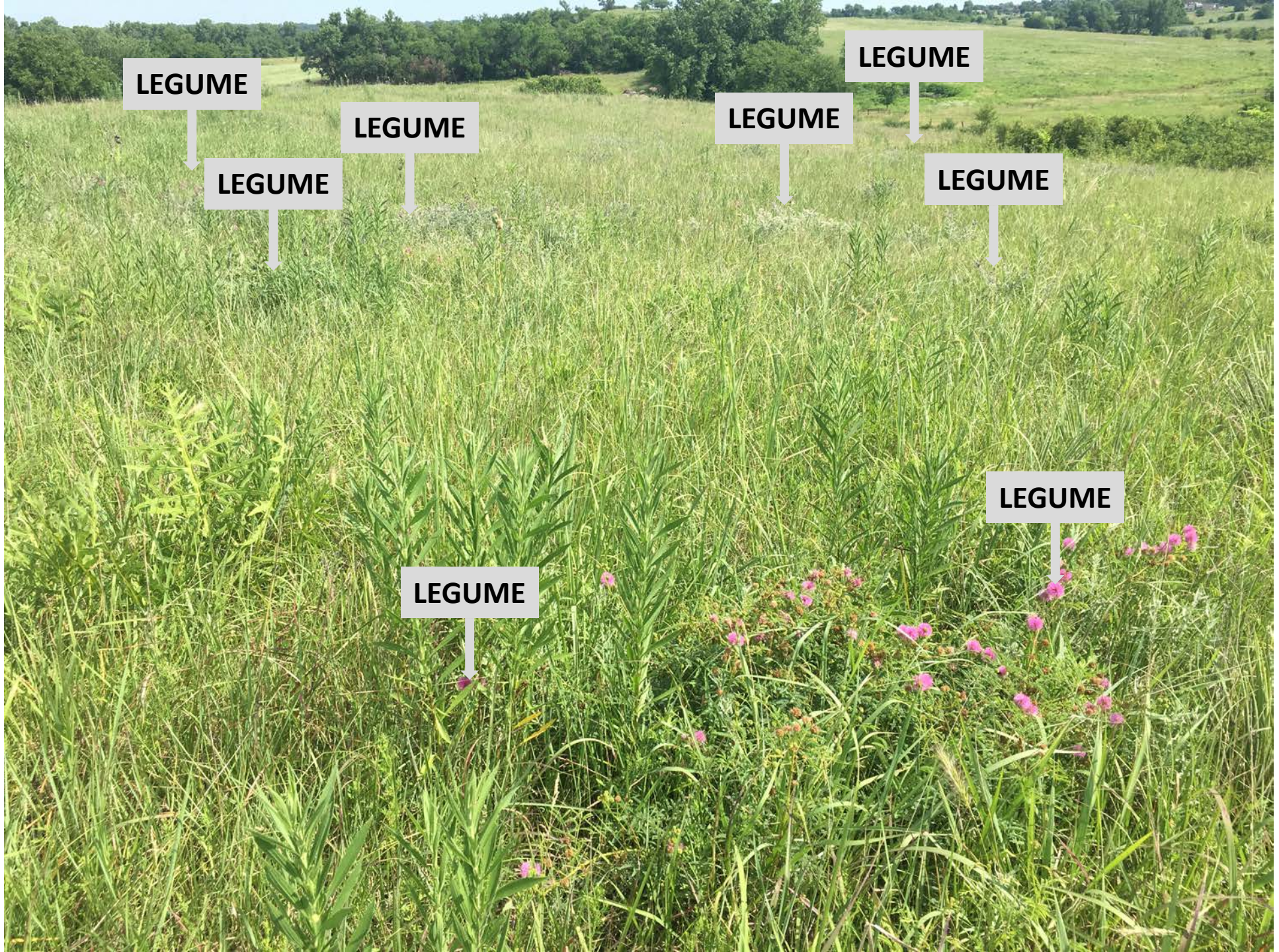
# Ecosystem Services of Kernza-Alfalfa Intercrops

2019 Kernza Conference, Madison, Wisconsin

Tim Crews, The Land Institute

1. Can intercropping with a legume support the nitrogen demands of an IWG crop?

2. Are there other ecosystem services captured by intercropping IWG and a legume?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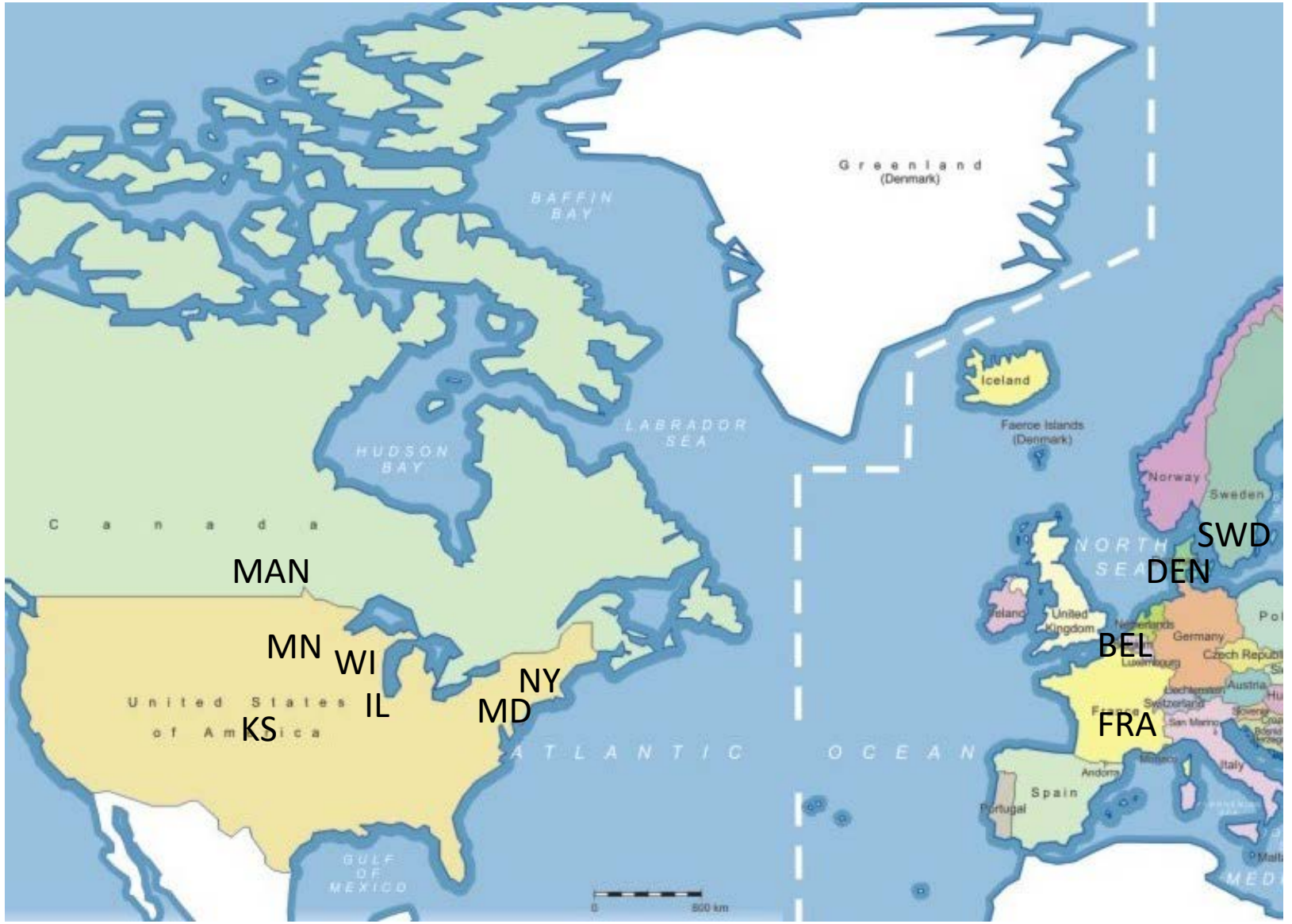
Legume abundance

