The indirect effects of atmospheric N deposition on C storage in grasslands: a mesocosm experiment

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NERC SCIENCE OF THE ENVIRONMENT

What are the indirect effects of N on C storage?

- Effects on C brought about by N-induced plant community change.

Mesocosm Research Questions

- Do plant communities associated with either high or low N deposition environments have different effects on C storage when exposed to N?
- When exposed to N, does lower functional group evenness (i.e. dominance by grass species) have an effect on the severity of any changes to C storage?
- Does mixing ‘high N’ species with ‘low N’ species (increasing richness) mitigate any changes to C storage caused when N is added to these groups separately?

- Do any plant species display larger effects on C storage than other species when exposed to N fertilisation?

Selection of species

Functional Group	Associated with HIGH N	Associated with LOW N
Grass	*Agrostis capillaris**	*Agrostis capillaris**
	Festuca ovina	*Anthoxanthum odoratum*
Forb	*Leontodon hispidus*	*Plantago lanceolata*
	Achillea millefolium	*Campanula rotundifolia*
Legume	*Trifolium repens*	*Lotus corniculatus*

**Agrostis capillaris* is not associated with either high or low N deposition. It has been chosen because it is a species that defines this acid grassland community.

Mesocosm Experiment

Treatments:

- 9 monocultures x 2 N treatments = 18
- 6 species treatments x 2 N treatments = 12
- Bare soil x 2 N treatments = 2
- 32 x 3 reps = 96 pots

N treatments:

- 0 kg/ha/yr N – control.
- 35kg/ha/yr N as NH_4NO_3 – top end of current atmospheric N deposition in the UK.

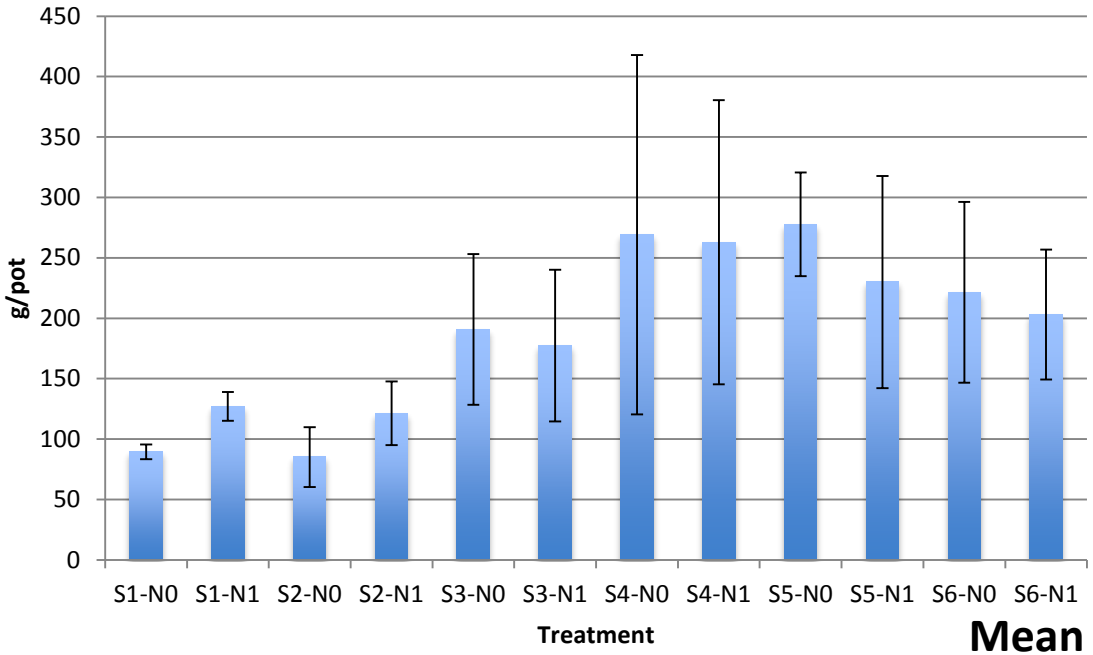
- Experiment was run over two growing seasons – 2014 and 2015

Species Treatments

	HIGH species richness	LOW species richness	
HIGH N community prevalence		**1** – High N species, grasses not dominant	HIGH functional group evenness
	3 – Mixture, grasses dominant	**2** – High N species, grasses dominant	LOW functional group evenness
LOW N community prevalence	**6** – Mixture, grasses not dominant	**4** – Low N species, grasses not dominant	HIGH functional group evenness
		5 – Low N species, grasses dominant	LOW functional group evenness



