

Coolringdon study: Background and Initial Results

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Background - Interseeding Legume

Study undertook in 2001 - 2004

Interseeding lucerne (alfalfa) in native rangeland (northern South Dakota)

- 380 mm precipitation
- 750-870 m elevation
- 1965 (36 yrs)
- 1987 (14 yrs)
- 1998 (3 yrs)

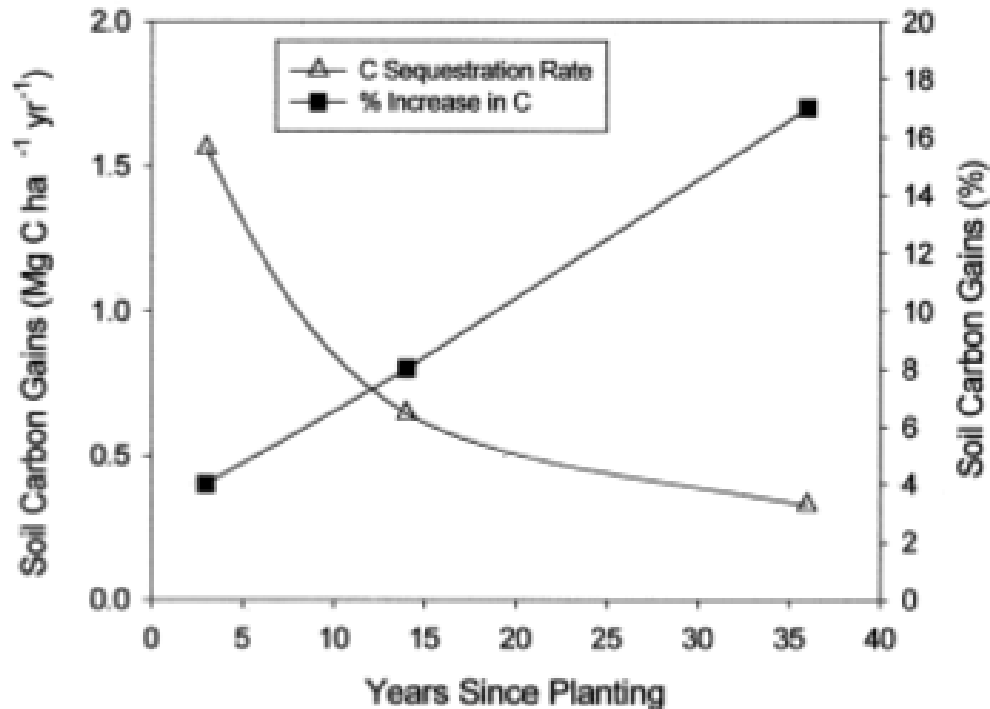


Vegetation Production

Yr planted	Trtmt	Lucerne	CS grasses	WS grasses (t/ha)	Other	Total
1965	Native	-	0.86	0.11	0.80	1.77
36 yrs	Interseeded	1.49	0.40	0.10	0.98	2.97
1987	Native	-	0.30	0.17	0.66	1.13
14 yrs	Interseeded	1.94	0.19	0.02	0.59	2.74
1998	Native	-	0.48	0.01	1.15	1.64
3 yrs	Interseeded	0.80	0.41	0.01	1.10	2.32

- Forage quality was greatly improved - lucerne + other species

Lucerne (alfalfa) in Nth American rangeland systems



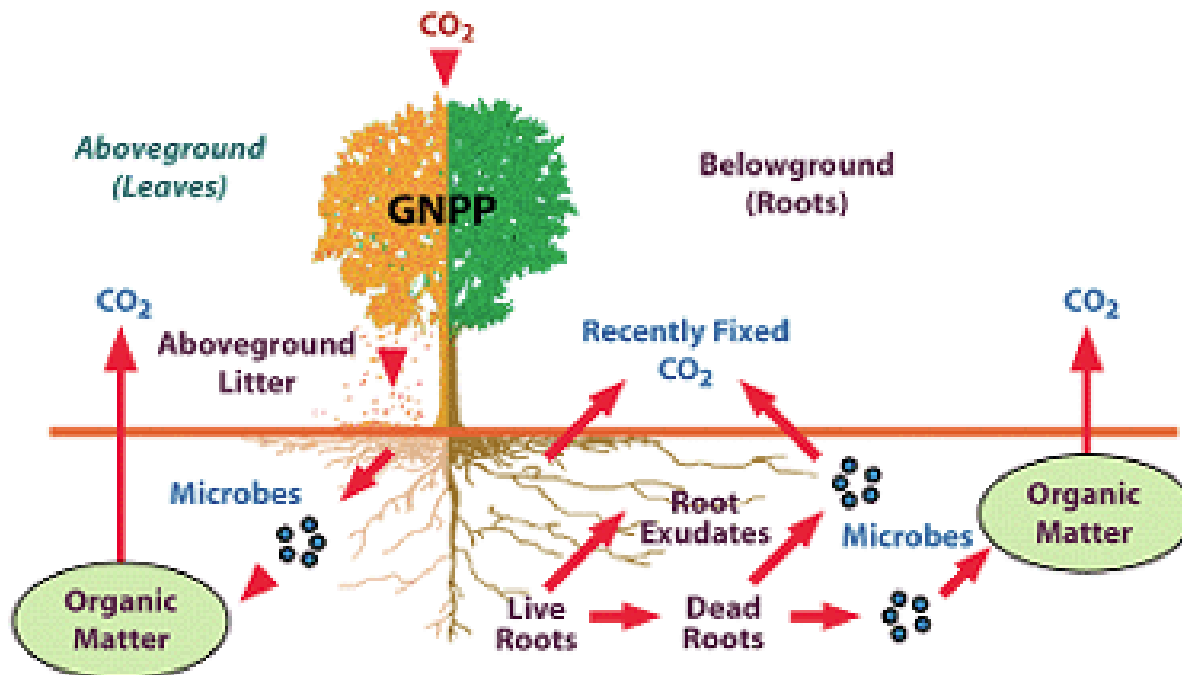
	Total N (t/ha) (0-30 cm)		
	1998	1987	1965
Native	4.26 b	4.66 b	3.19 b
Lucerne	5.57 a	5.60 a	4.10 a