Low

High

# Research sites and on-farm trials of IWG-legume intercrops



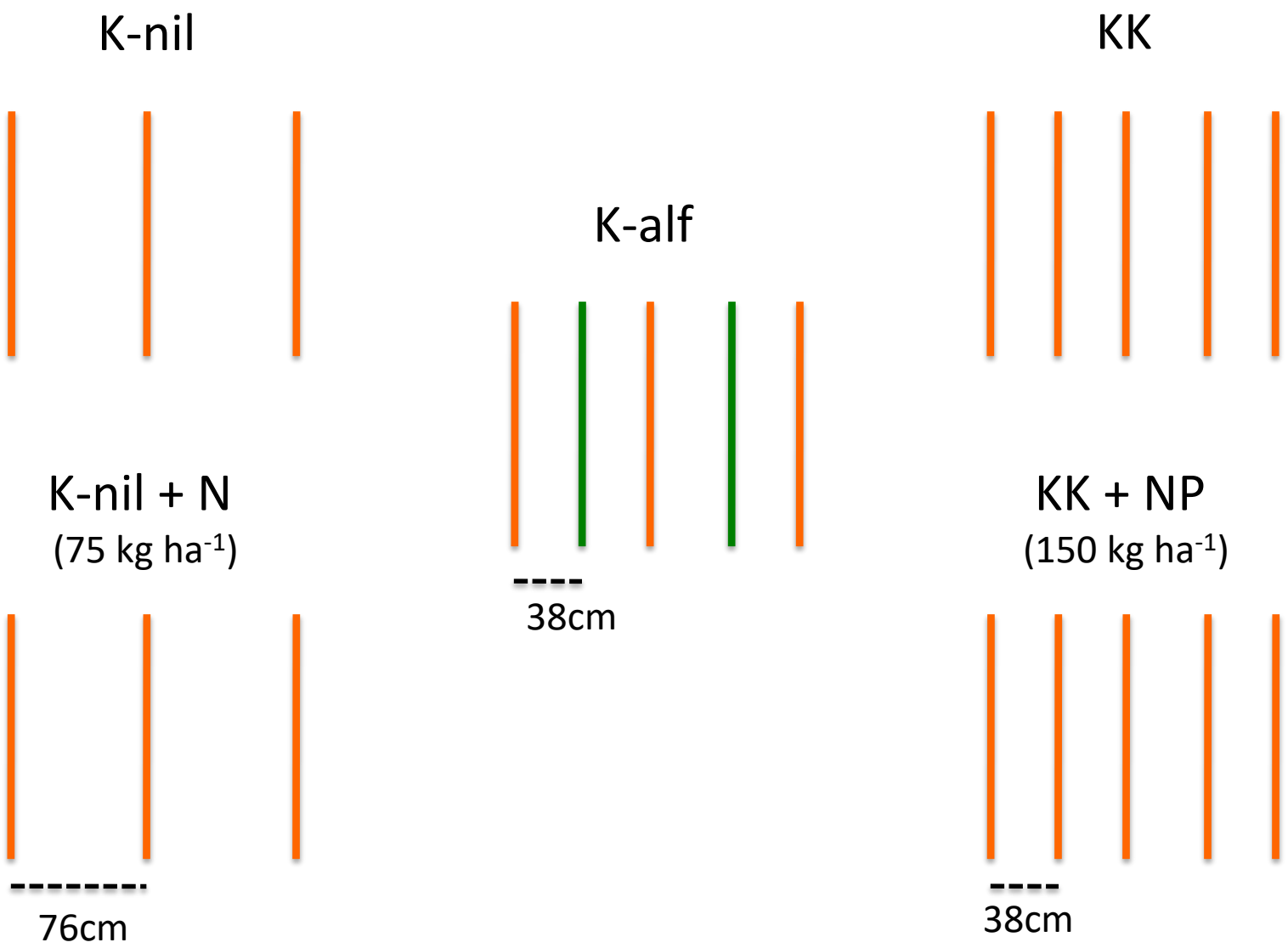

AUS (Down under)

1. Can intercropping with a legume support the nitrogen demands of an IWG crop?

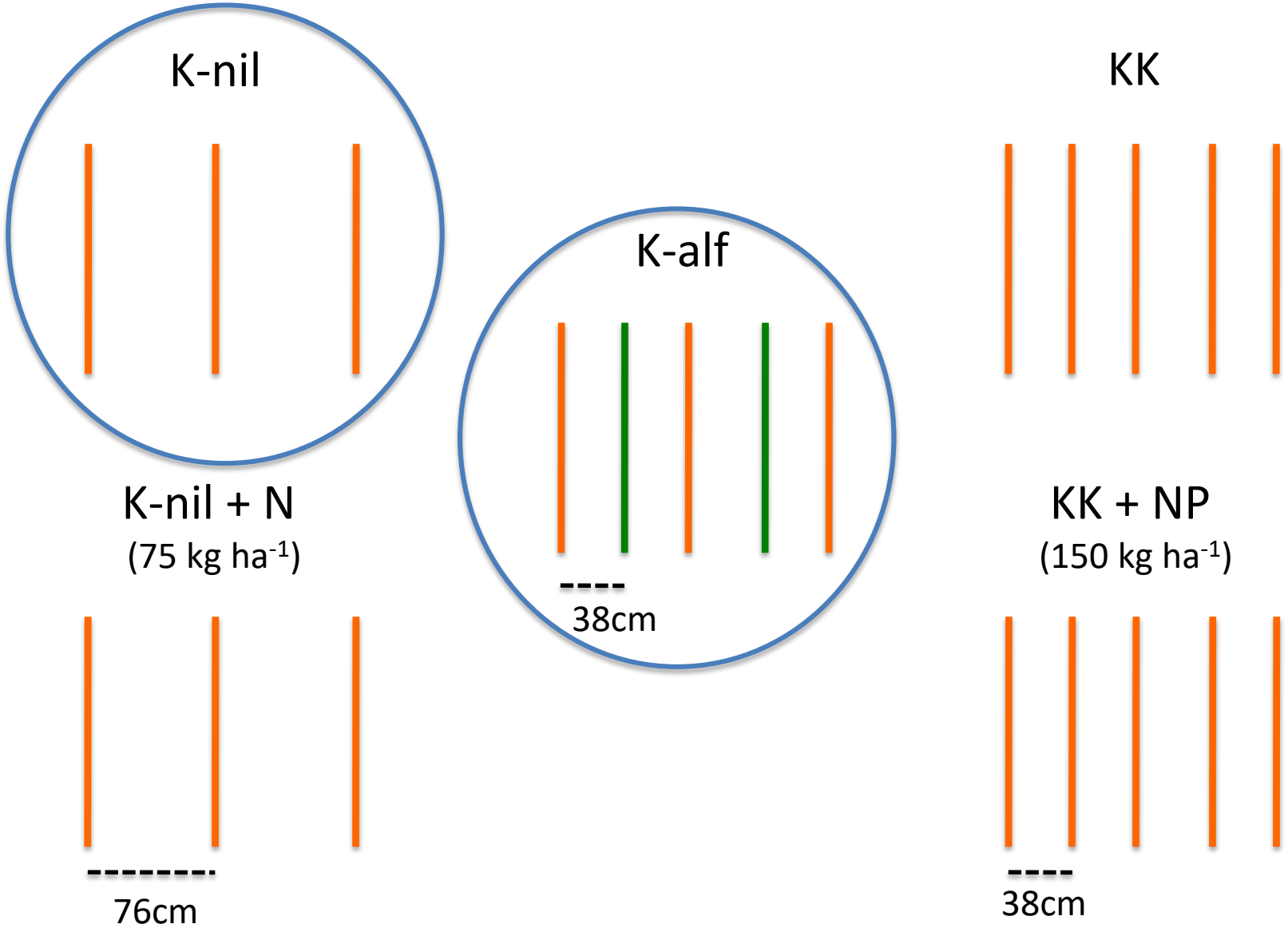
2. Are there other benefits or drawbacks to intercropping other than N fixation?


Perennial Kernza-alfalfa biculture plots

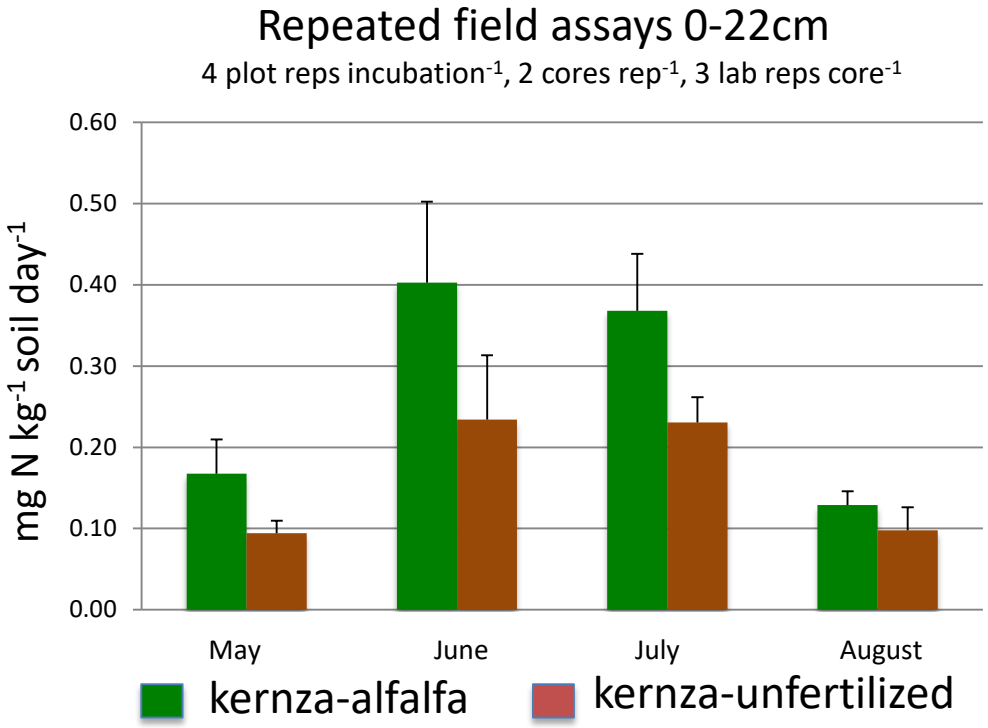
# Kernza (K) and Kernza-alfalfa(A) intercrop treatments