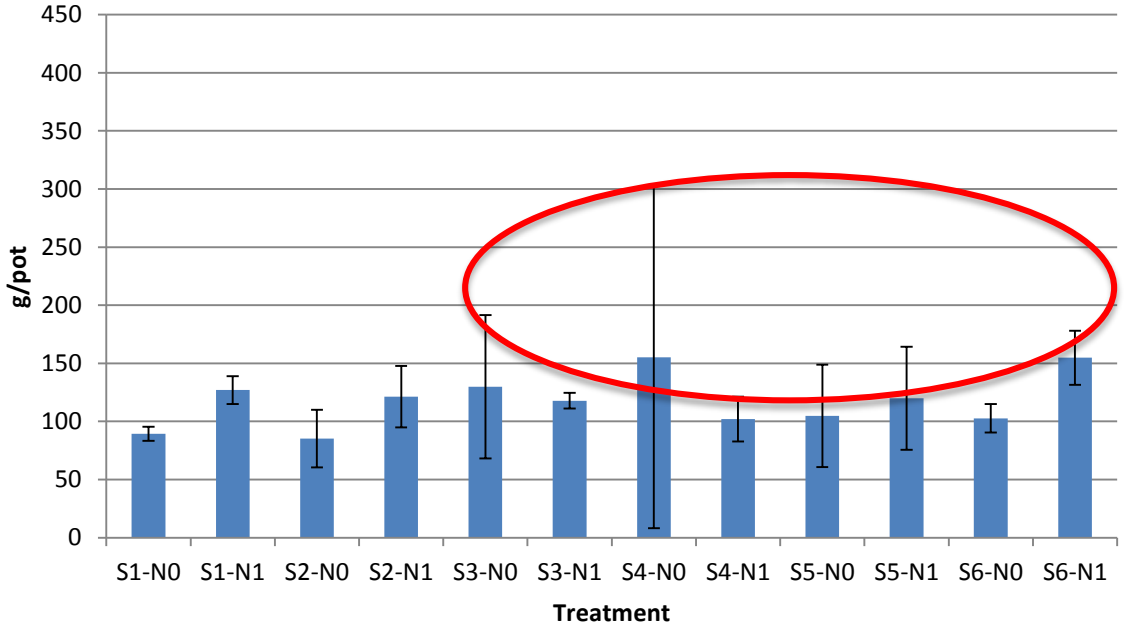

Mean aboveground biomass



Lotus c. is present in species treatments 3 to 6.

It makes up a large proportion of the biomass in treatments 4 to 6.

Mean biomass without Lotus



Error bars represent 1SD.

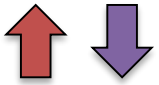
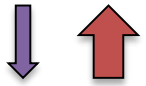
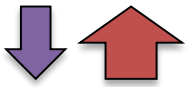
Do plant communities associated with either high or low N deposition have different effects on C storage when exposed to N?

C pool	N added to 'high N' communities	N added to 'low N' communities
Aboveground Biomass	C gain	C loss*
Roots	C gain	C gain?**
Soil (total)	C gain*	C gain?**
Microbial	C gain	C gain?**
Overall	C gain*	C gain?**

*high variability

**change dependent on evenness

When exposed to N, does lower functional group evenness (i.e. dominance by grass species) have an effect on the severity of any changes to C storage?

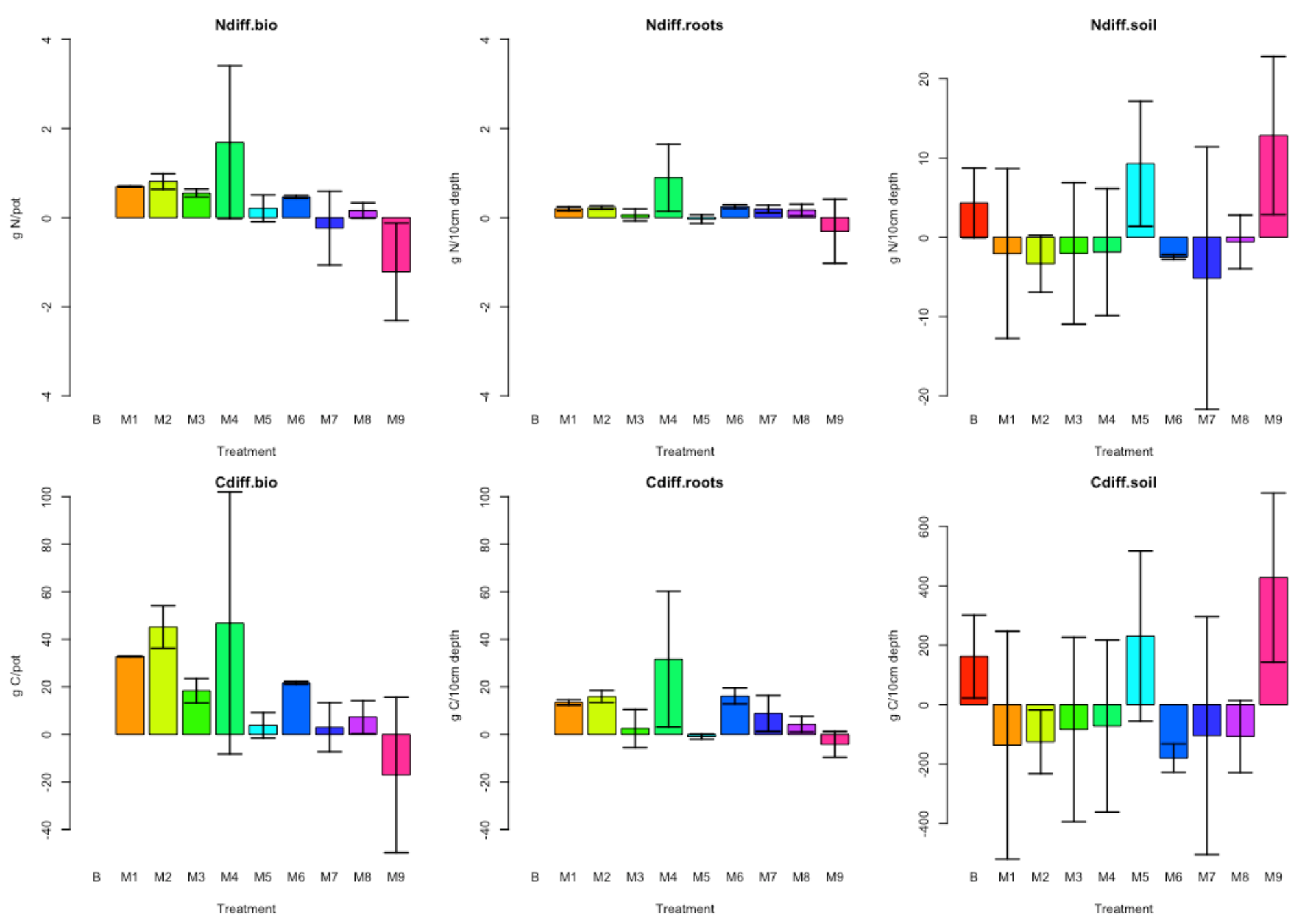
C pool	N added to 'high N' communities	N added to 'low N' communities
Aboveground Biomass	No difference (but uneven is more variable) 	No difference (but **even has less loss**). Both have high variability 
Roots	No difference 	Even shows gain, uneven shows loss 
Soil (total)	No difference (but uneven is more variable) 	Even shows loss, uneven shows gain 
Microbial	No difference (but uneven has less gain) 	Even shows slight loss, uneven shows gain 
Overall	No difference (but uneven has **less gain** and **more variability**) 	Even shows loss, uneven shows large gain 