Soil properties in prairies interseeded with lucerne

Site	Treatment	SOC	TN	GSM	WFPS	N _i μg soil ⁻¹
		g m ⁻² (0-10 cm)		(%)		
1965	Native	3,500	257 b	8.4 b	20 b	4.2
	Legume	3,657	353 a	11.3 a	25 a	4.1
1987	Native	3,352	269	7.8 b	16 b	1.6 b
	Legume	3,427	300	9.5 ab	19 a	5.2 a
1998	Native	3,475	309	9.0	18	1.6
	Legume	3,683	311	8.7	18	3.3

Coolringdon Study - Background

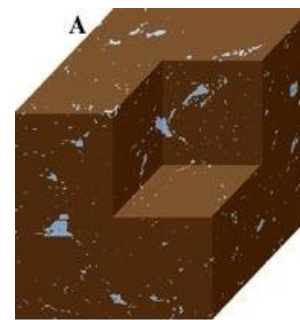
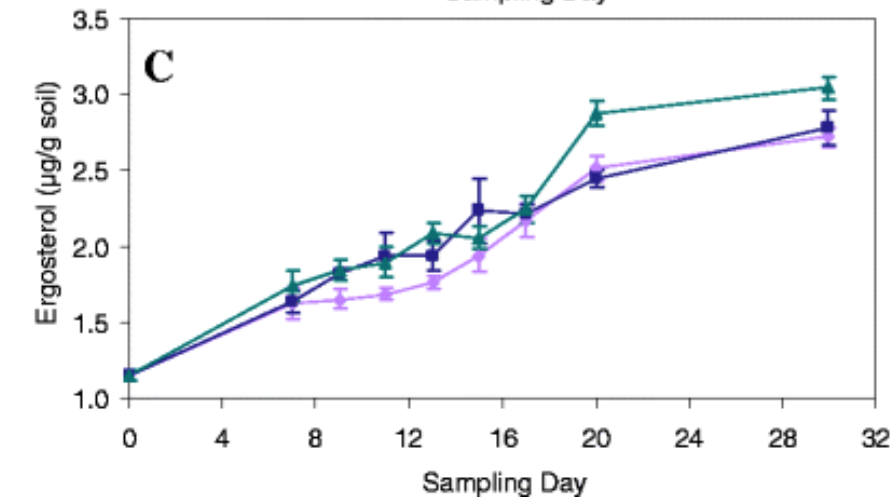
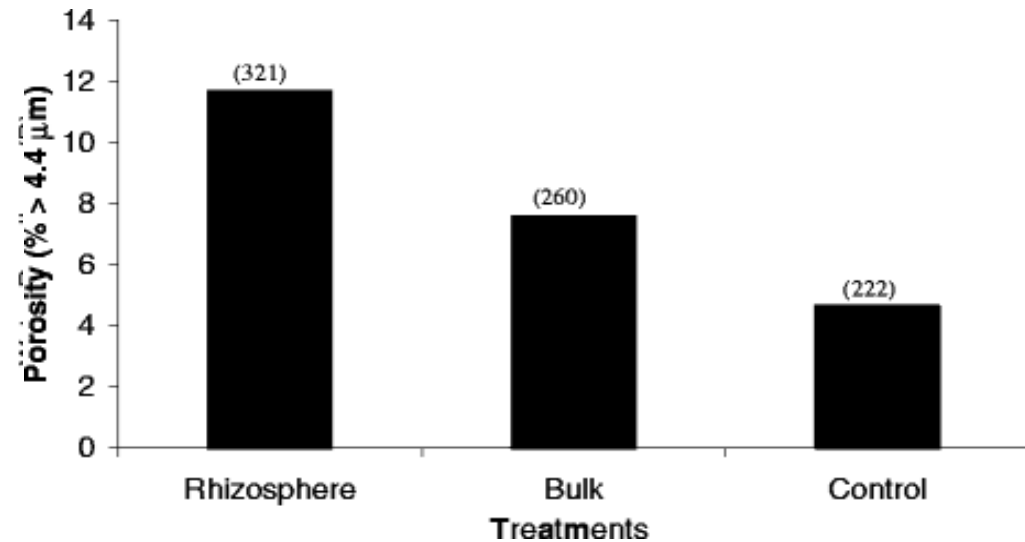
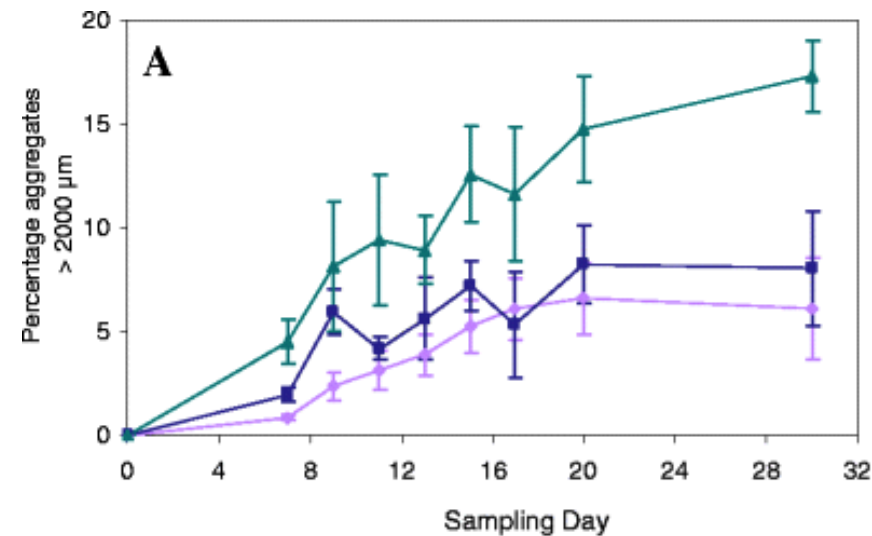
1. Legumes increase soil N via N_2 fixation
2. Increase vegetation production
3. Increase soil C via root turnover
4. Modify microbial community
5. Modify soil water properties of the soil