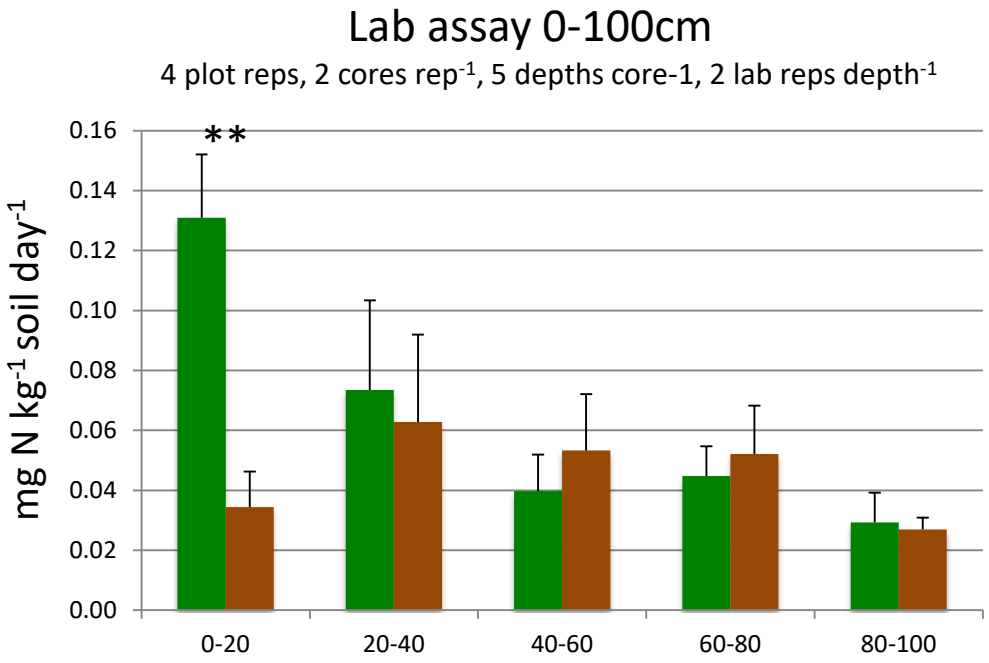


# Kernza (K) and Kernza-alfalfa(A) intercrop treatments

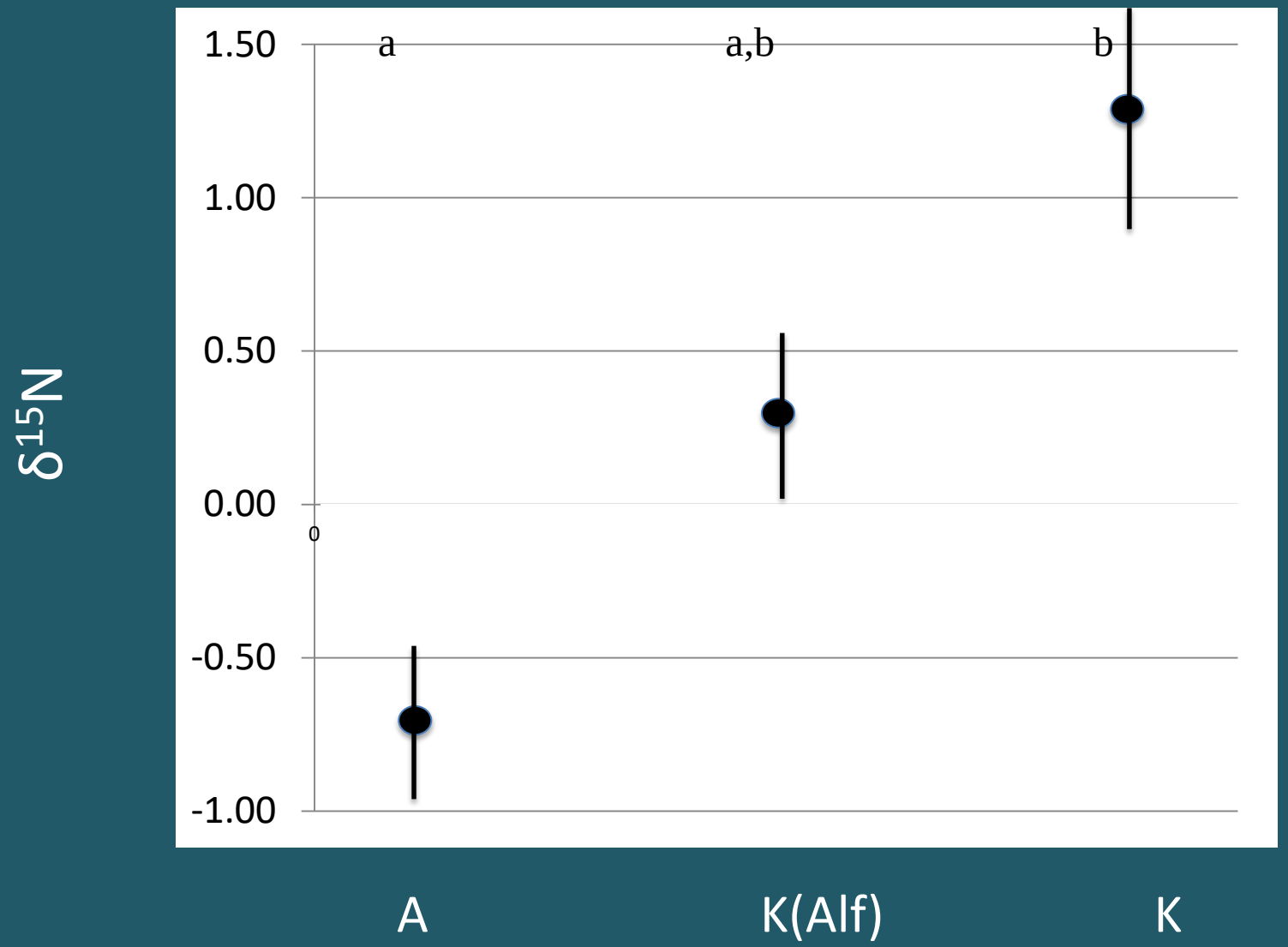


# Net N mineralization in field and lab soil incubations



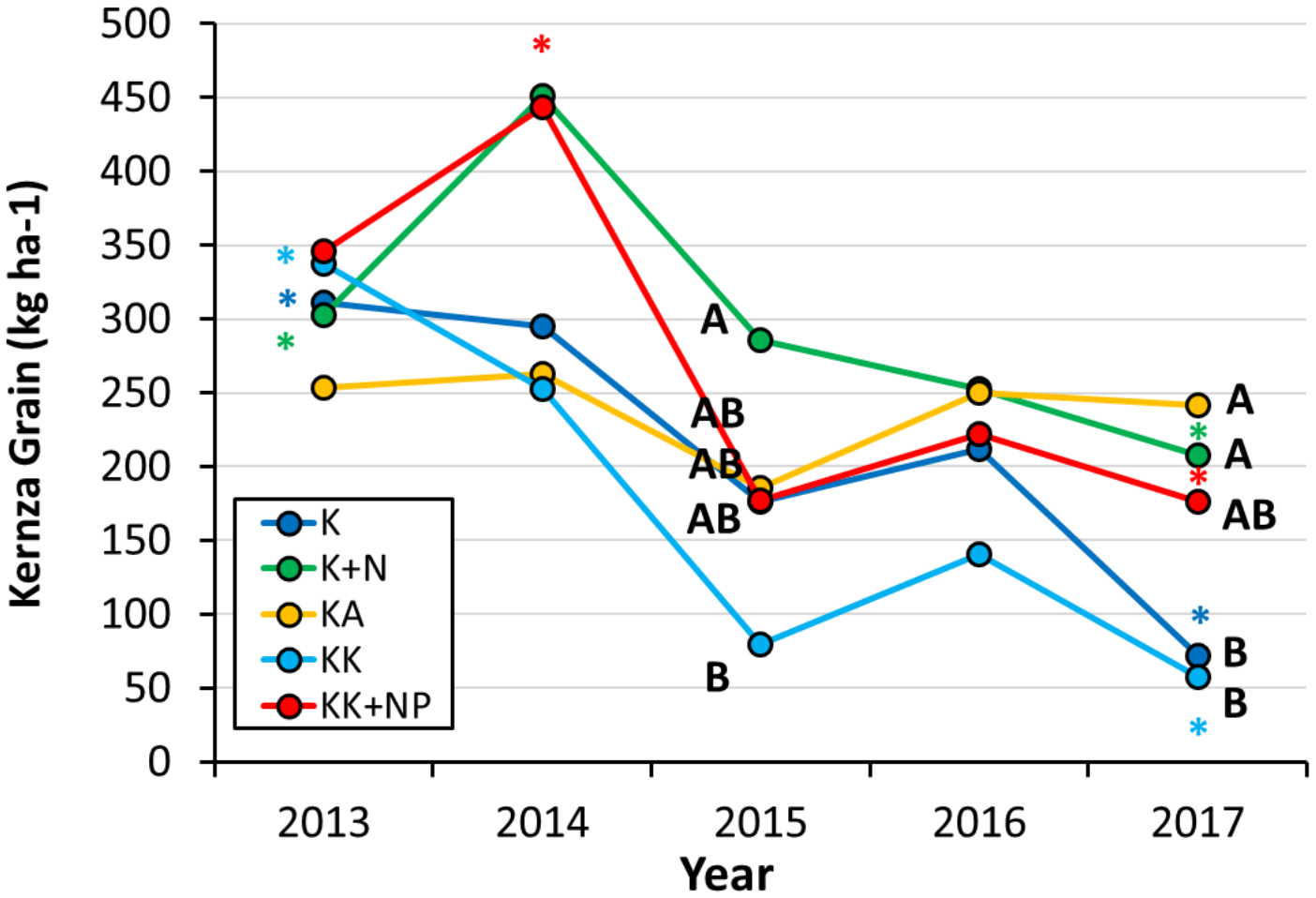



# Natural abundance $^{15}N$ of shoots from alfalfa (A), Kernza intercropped with alfalfa (KA) and Kernza monocropped (K) in the third year of production




