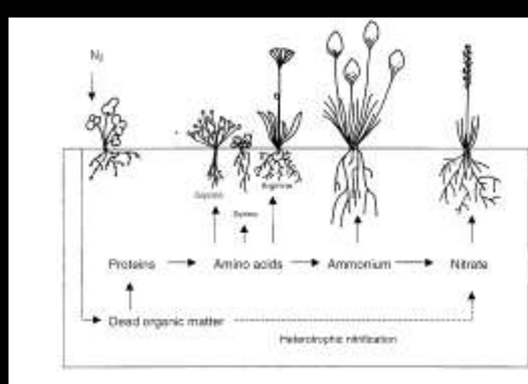
Bardgett et al. 2003 Ecology, 84, 1277-1287.

Evidence of resource partitioning based on chemical form (*fundamental niche*): *Lolium* show preference for inorganic N, whereas slower growers display plasticity for N form or preference for organic N



Weigelt et al. (2005) *Oecologia* 142:627-635

Model for resource partitioning based on chemical form N: mechanism for efficient N use and species co-existence



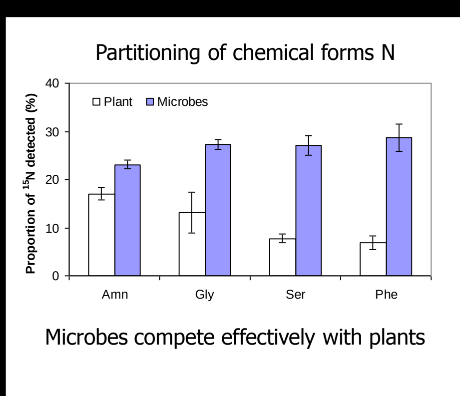
Bardgett (2005) The Biology of Soil, Oxford.

Preferential use of different N forms by microbes and coexisting plant species of grassland – *in situ* labelling

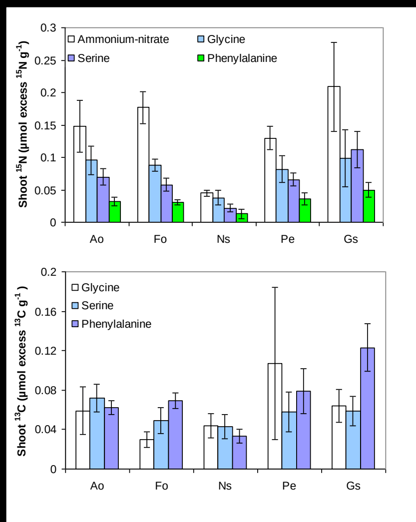
Plant species	Label
Anthoxanthum odoratum	^{15}N ammonium nitrate
Festuca ovina	$^{15}N^{13}C$ glycine
Galium saxatile	$^{15}N^{13}C$ serine
Nardus stricta	$^{15}N^{13}C$ phenylalalanine
Potentilla erecta	Control

Harrison et al. (2007), Ecology, 88, 989-999

Microbes compete effectively with plants for added N



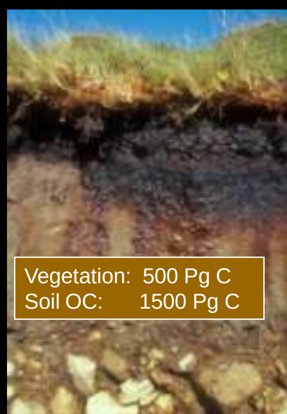
Co-existing species highly versatile in uptake chemical forms N, but show consistent preference for inorganic over organic N, and simple over complex amino acids

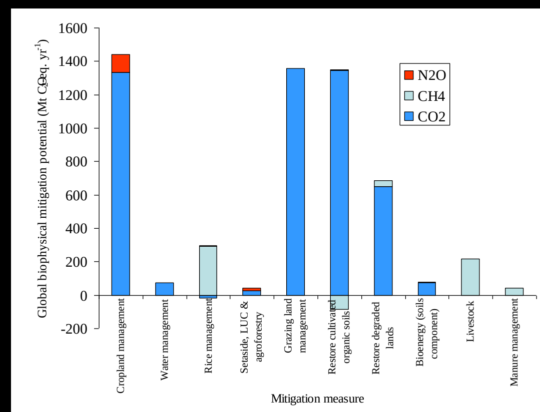


Conclusions

1. Plants highly versatile in terms of their ability to compete with microbes for a range of N forms – rethink ideas on soil nutrient cycling
2. Potential mechanisms for efficient exploitation soil N (and P) pool in low intensity, species-rich grassland
3. Potential mechanisms of diversification in grassland – complexity N forms contribute to diversity restoration

Case 2: New challenges for grassland agriculture: climate change mitigation via soil carbon sequestration





Smith et al. (2008)

National survey DIGFOR: effects of long-term grassland management on plant diversity, soil microbes, and soil carbon