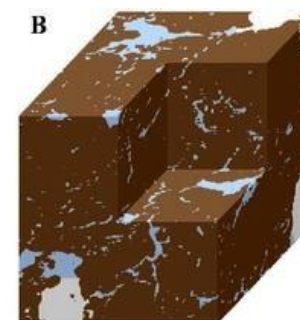
Root death and decomposition are where SOM get it's C from

- As we change plant environment we change the soil environment & thus potentially the microbes present within the environment
- Microbes physically modify their soil environment

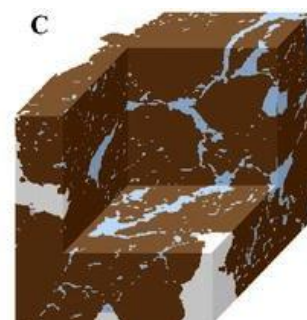
Microbes impacts on soils



Control



Bulk



Rhizosphere

Porosity, water & plants

Pore class	Diameter (mm)	Characteristics/function
Macropore	0.08 - 5	Water drains by gravity, transmits air, large enough to accommodate plant roots and certain soil animals
Micropore - mesopores	0.03 - 0.08	Retain water after drainage, transmit water by capillary action, accommodate fungi and root hairs
Micropore - micropores	0.005 - 0.03	Retains water plants can use, accommodate most bacteria
Micropore - ultramicropores	0.0001 - 0.005	Retains water that plants can't use, excludes most organisms
Micropore - Cryptospores	<0.0001	Excludes all organisms, too small for large molecule to enter