Error bars = 1 S.E., letters Tukey HSD <0.05

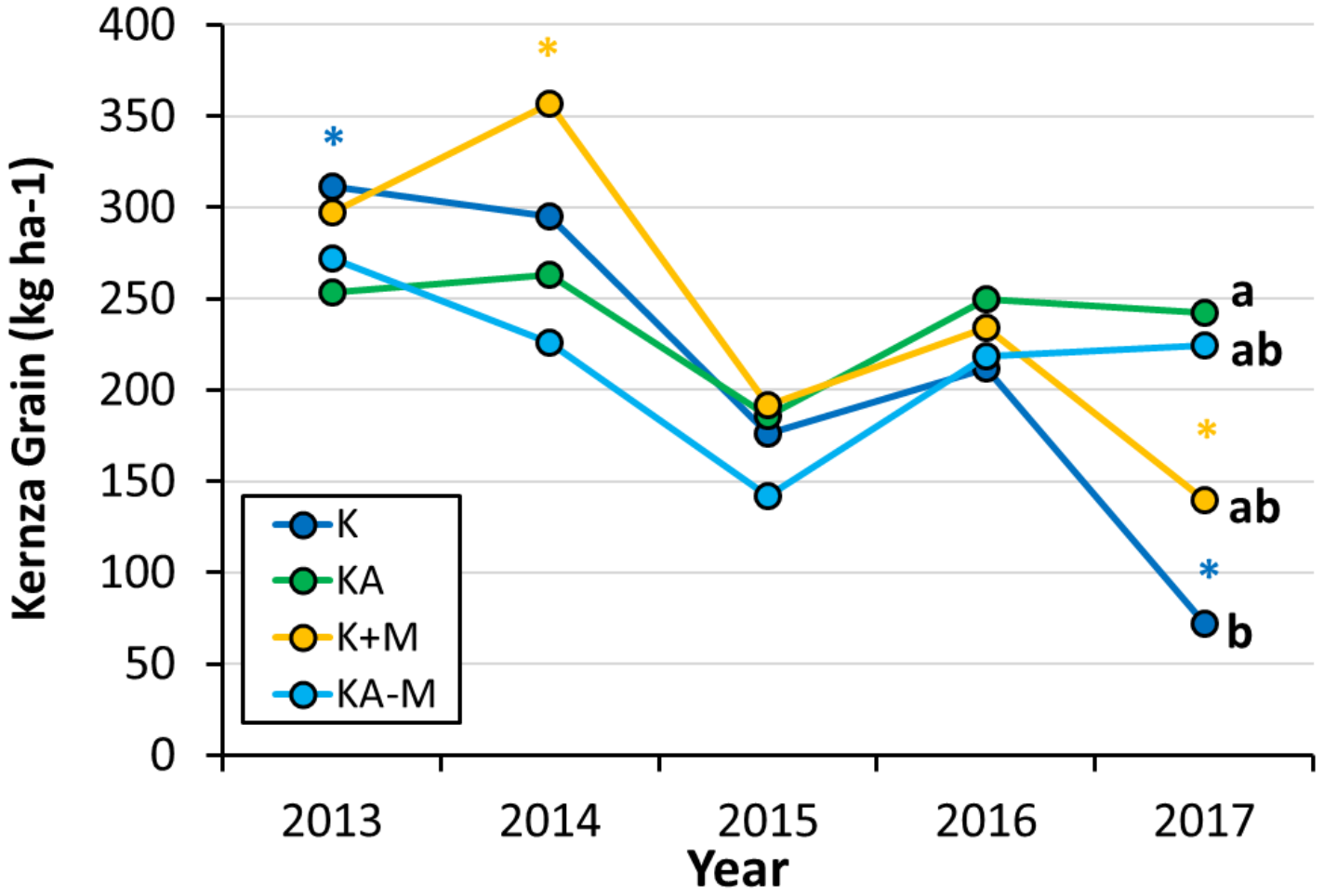
# Kernza nitrogen sources– Grain




| Mixed Model Type 3 Tests of Fixed Effects | | | | |
|---|---|---|---|---|
| **Effect** | Num DF | Den DF | F Value | Pr > F |
| **Treatment** | 4 | 15 | 10.83 | 0.0002 |
| **Year** | 4 | 59 | 32.75 | <.0001 |
| **Treatment*Year** | 16 | 59 | 3.35 | 0.0004 |

- KA yield was significantly higher than K or KK in 2017.
- KA was the only treatment that did not significantly decrease in yield over time.
- K+N yield was significantly higher than KK yield in 2014 and 2017.

# Mulching Experiment – Grain



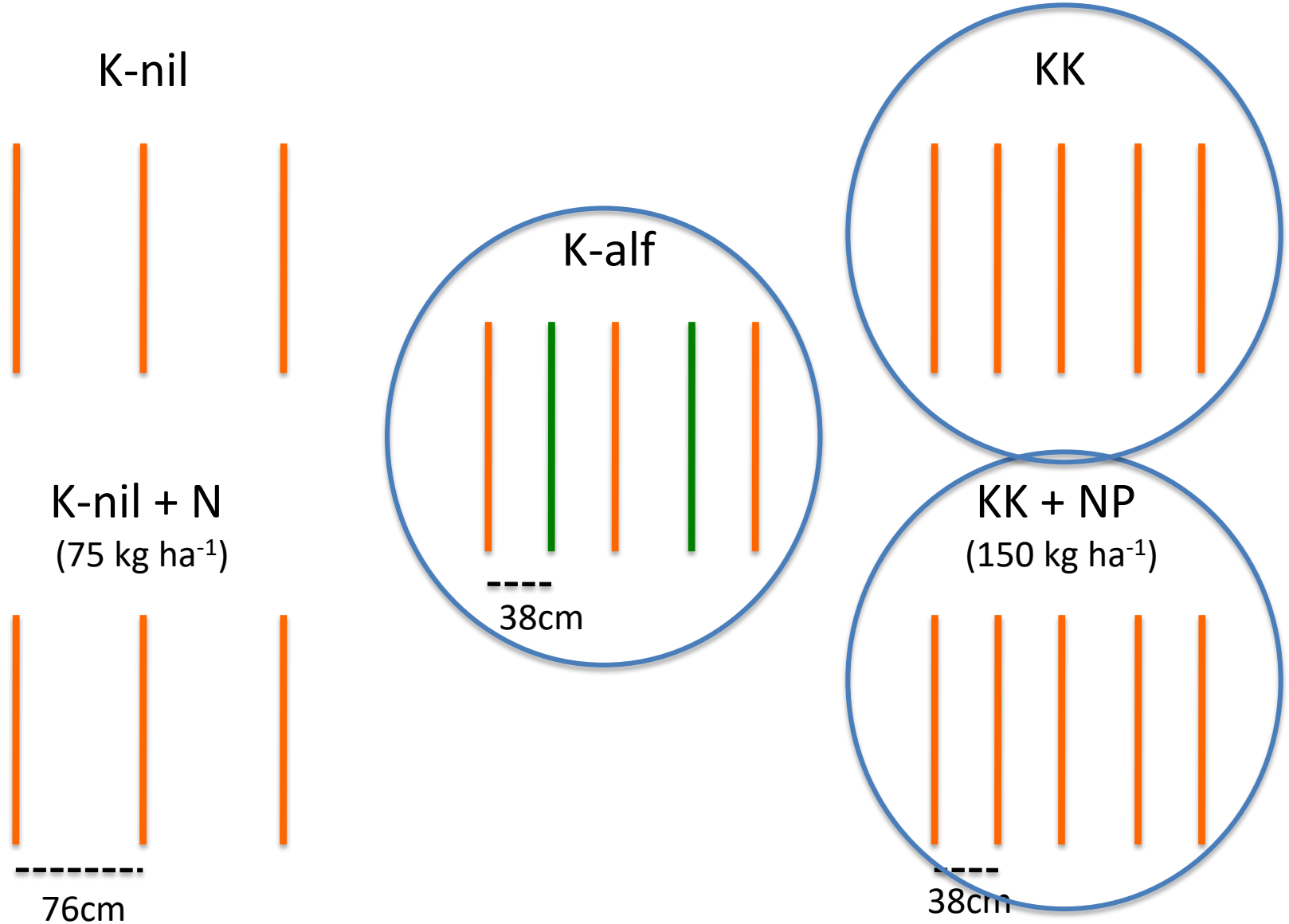

| Mixed Model Type 3 Tests of Fixed Effects | | | | |
|---|---|---|---|---|
| **Effect** | Num DF | Den DF | F Value | Pr > F |
| **Treatment** | 3 | 12 | 0.98 | 0.4332 |
| **Year** | 4 | 46 | 10.98 | <0.0001 |
| **Treatment*Year** | 12 | 46 | 2.11 | 0.0350 |

- Grain yield significantly decreased over time in K+M and K treatments, but not in KA or KA-M treatments
- Grain yield in 2017 was significantly higher in KA than in K plots.

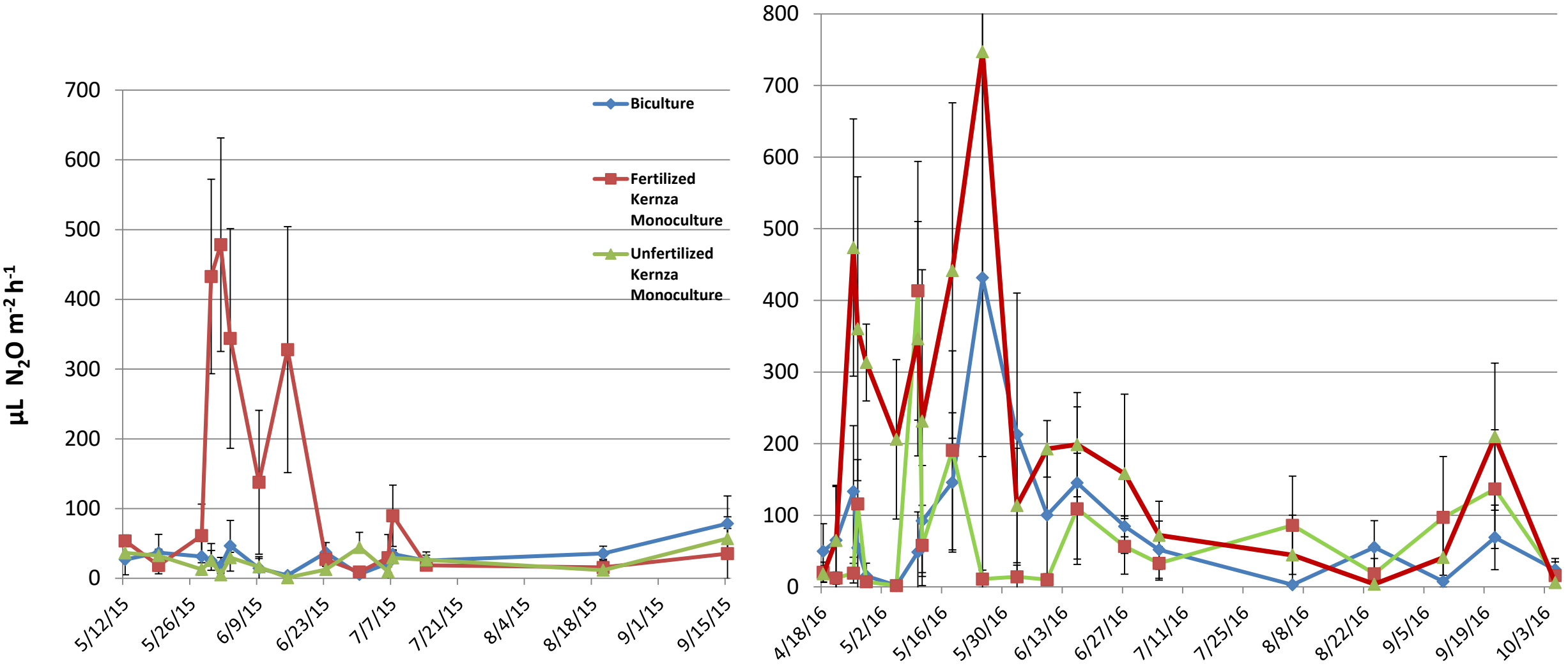
# Ecosystem Services: $N_2O$ emissions reduced