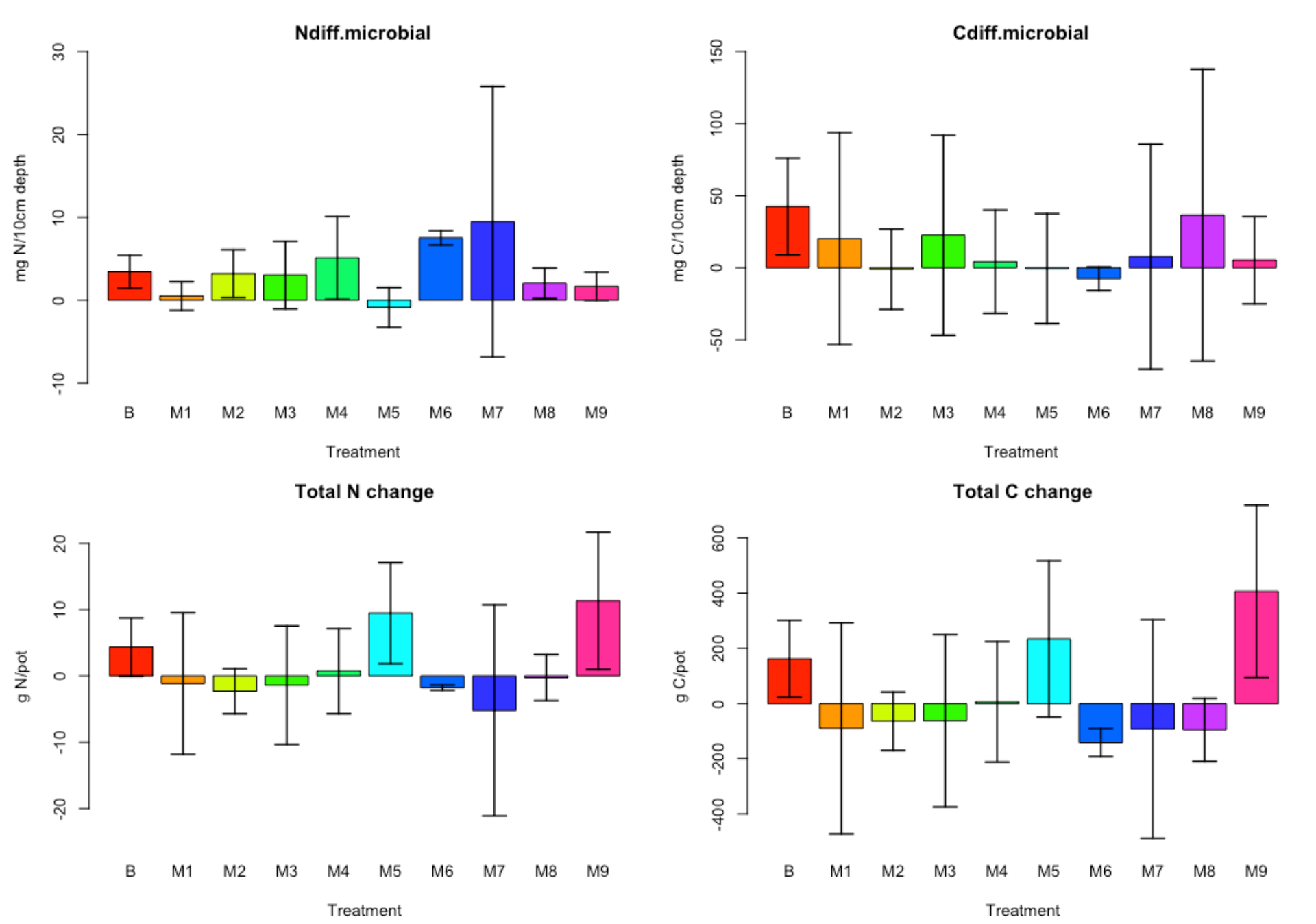
Does mixing 'high N' species with 'low N' species (increasing richness) mitigate any changes to C storage caused when N is added to these groups separately?