2.5 x increase in micropores in the previous study

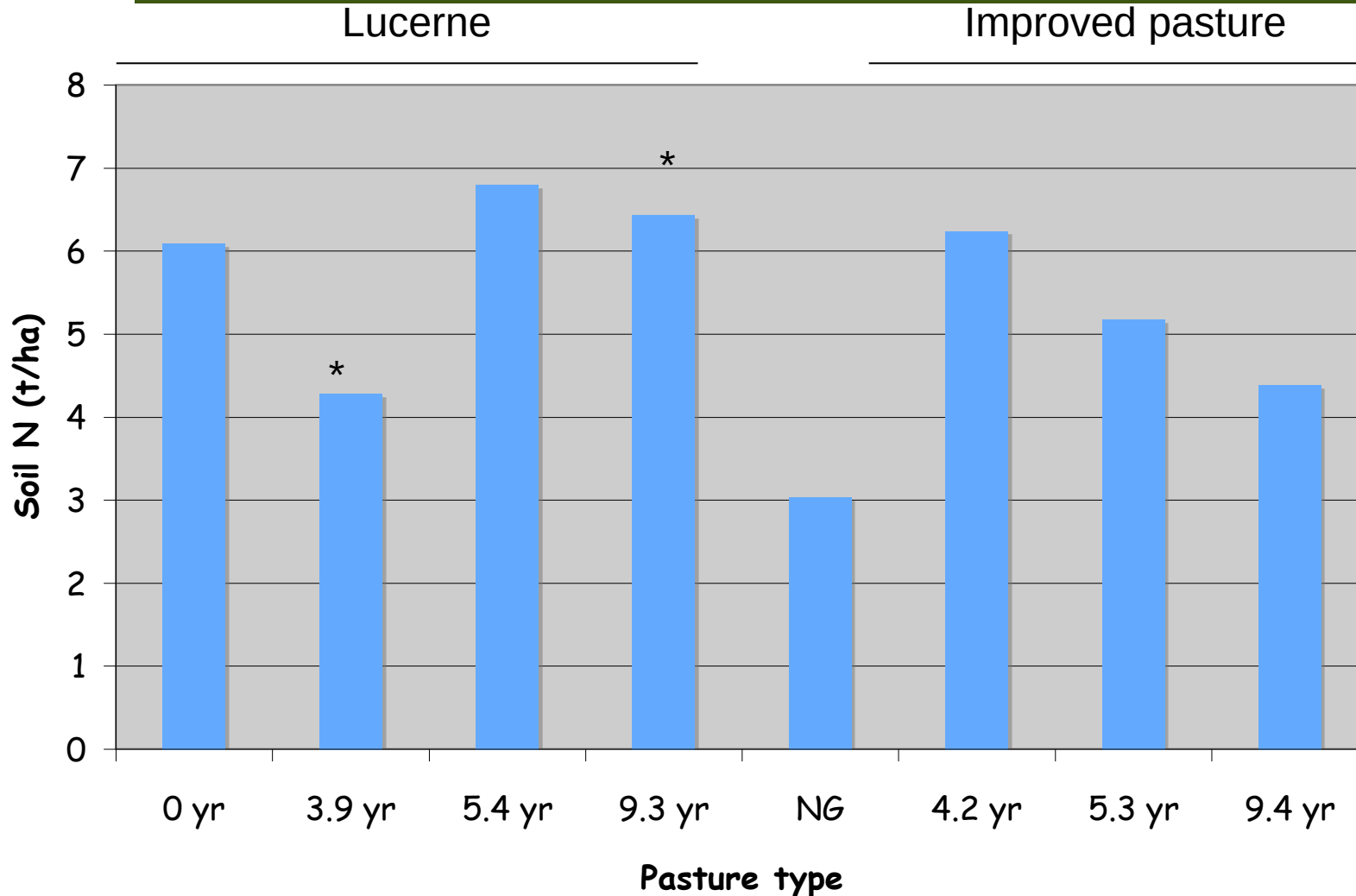


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Previous study

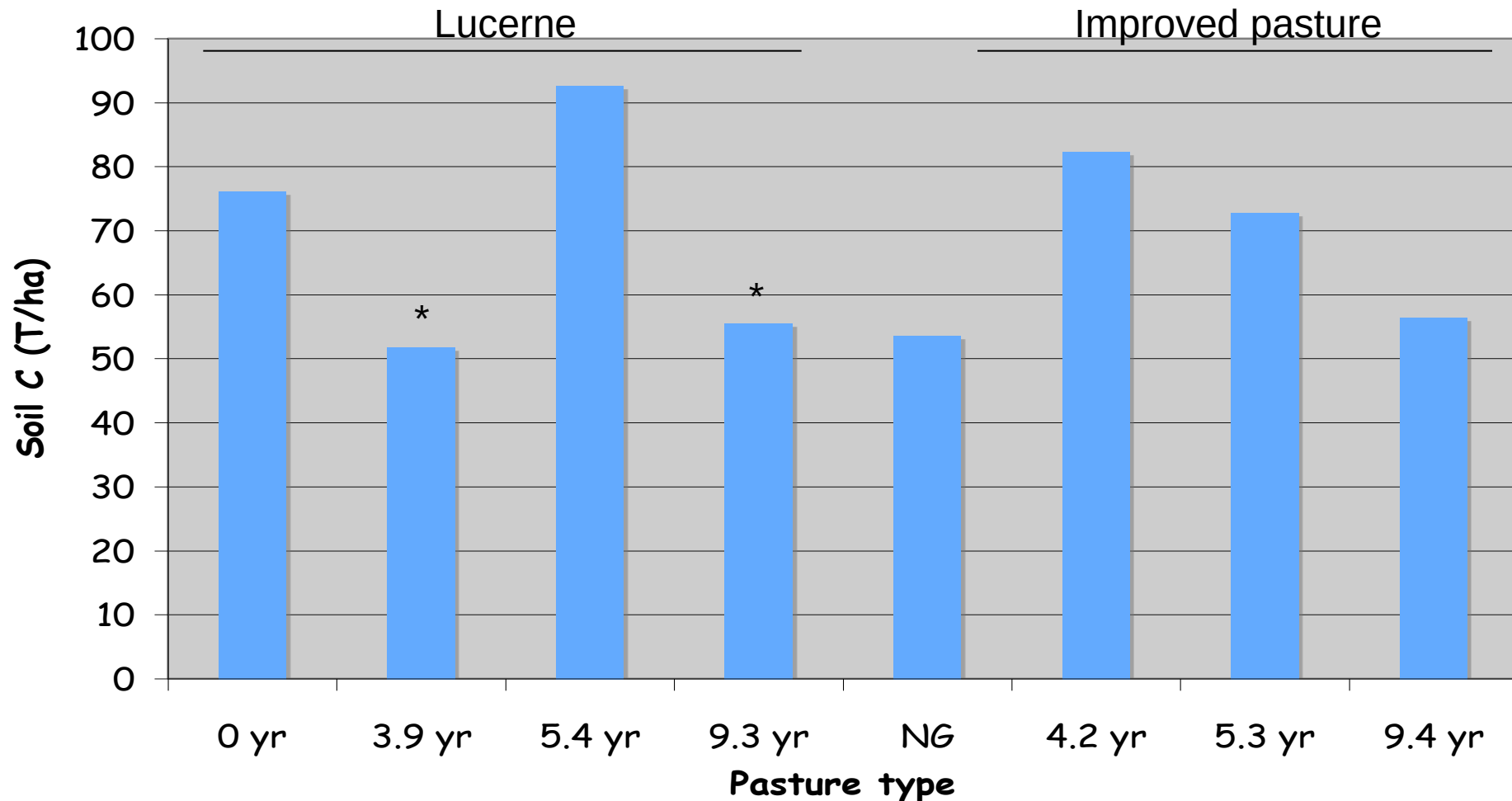
- Master student undertook an initial study in 2010
- Compare two chronosequences (legume monoculture, improved pasture) of comparable ages ~ 4, 5 $\frac{1}{2}$, 9 $\frac{1}{2}$ yrs + native + 0 time since planting
 - Carbon, nitrogen
 - Infiltration
 - Vegetation production
 - Lucerne
 - 4 yrs - 1,427 kg ha⁻¹
 - 5 $\frac{1}{2}$ yrs - 3,175 kg ha⁻¹
 - 9 $\frac{1}{2}$ - 1,536 kg ha⁻¹