Photo : Jim Richardson

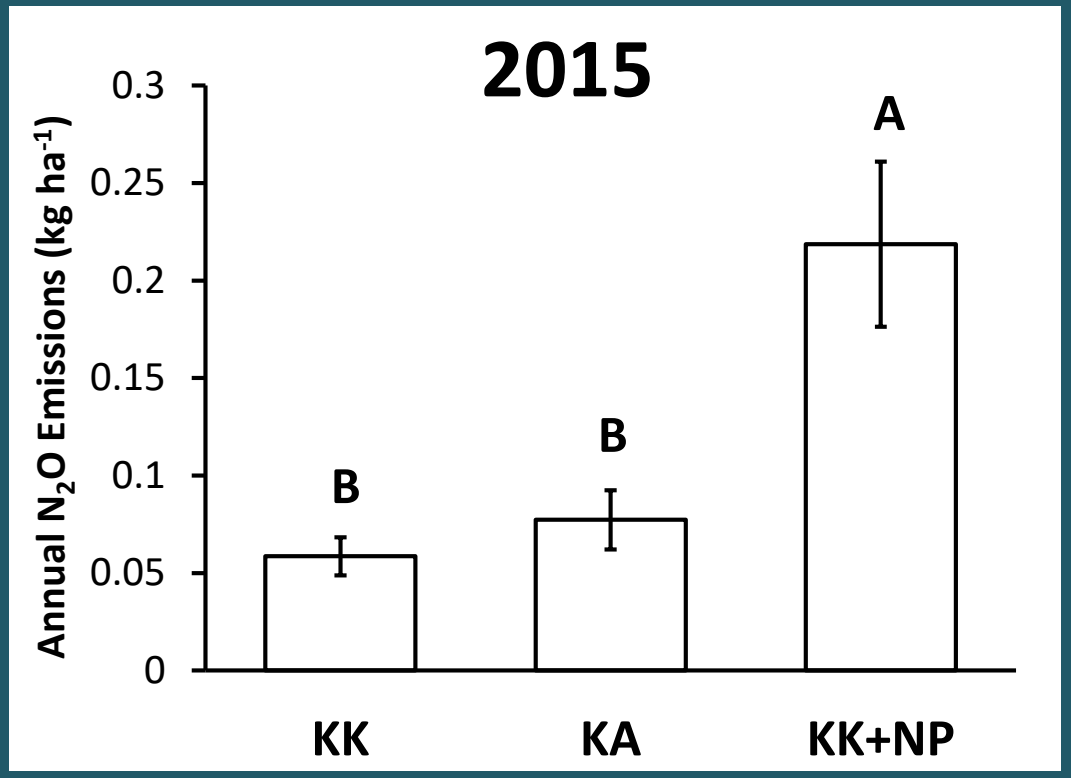
# Kernza (K) and Kernza-alfalfa(A) intercrop treatments

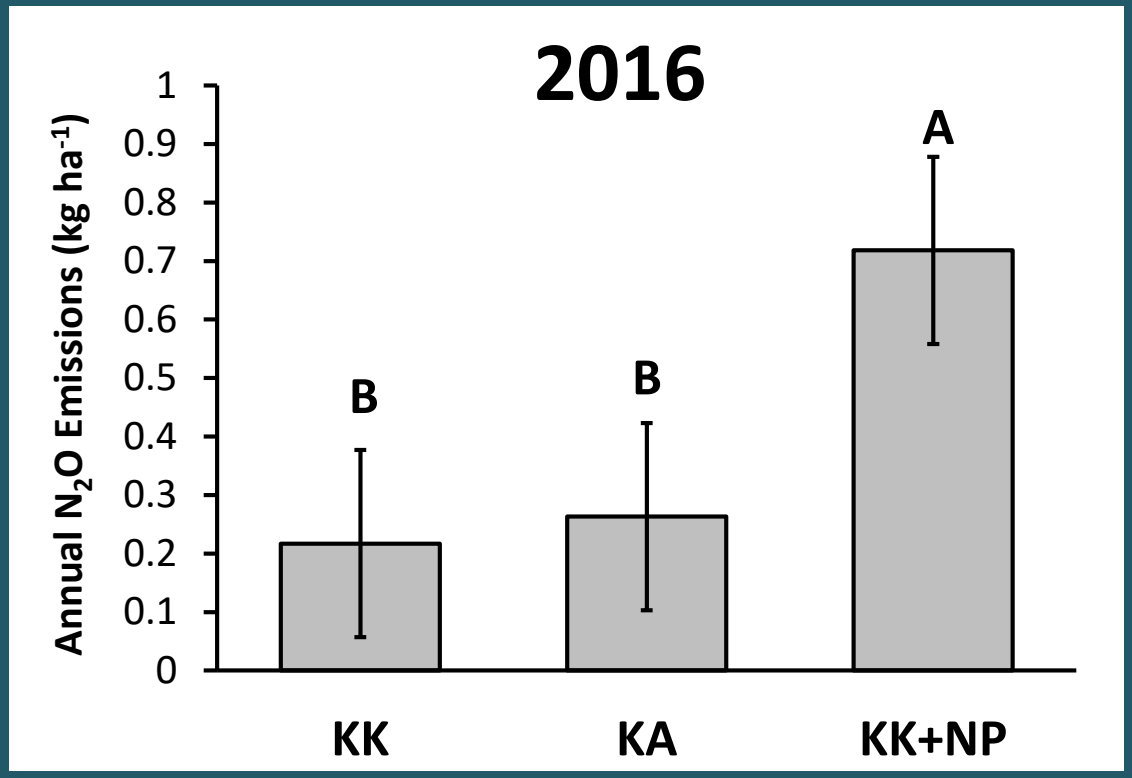


# $N_2O$ Fluxes from single species Kernza plots (fertilized and unfertilized) and Kernza-alfalfa intercrops

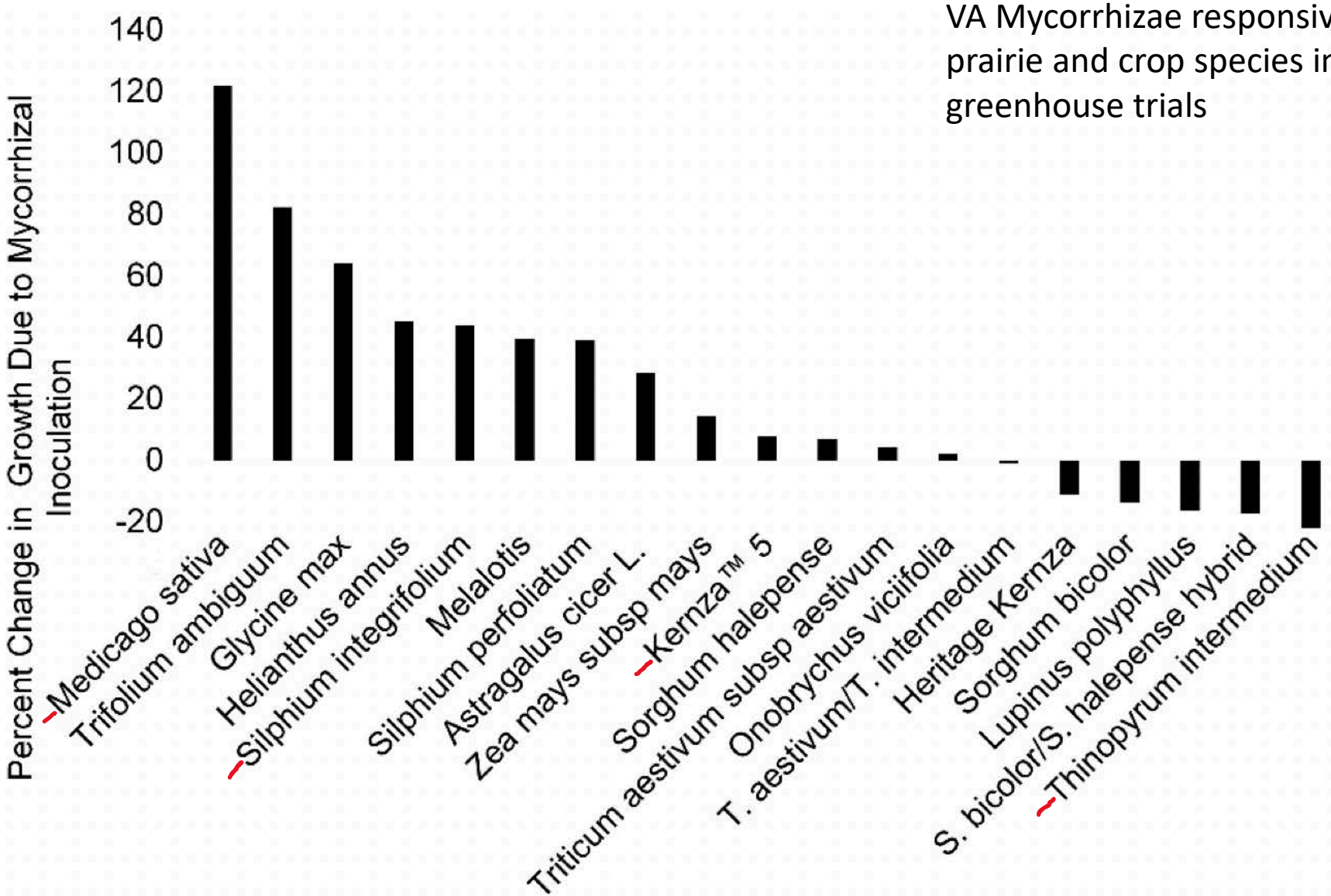


N2O emissions during two growing seasons in unfertilized Kernza-Kernza (KK), Kernza-alfalfa (KA), and fertilized Kernza-Kernza (KK+NP) plots