Newcastle University

Yorkshire Dales
Yorkshire Ings
North-West Limestone
Lake District

12 Regions (60 sites with 3 intensity levels = 180 grasslands)

Traditionally managed - semi-improved - improved

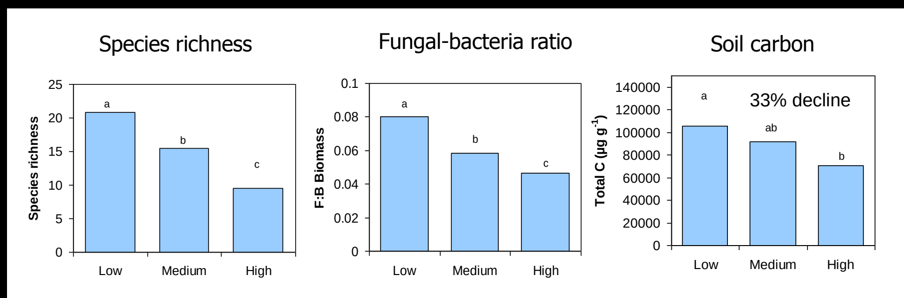
CAER

Cotswolds
High Weald
South Downs
Breckland

IGER

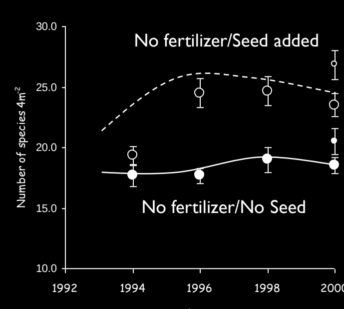
Worcestershire
Upper Thames
Somerset
Devon

180 grassland sites - long-term intensive management reduce plant diversity, fungal dominance and soil carbon storage



Potential manage grassland biodiversity for soil C sequestration

Colt Park experiment: Does grassland biodiversity restoration enhance C-storage: win-win strategy?

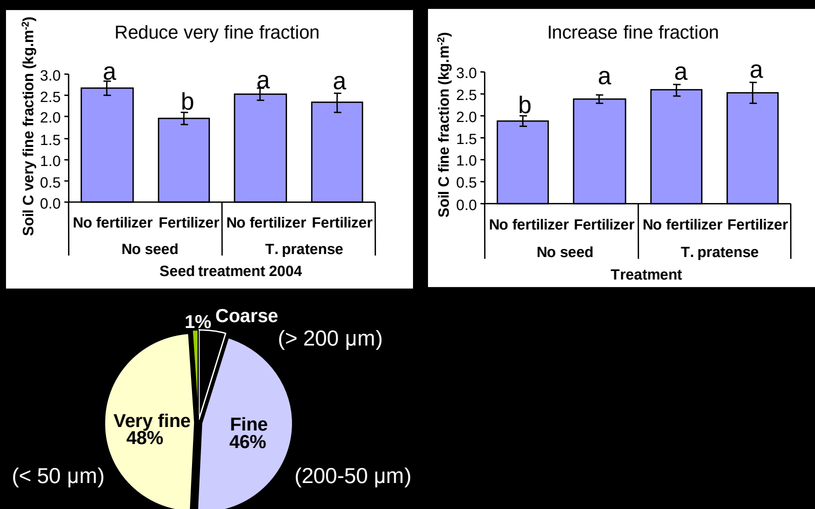


18 yr factorial experiment: management treatments on improved grassland to restore plant diversity – cessation of fertilizer and seed addition (1990), nested treatment *Trifolium pratense* (2004)

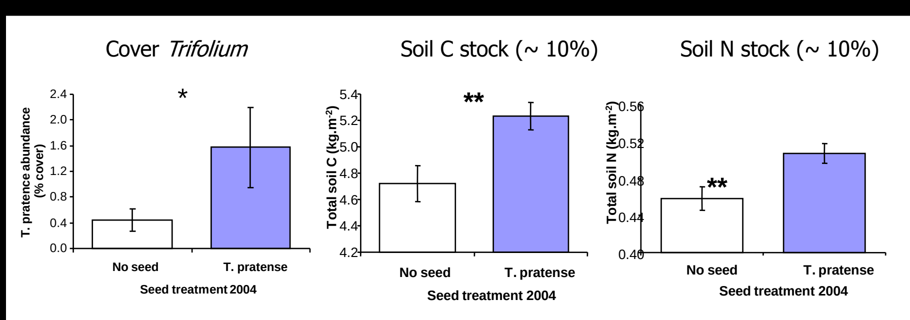
Smith *et al* (2003, 2008) *Journal of Applied Ecology*