Soil N & pasture type



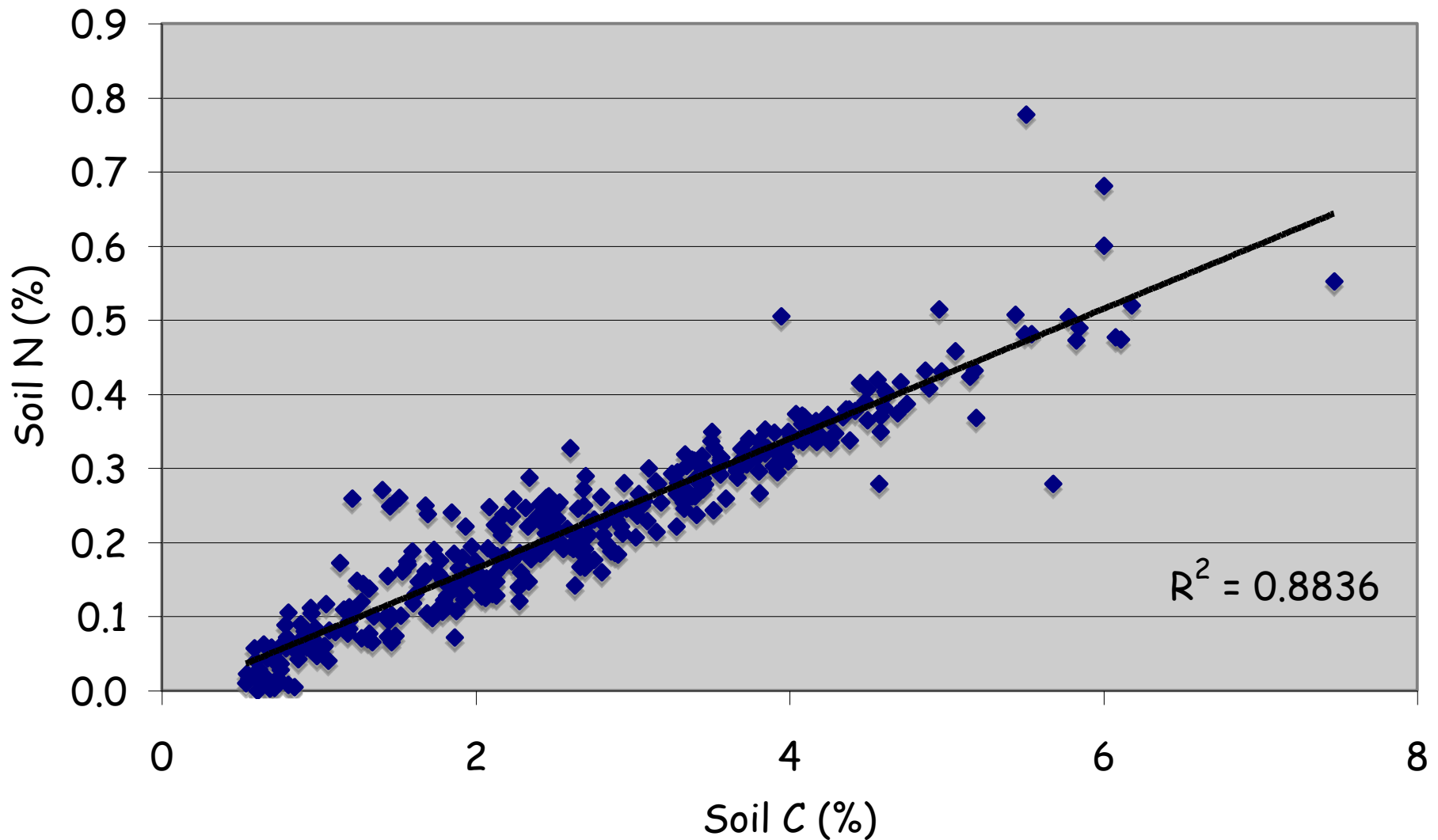
(↑ N during a drought period)