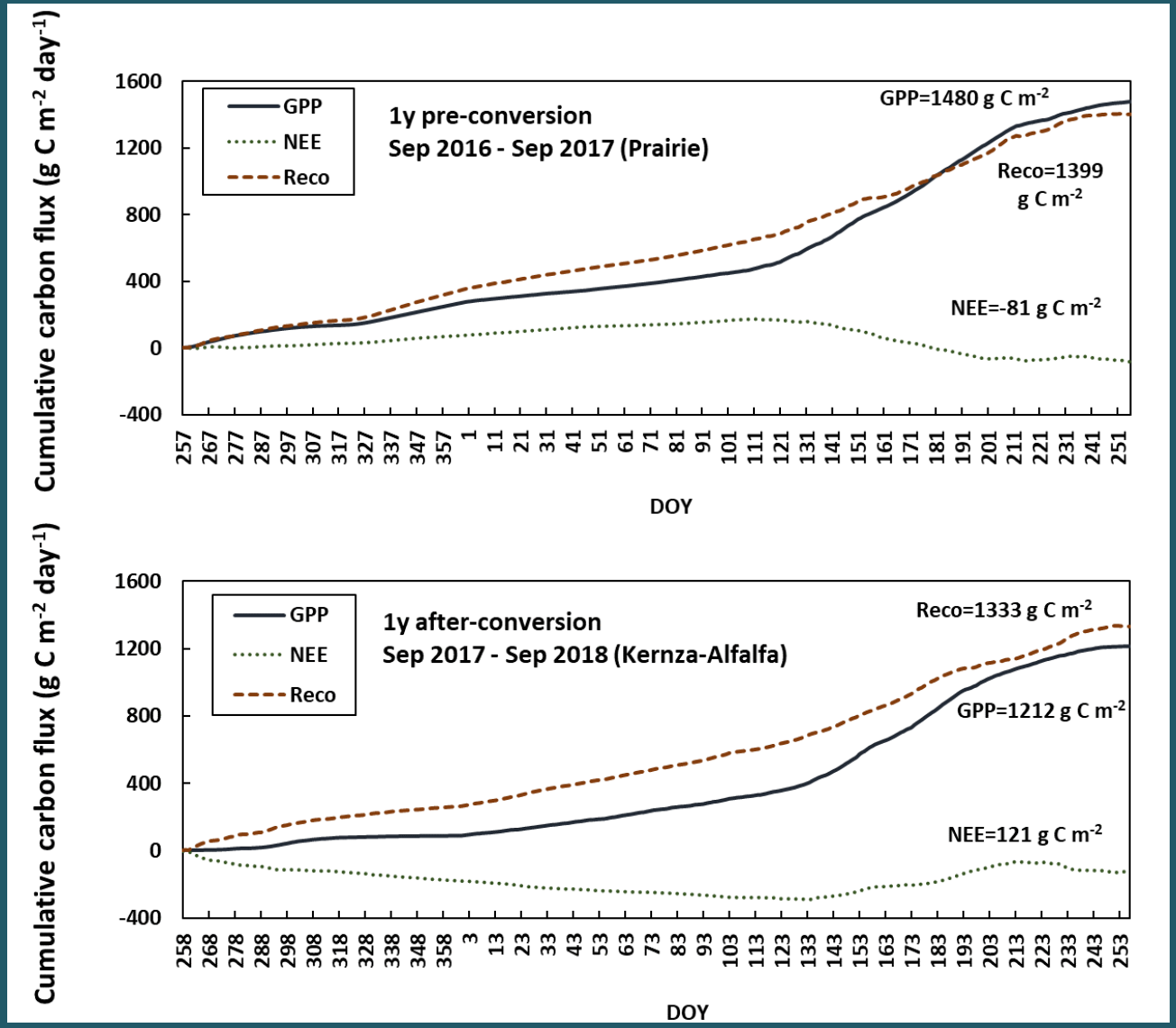
VA Mycorrhizae responsiveness of 19 prairie and crop species in greenhouse trials




Koziol, Crews & Bever in press

# Ecosystem Services: Carbon sequestration

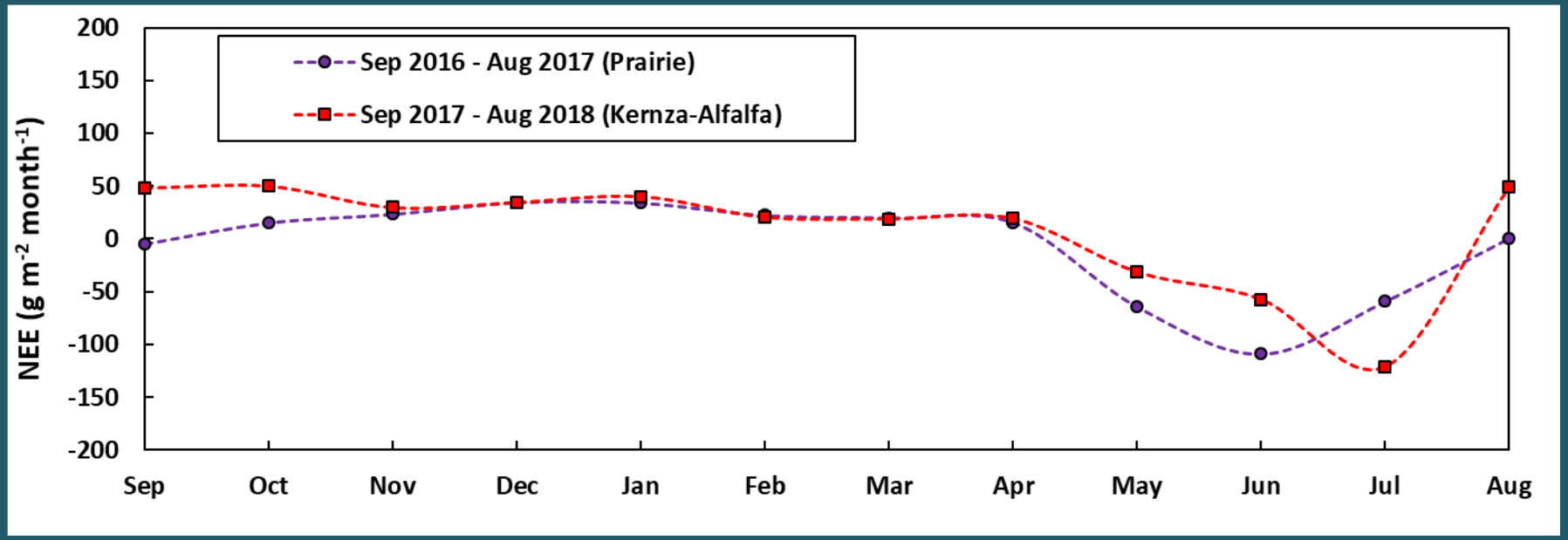
# Net Carbon Balance of Grassland to Kernza-alfalfa Conversion in Eastern Kansas




GPP = Gross Primary Production
NEE = Net Ecosystem Exchange
Reco = Ecosystem respiration

GPP = Gross Primary Production
NEE = Net Ecosystem Exchange
=Reco - GPP
Reco = Ecosystem respiration

de Oliveira, Brunsell, Crews and Kemp unpublished



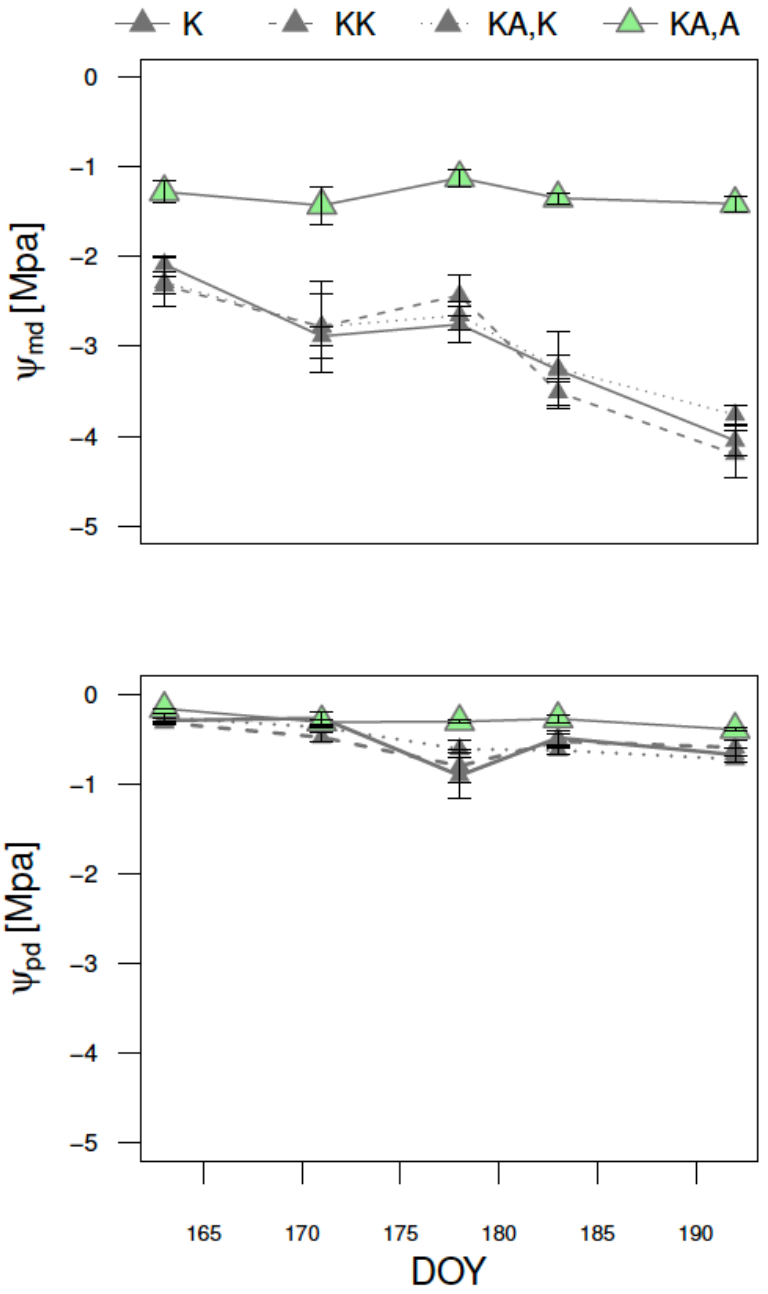

de Oliveira, Brunsell, Crews and Kemp unpublished

# Ecosystem Services: Water Resource Partitioning

Mid-day (top) and pre-dawn (bottom)
Leaf water potential in IWG (K) and IWG-alfalfa
Intercrops from June 9 - July 13