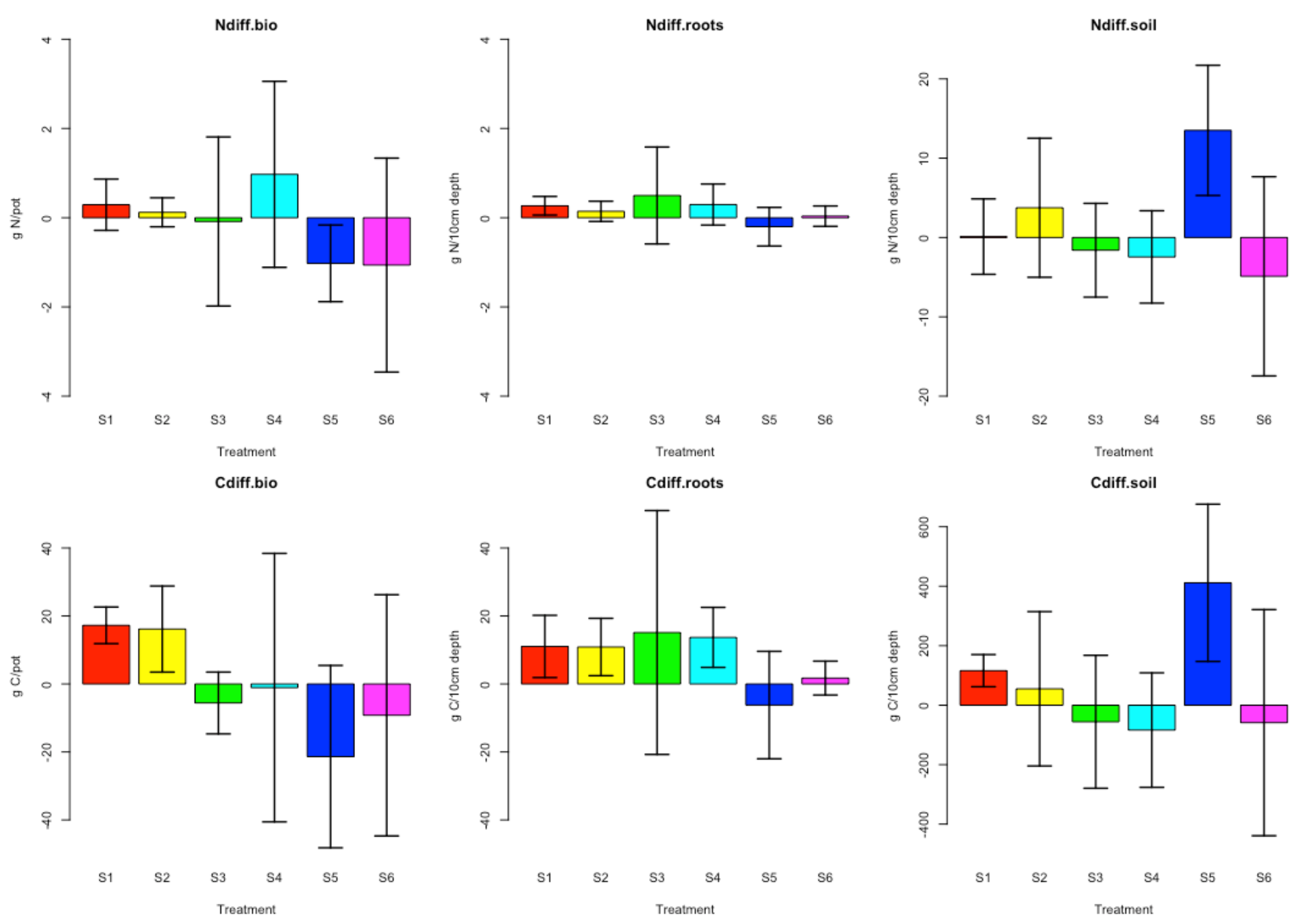
C pool	N added to mixture vs. 'high N' communities	N added to mixture vs. 'low N' communities
Aboveground Biomass	C loss (reverses trend) 	Smaller C loss (midpoint between even & uneven communities)* 
Roots	C gain (no change)* 	Smaller C gain (midpoint between even & uneven) 
Soil (total)	C loss (reverses trend)* 	C loss (reverses trend – **more like even** comm.)* 
Microbial	C loss (reverses trend)* 	C loss (reverses trend – **more like even**)* 
Overall	C loss (reverses trend)* 	C loss (reverses trend – **more like even**)* 