Soil C & pasture type



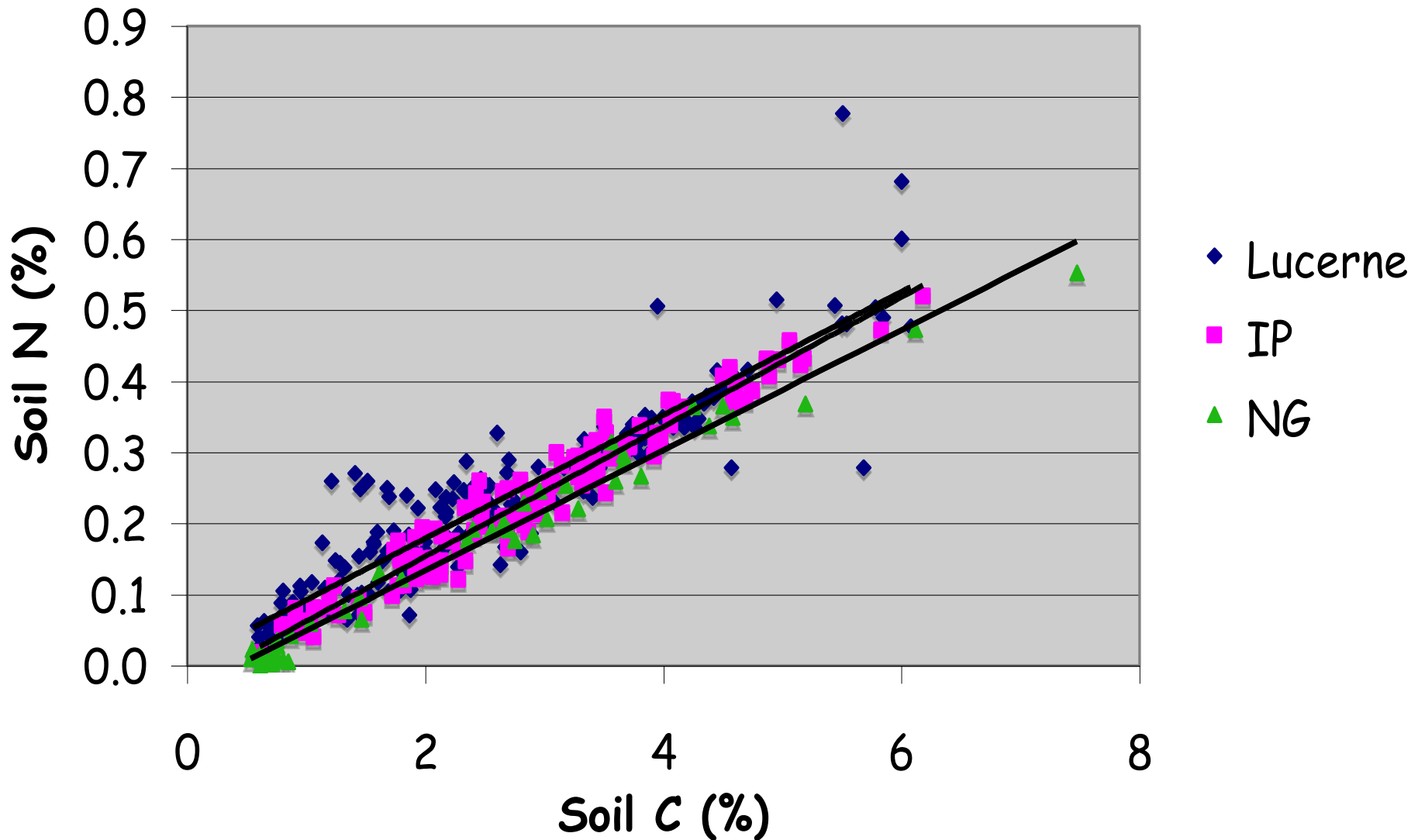


Soil organic C vs N



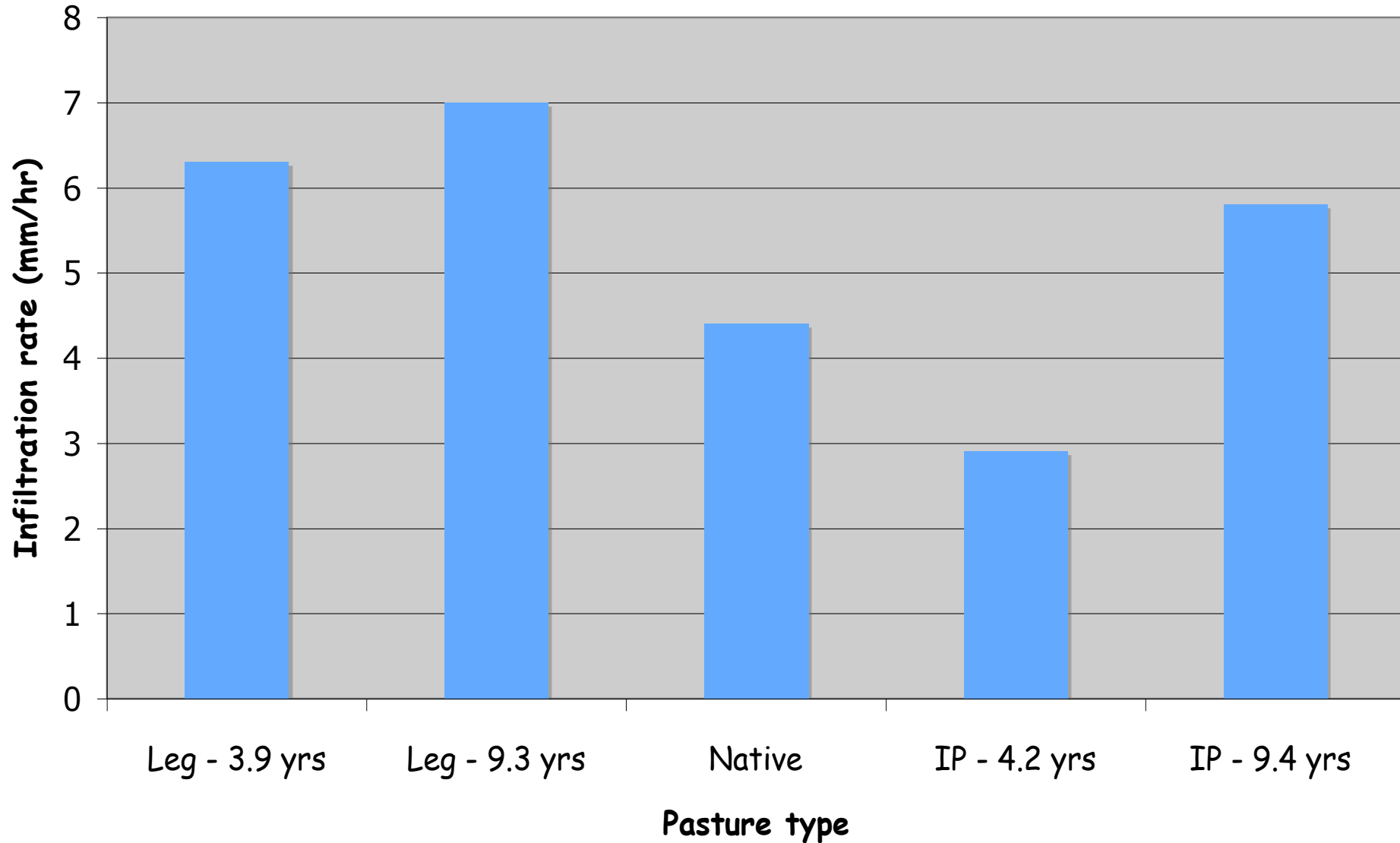


Soil organic C vs N



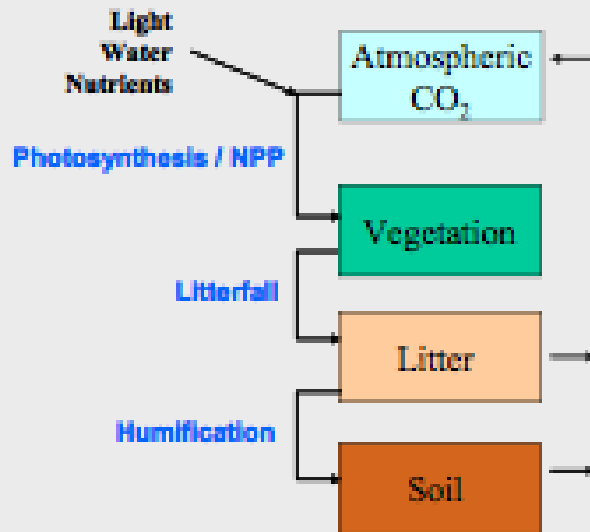


Infiltration rate



Current Study- where are we coming from?

Methods for studying the terrestrial C cycle



- The C cycle is made up of pools (boxes) and fluxes (arrows)
- Pools are relatively easy to measure (tC/ha)
- Fluxes are much more difficult (tC/ha/yr)

Determine the extent that C inputs (exudates, root turnover) from two different plant communities (grassland, legume) drive SOC/SOM stability.

- Pools of C
 - C in the soil (SOC/SOM)
 - C in plants (aboveground, belowground)
- Fluxes of C
 - Photosynthesis
 - Exudates from the rhizosphere
 - Root turnover
- Fluxes of N (linked to C)
 - Availability of N for plant uptake - field



Rhizosphere

- Is the zone of soil significantly influence by living roots (~ 2mm)
- Is greatly different from bulk soil
- Exudation of sugars, organic acids, amino acids
- Mucigel
- Plants exude significant amounts of C: 5 - 40%
- Microbial numbers 2-10x greater in the rhizosphere





Objective 2

Ascertain how C inputs and changes in SOC/SOM stability modify microbial community structure.