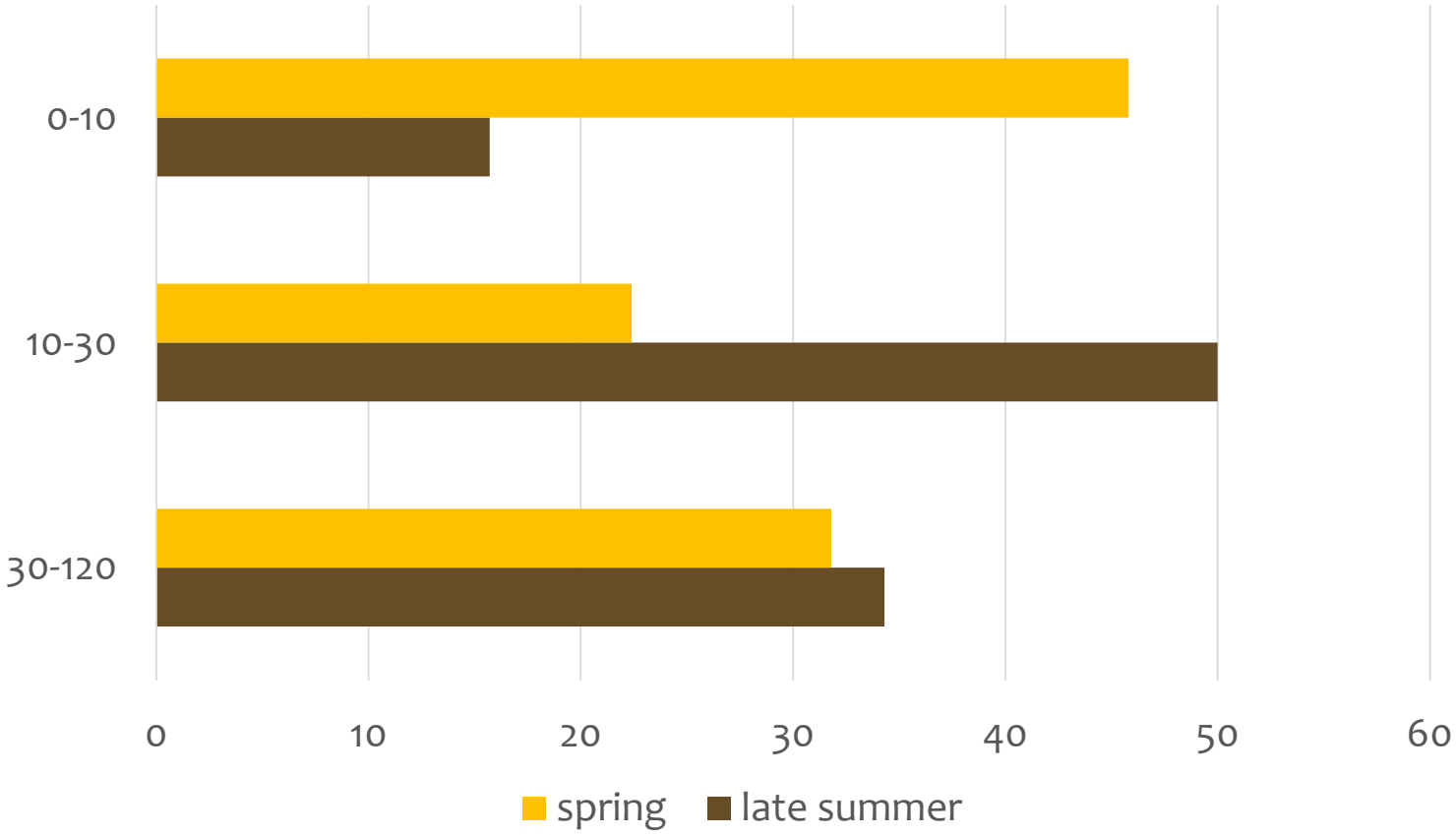
IWG growing with alfalfa (KA,K) is not more
Stressed than wide-spaced IWG single species (K)

As the summer progresses, alfalfa does not
experience the moisture stress of IWG.

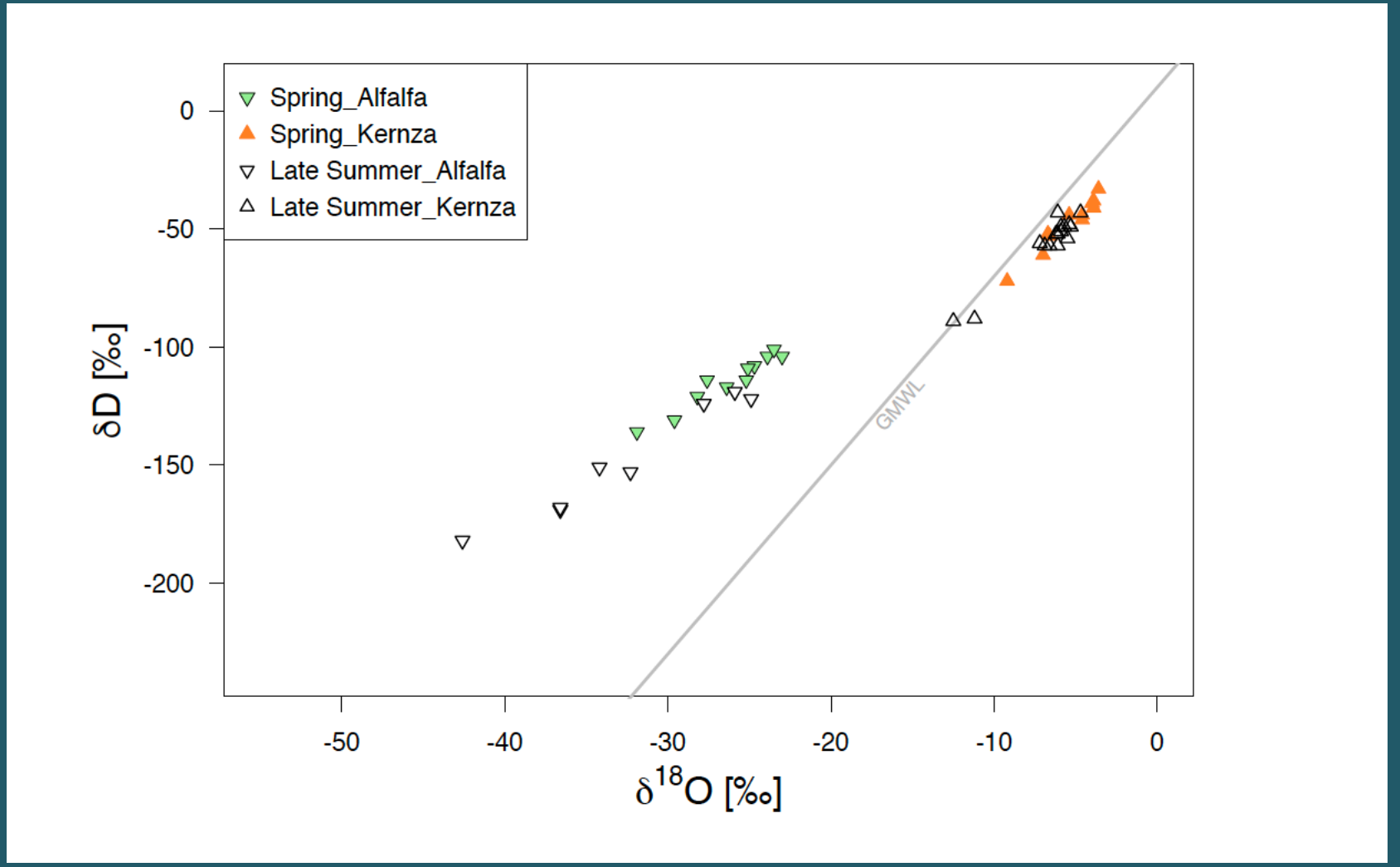



Nosshi (2019)

Percent of water uptake by intermediate wheatgrass intercropped with alfalfa from three soil depths In spring and late summer




Nosshi (2019)


Spring_Alfalfa
Spring_Kernza
Late Summer_Alfalfa
Late Summer_Kernza
GMWL
δD [‰]
0
-50
-100
-150
-200
-50
-40
-30
-20
-10
0
δ18O [‰]

Nosshi (2019)

1. Can intercropping with a legume support the nitrogen demands of an IWG crop?
   Getting there.

2. Are there other ecosystem services captured by intercropping IWG with a legume?
   Reduction in N2O emissions
   C sequestration
   Water resource partitioning and possible facilitation
   Attenuate yield decline
   Dual use forage quality