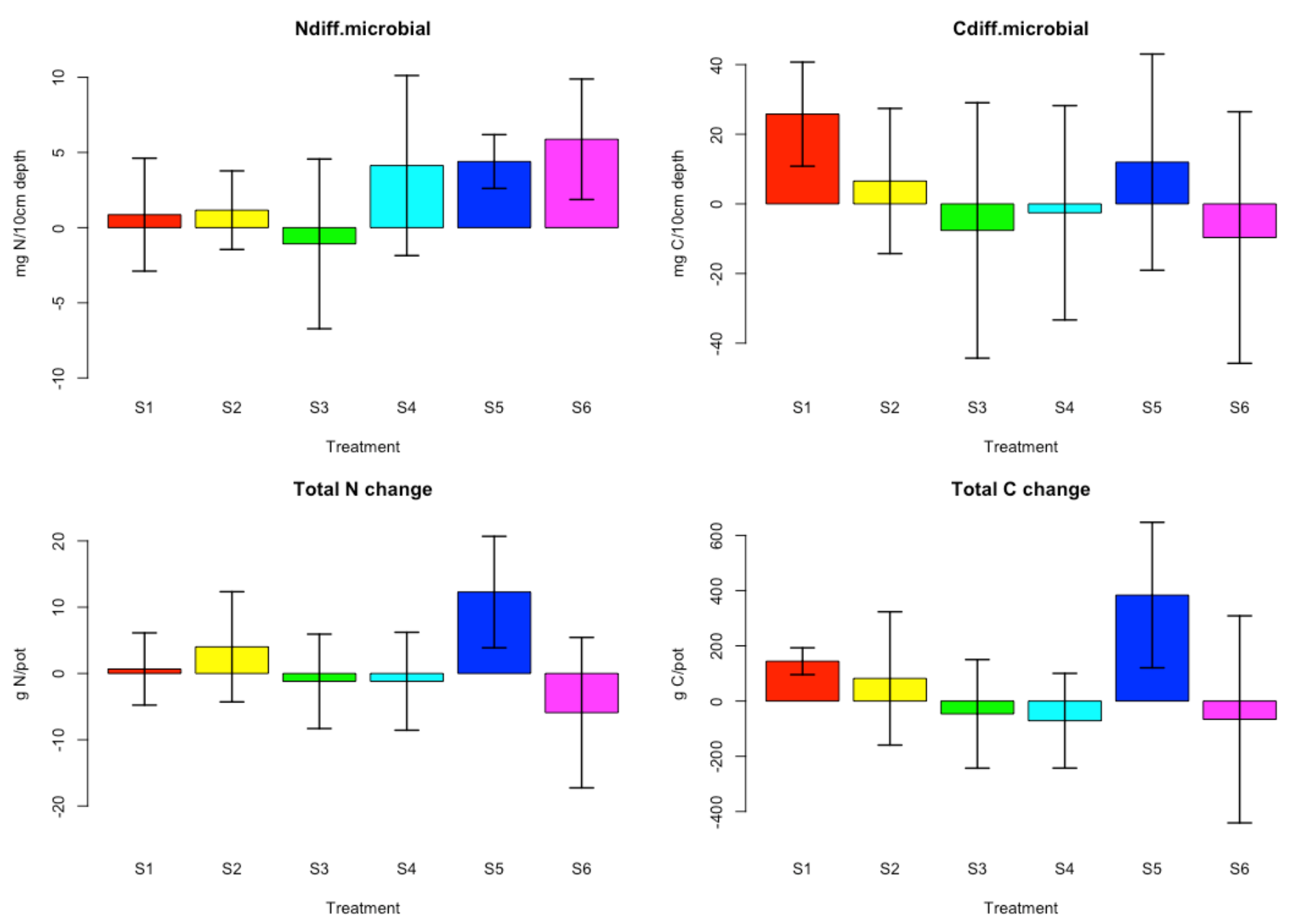
*high variability

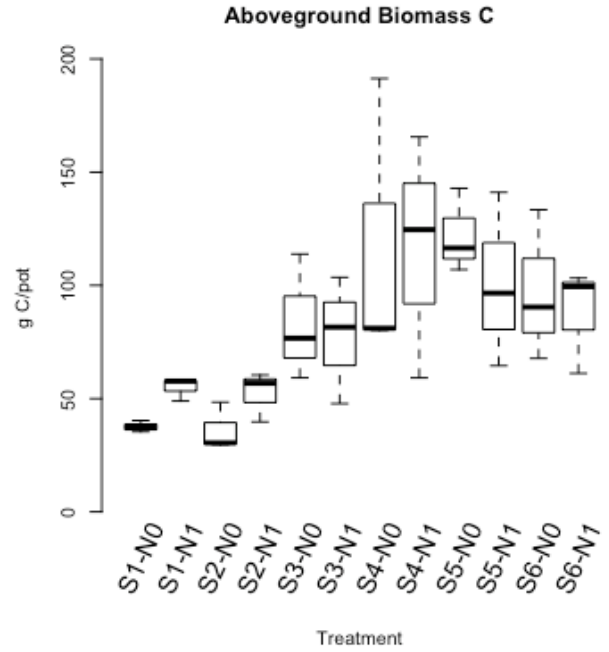

Thank You

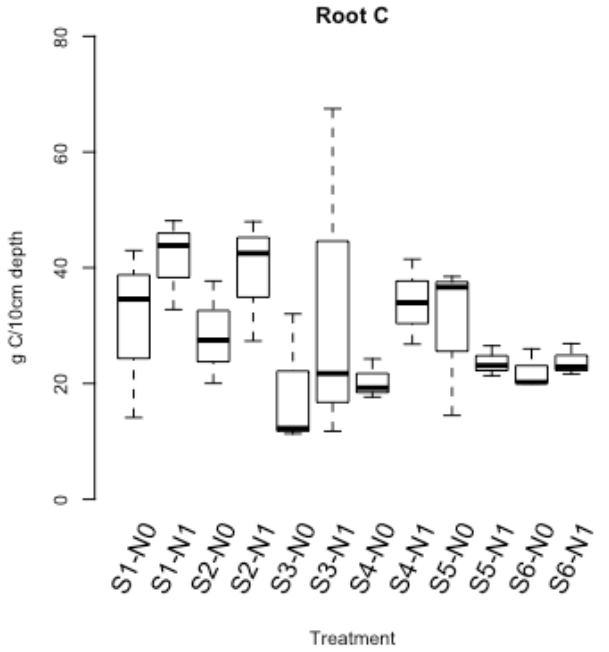

Ndiff.bio
g N/pot
Ndiff.roots
g N/10cm depth
Ndiff.soil
g N/10cm depth
Cdiff.bio
g C/pot
Cdiff.roots
g C/10cm depth
Cdiff.soil
g C/10cm depth
B M1 M2 M3 M4 M5 M6 M7 M8 M9
Treatment
B Bare
1 Agrostis
2 Festuca
3 Leontodon
4 Achillea
5 Trifolium
6 Anthoxanthum
7 Plantago
8 Campanula
9 Lotus