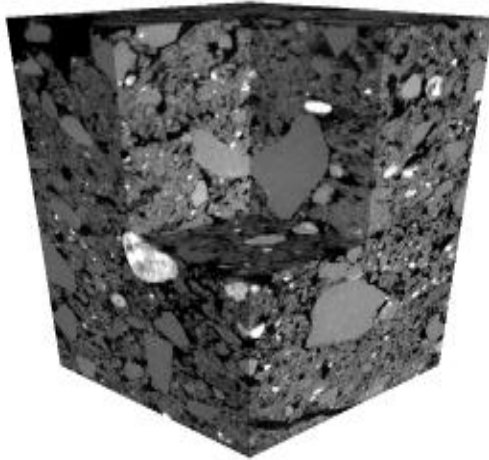
- Measure the stability of soil C
 - Incubations - Lab
 - Soil respiration - Field
- Microbial communities
 - Molecular methods (DNA)
 - Broad groupings (fungi, mycorrhizal fungi, different bacterial groupings)

Determine the role of microbial communities in transforming soil physical structure and improving its water holding capacity.

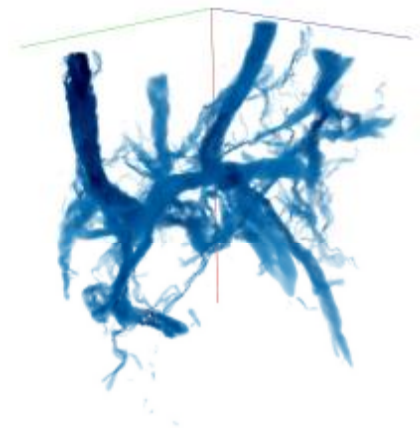
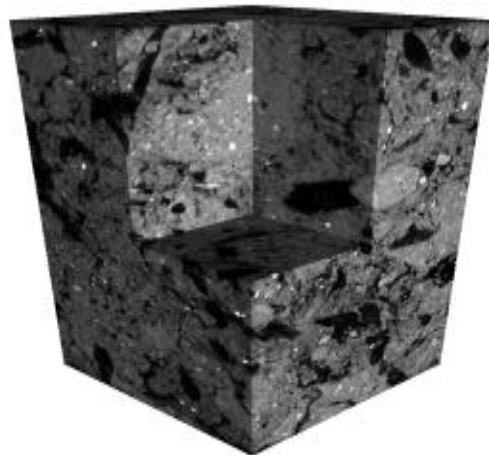
- Field estimates of water infiltration
- Soil Moisture release curves - Lab estimate Picture
- Plant water status
 - how water stressed are plants? Picture
 - How efficiently do they use water - stable isotopes
- Determine porosity in these soils
 - CT scans
 - Modelling
- Lab study to determine to what extent do different microbial communities impact on soil porosity - microbial characterisation / CT scan