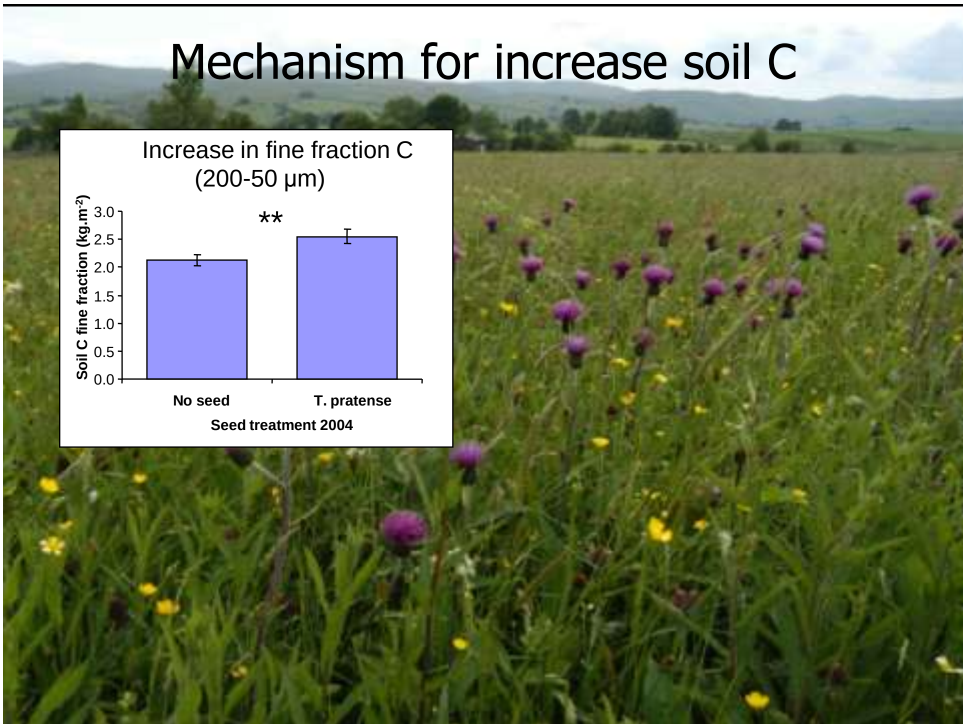
Treatments that enhance plant diversity and alter microbial community composition (i.e. cessation of fertilizer/seed addition) had no effect on total soil C

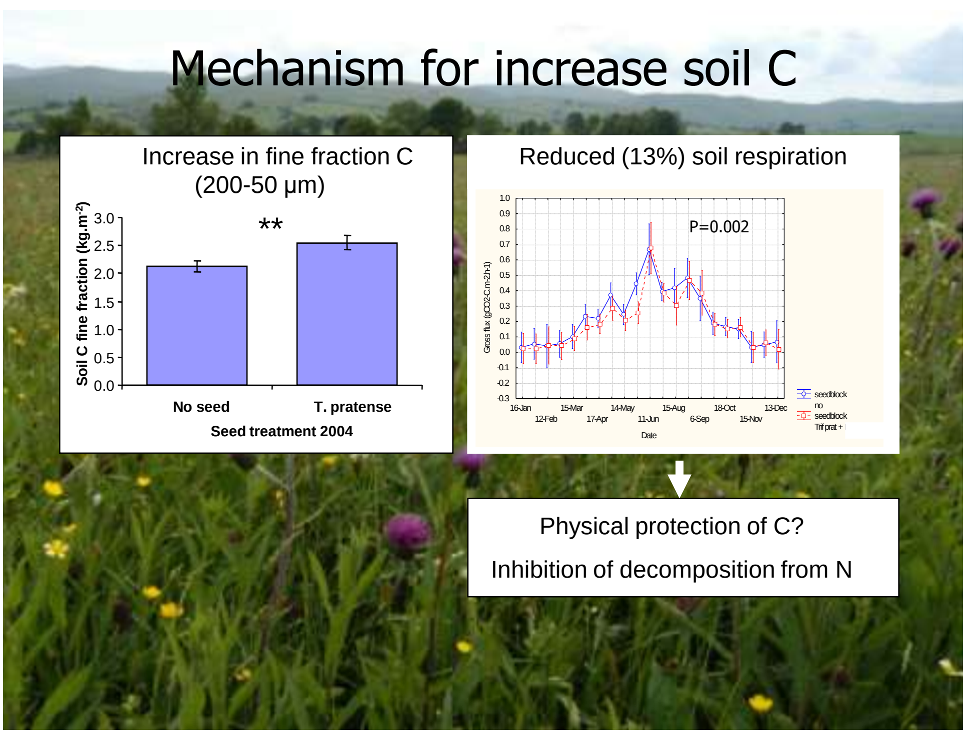
Fertilizer affect distribution C



Total soil carbon storage: unexpected benefits of legumes




Mechanism for increase soil C
Increase in fine fraction C
(200-50 µm)
Soil C fine fraction (kg.m-2)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
**
No seed
T. pratense
Seed treatment 2004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3.0
2.5
2.0
1.5
1.0
0.5
0.0
**
No seed
T. pratense
Seed treatment 2004
Reduced (13%) soil respiration
P=0.002
Gross flux (gCO2-C.m-2.h-1)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
16-Jan
12-Feb
15-Mar
17-Apr
14-May
11-Jun
15-Aug
6-Sep
18-Oct
15-Nov
13-Dec
Date
seedblock
no seedblock
Trif prat +
Physical protection of C?
Inhibition of decomposition from N

Conclusions -

1. Plant-soil-microbial interactions play key role in functioning agricultural ecosystems
2. Potential to exploit in agricultural systems for maximisation of N use, diversity restoration and carbon sequestration
3. Need for combined aboveground-belowground approach to enhance understanding of functioning managed and natural ecosystems.

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