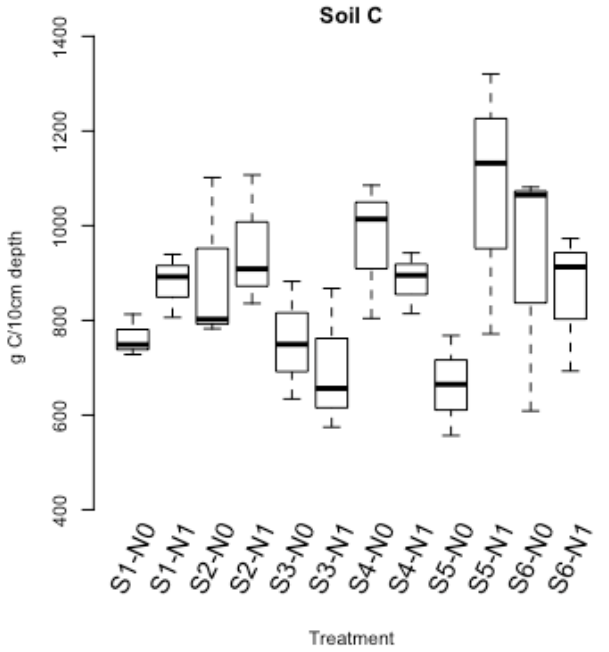

Ndiff.microbial
mg N/10cm depth
30
20
10
0
-10
B
M1
M2
M3
M4
M5
M6
M7
M8
M9
Treatment
Cdiff.microbial
mg C/10cm depth
150
100
50
0
-50
B
M1
M2
M3
M4
M5
M6
M7
M8
M9
Treatment
Total N change
g N/pot
20
10
0
-10
-20
B
M1
M2
M3
M4
M5
M6
M7
M8
M9
Treatment
Total C change
g C/pot
600
400
200
0
-200
-400
B
M1
M2
M3
M4
M5
M6
M7
M8
M9
Treatment
B Bare
1 Agrostis
2 Festuca
3 Leontodon
4 Achillea
5 Trifolium
6 Anthoxanthum
7 Plantago
8 Campanula
9 Lotus

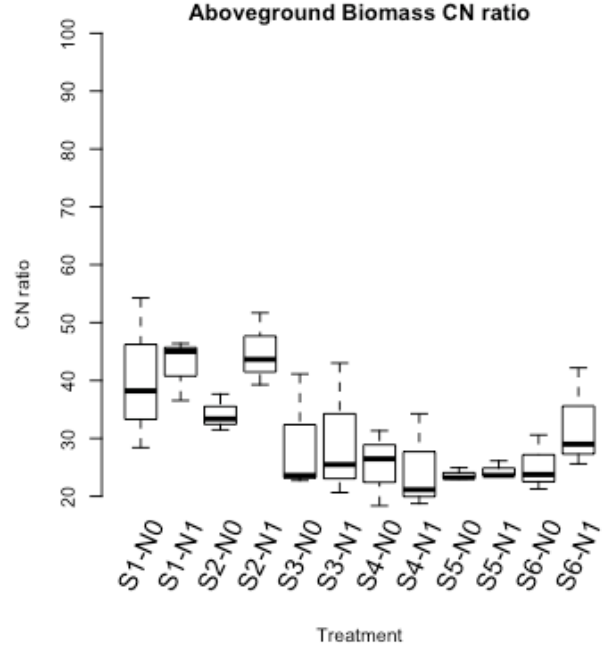

Ndiff.bio
g N/pot
Ndiff.roots
g N/10cm depth
Ndiff.soil
g N/10cm depth
Cdiff.bio
g C/pot
Cdiff.roots
g C/10cm depth
Cdiff.soil
g C/10cm depth
S1
S2
S3
S4
S5
S6
Treatment
1 'High N' sp.; Even
2 'High N' sp.; Uneven
3 'High N' Mixture
4 'Low N' sp.; Even
5 'Low N' sp.; Uneven
6 'Low N' Mixture