“Cool” (read Nerdy) Science



IP - 9.4 yrs
22,720 kg C ha⁻¹



IP - 4.2 yrs
18,556 kg C ha⁻¹



Results - preliminary

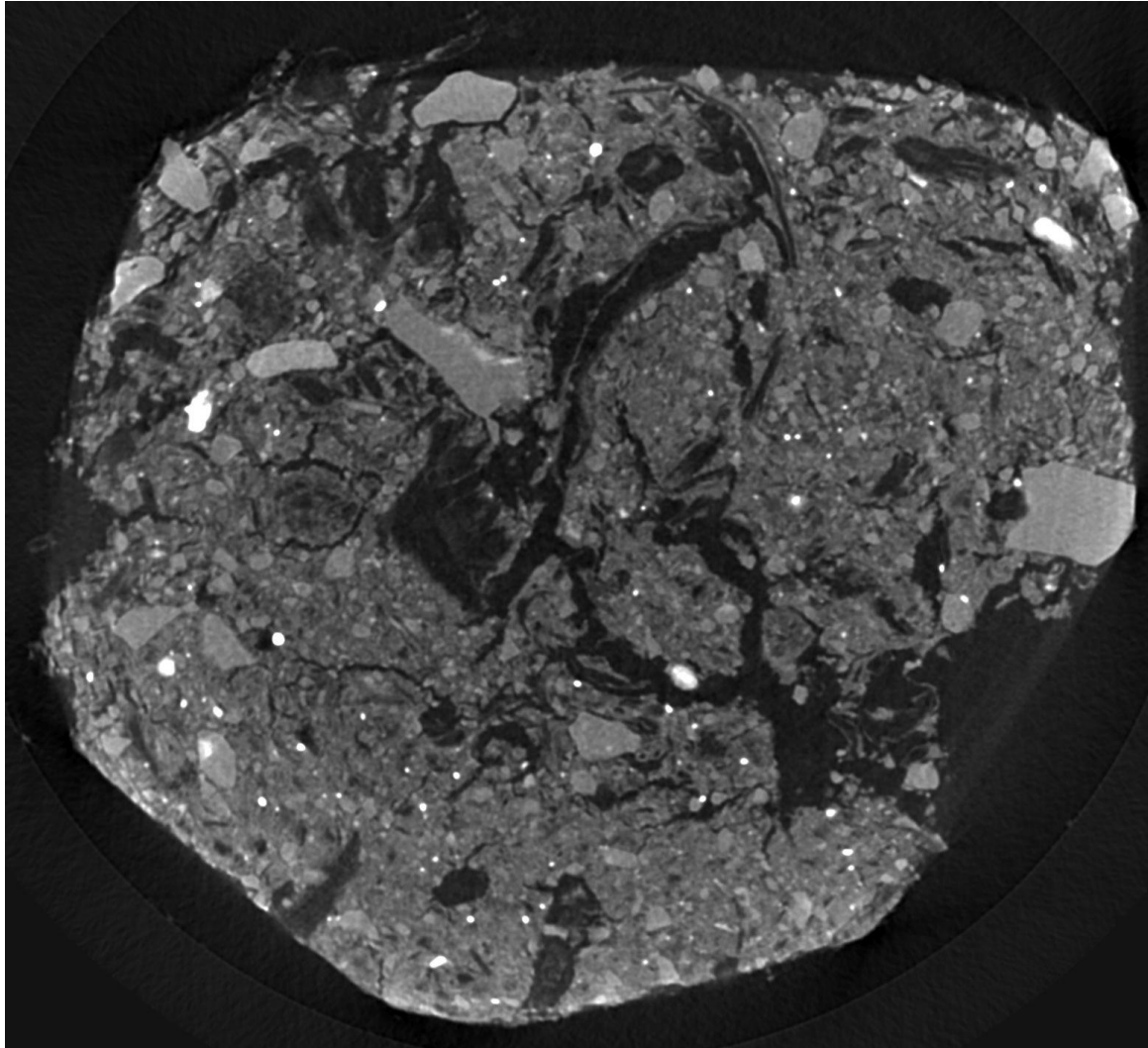
Vegetation Dec 2012

Paddock	Trtmt - Age	Green Lucerne (t/ha)	Green Other (t/ha)	Total Green (t/ha)	Dead Lucerne (t/ha)	Dead Other (t/ha)	Total Dead (t/ha)
Meadows	L-7	1.31	0.79	2.10	0.55	1.53	2.07
Top Meadows	IP-7	0.53	0.00	0.53	0.22	1.21	1.33
No. 2	L-10	0.86	0.06	0.92	0.08	0.42	0.50
Craigs	IP-10	0.02	0.00	0.02	0.01	2.25	2.26
7 mile	L-12	0.99	0.08	1.07	0.25	0.16	0.41
No.1	IP-12	0.00	0.00	0.00	0.42	2.34	2.76

- Not true biomass - been grazed



Aggregates in space



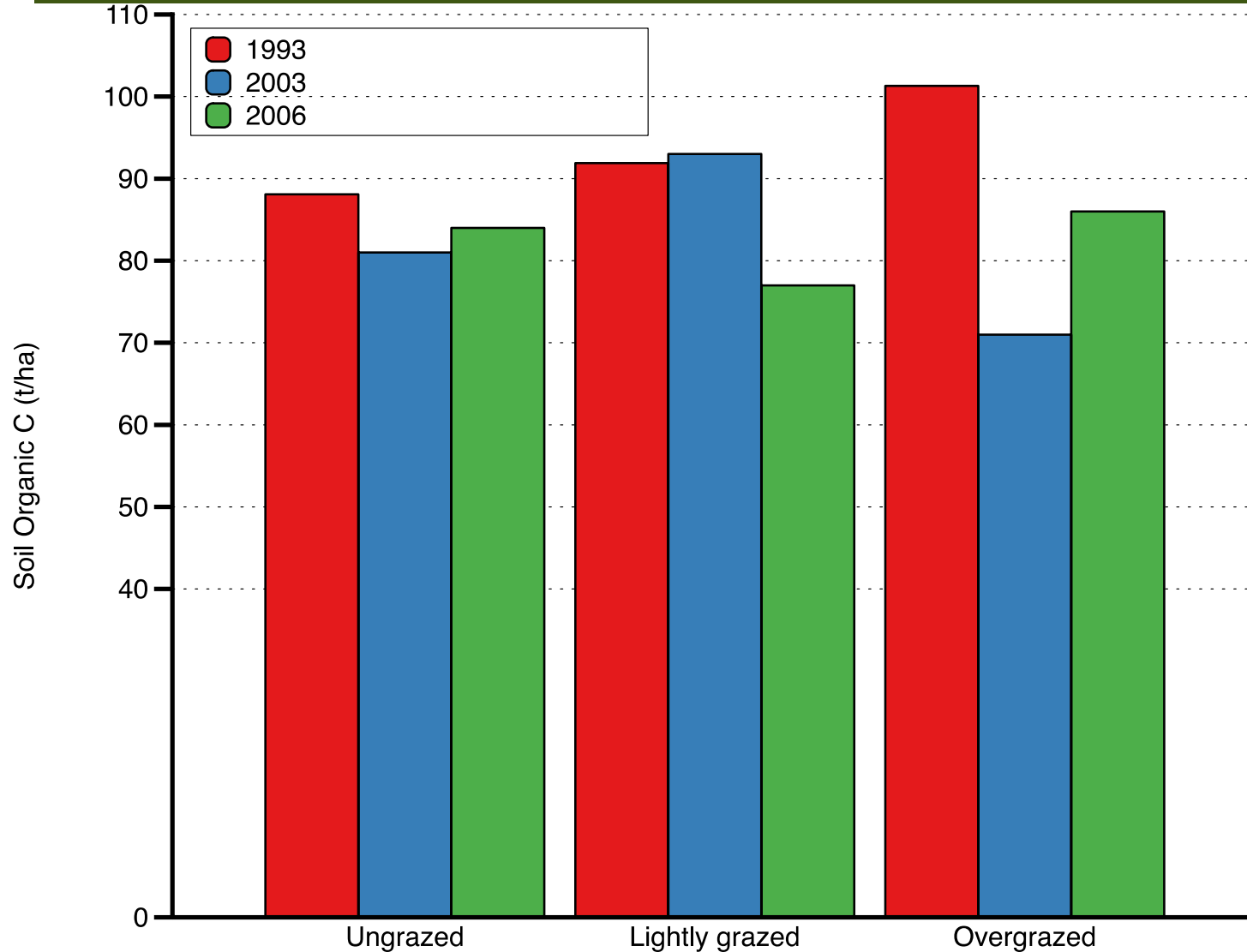
Texture: clay ranges
from 17-30% (17-22%)







Grazing, climate and Soil C







Acknowledgements

"Coolringdon"
James Litchfield
Malcolm Pearce

Luke Spencer
Tim Burykin