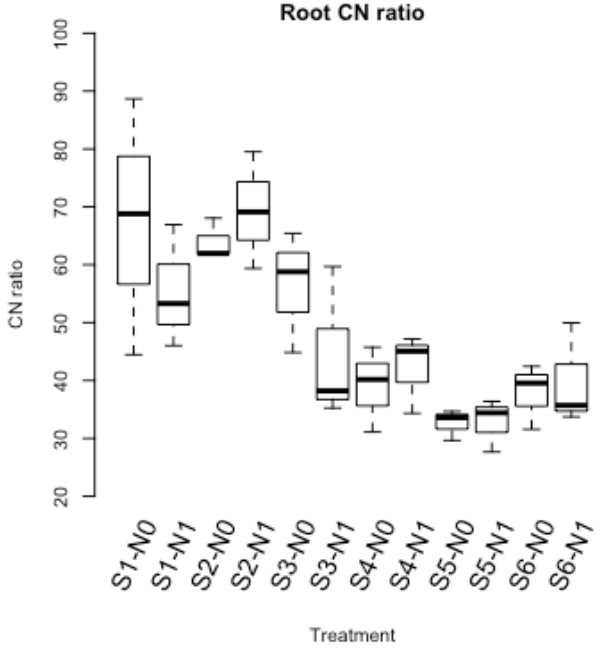

Ndiff.microbial
mg N/10cm depth
10
5
0
-5
-10
S1
S2
S3
S4
S5
S6
Treatment
Cdiff.microbial
mg C/10cm depth
40
20
0
-20
-40
S1
S2
S3
S4
S5
S6
Treatment
Total N change
g N/pot
20
10
0
-10
-20
S1
S2
S3
S4
S5
S6
Treatment
Total C change
g C/pot
600
400
200
0
-200
-400
S1
S2
S3
S4
S5
S6
Treatment
1 'High N' sp.; Even
2 'High N' sp.; Uneven
3 'High N' Mixture
4 'Low N' sp.; Even
5 'Low N' sp.; Uneven
6 'Low N' Mixture

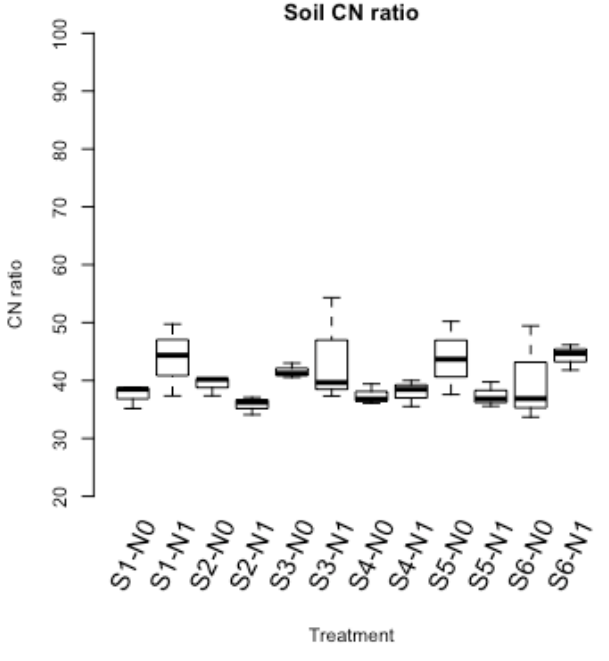

Aboveground Biomass C
g C/pot
0
50
100
150
200
S1-N0
S1-N1
S2-N0
S2-N1
S3-N0
S3-N1
S4-N0
S4-N1
S5-N0
S5-N1
S6-N0
S6-N1
Treatment

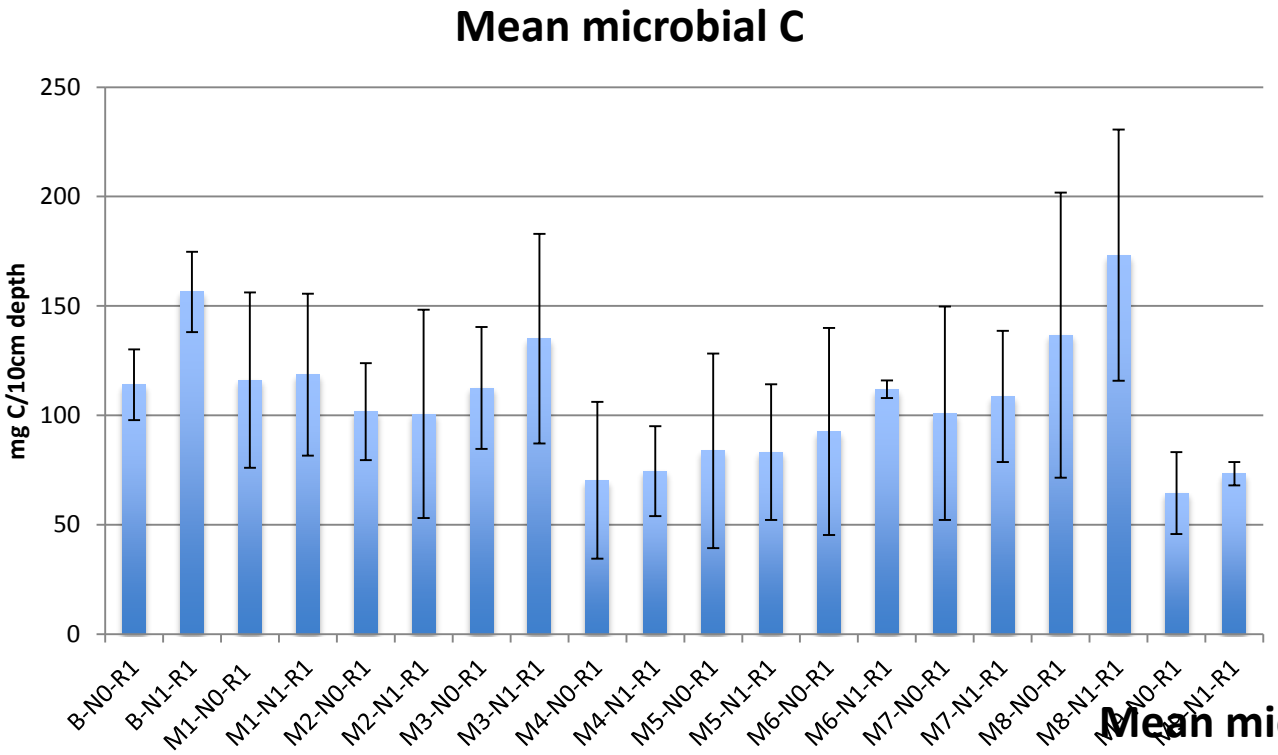

Root C
g C/10cm depth
0
20
40
60
80
S1-N0
S1-N1
S2-N0
S2-N1
S3-N0
S3-N1
S4-N0
S4-N1
S5-N0
S5-N1
S6-N0
S6-N1
Treatment

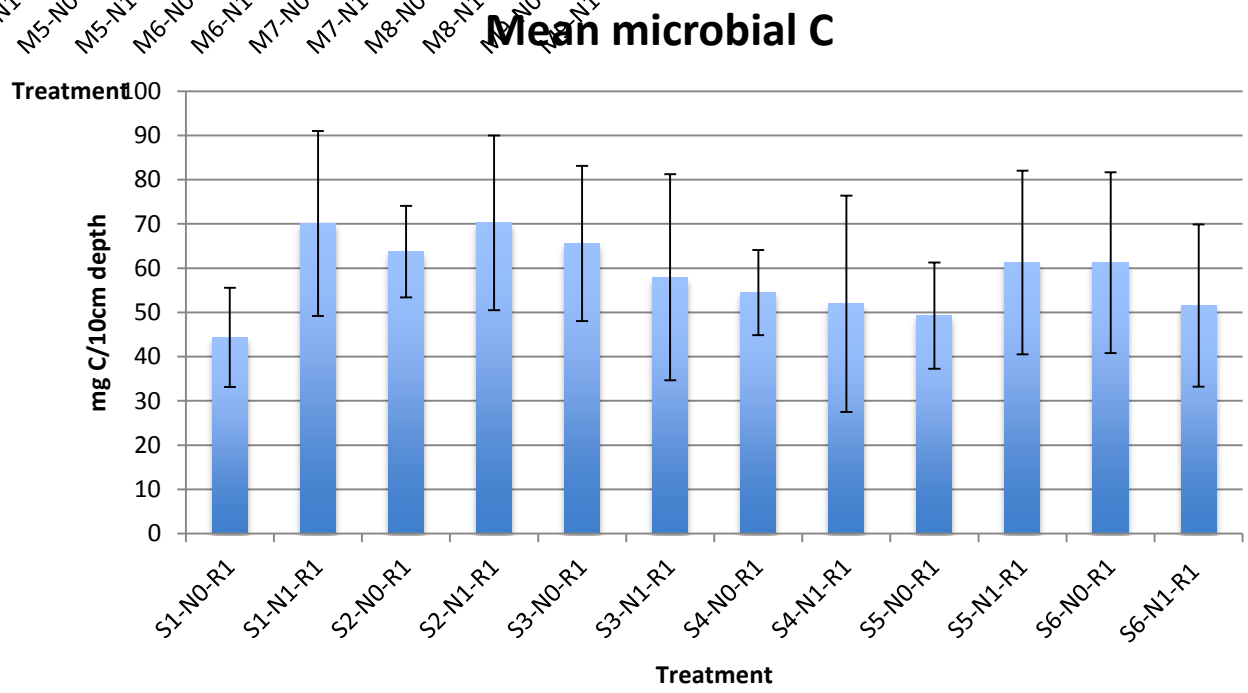

Soil C
g C/10cm depth
400
600
800
1000
1200
1400
S1-N0
S1-N1
S2-N0
S2-N1
S3-N0
S3-N1
S4-N0
S4-N1
S5-N0
S5-N1
S6-N0
S6-N1
Treatment


Aboveground Biomass CN ratio
CN ratio
20
30
40
50
60
70
80
90
100
S1-N0
S1-N1
S2-N0
S2-N1
S3-N0
S3-N1
S4-N0
S4-N1
S5-N0
S5-N1
S6-N0
S6-N1
Treatment


Root CN ratio
CN ratio
20
30
40
50
60
70
80
90
100
S1-N0
S1-N1
S2-N0
S2-N1
S3-N0
S3-N1
S4-N0
S4-N1
S5-N0
S5-N1
S6-N0
S6-N1
Treatment


Soil CN ratio
CN ratio
20
30
40
50
60
70
80
90
100
S1-N0
S1-N1
S2-N0
S2-N1
S3-N0
S3-N1
S4-N0
S4-N1
S5-N0
S5-N1
S6-N0
S6-N1
Treatment


Mean microbial C
mg C/10cm depth
250
200
150
100
50
0
B-N0-R1
B-N1-R1
M1-N0-R1
M1-N1-R1
M2-N0-R1
M2-N1-R1
M3-N0-R1
M3-N1-R1
M4-N0-R1
M4-N1-R1
M5-N0-R1
M5-N1-R1
M6-N0-R1
M6-N1-R1
M7-N0-R1
M7-N1-R1
M8-N0-R1
M8-N1-R1


Mean microbial C
Treatment
mg C/10cm depth
100
90
80
70
60
50
40
30
20
10
0
S1-N0-R1
S1-N1-R1
S2-N0-R1
S2-N1-R1
S3-N0-R1
S3-N1-R1
S4-N0-R1
S4-N1-R1
S5-N0-R1
S5-N1-R1
S6-N0-R1
S6-N1-R1
Treatment