# Thanks To:


Collaborators
Ebony Murrell
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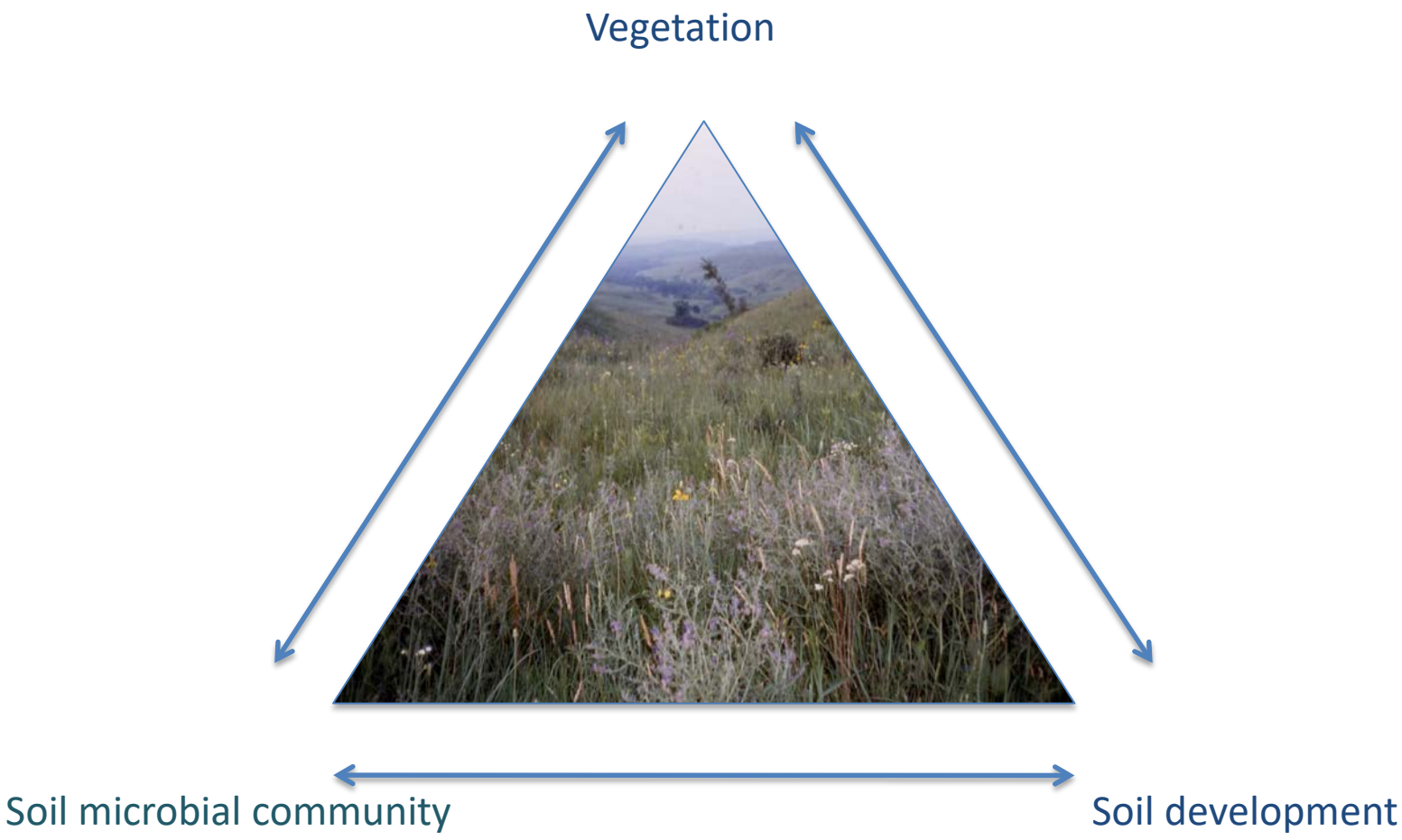
Gabriel de Oliveira
Maged Nosshi

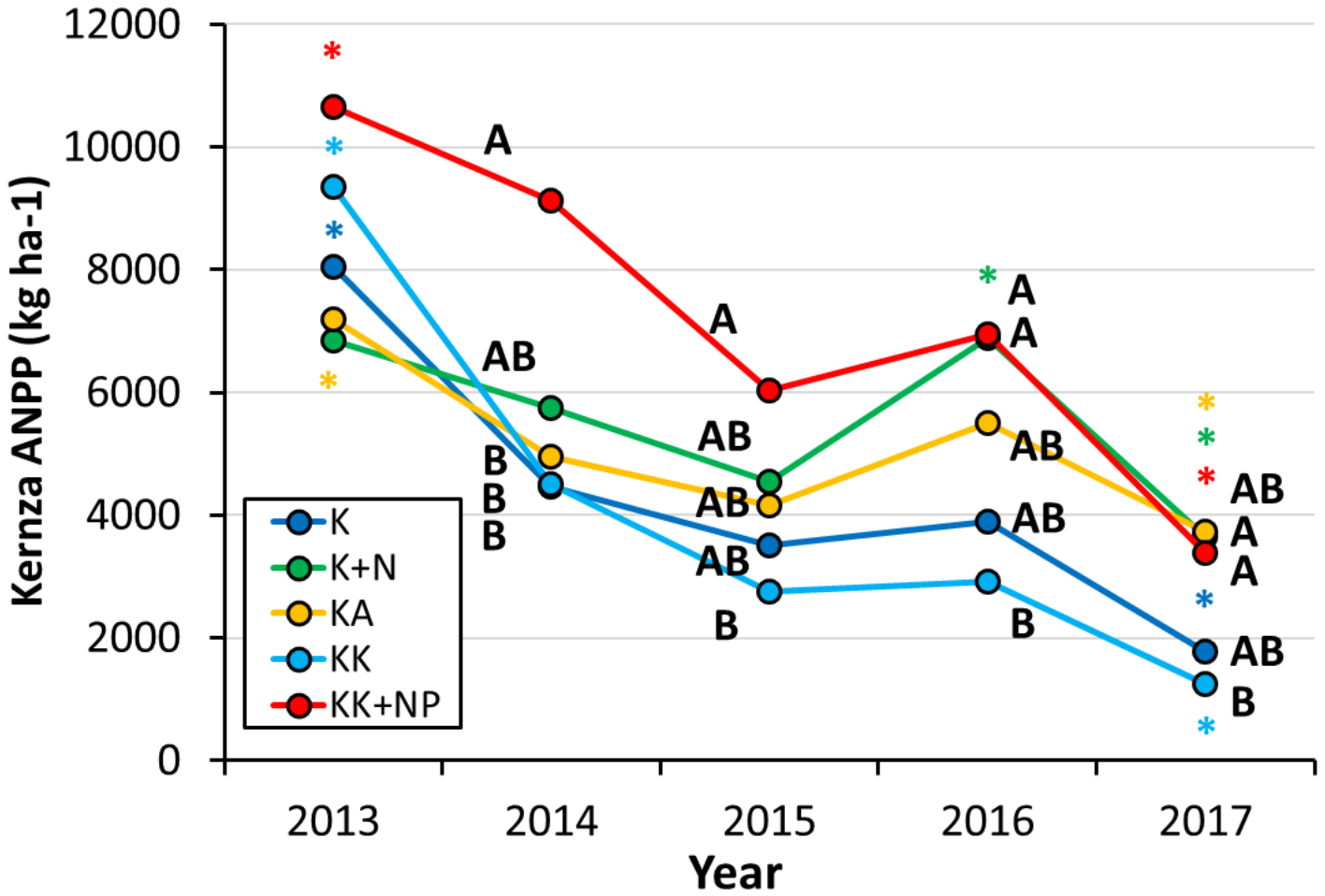
Field Assistance
Laura Kemp
James Bowden
TLI Summer Interns

Support
Malone Family Land Preservation Foundation

# Ecological Intensification



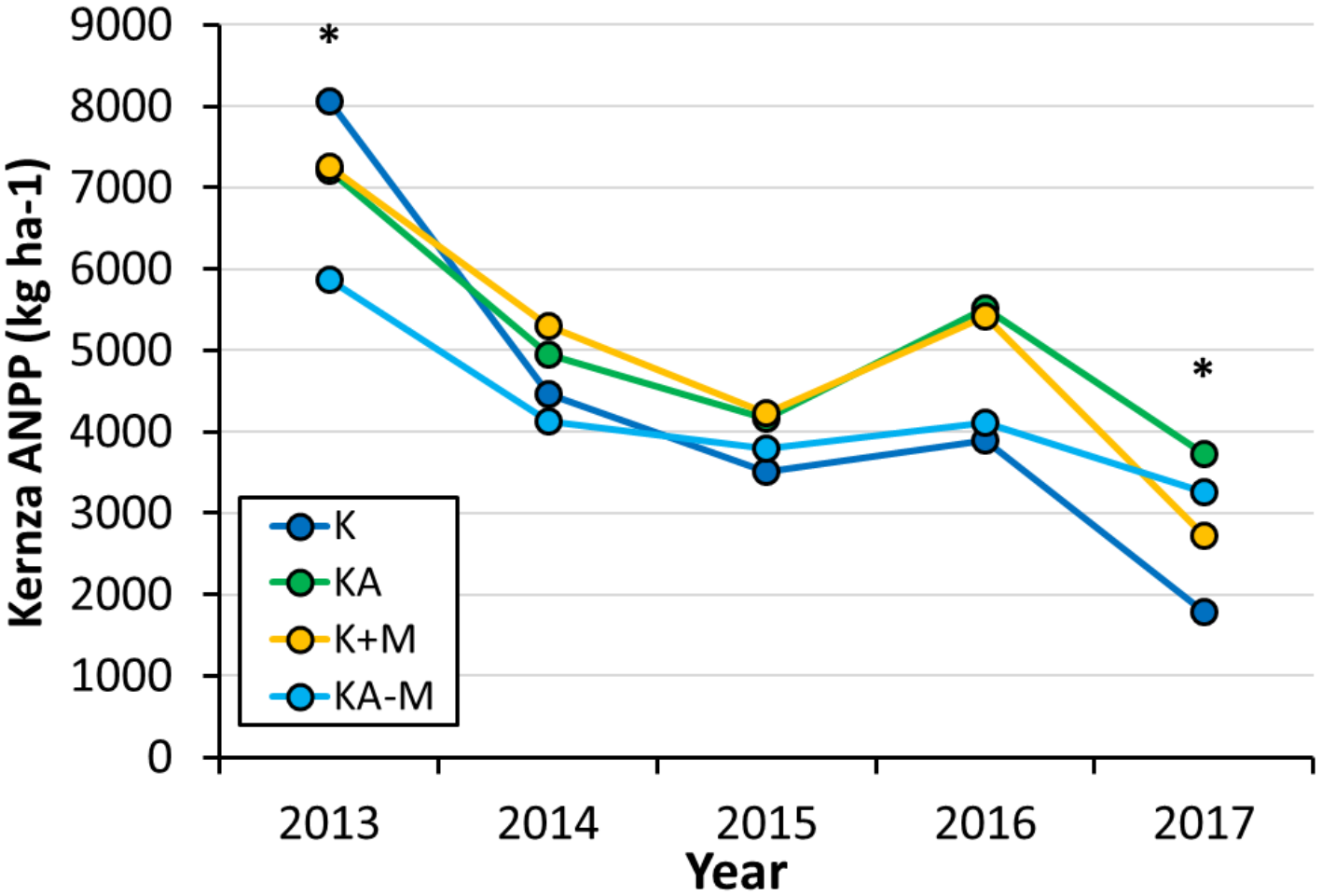
# Nitrogen Experiment – ANPP




| Mixed Model Type 3 Tests of Fixed Effects | | | | |
|---|---|---|---|---|
| **Effect** | Num DF | Den DF | F Value | Pr > F |
| **Treatment** | 4 | 15 | 11.16 | 0.0002 |
| **Year** | 4 | 59 | 69.27 | <.0001 |
| **Treatment*Year** | 16 | 59 | 3.07 | 0.0009 |

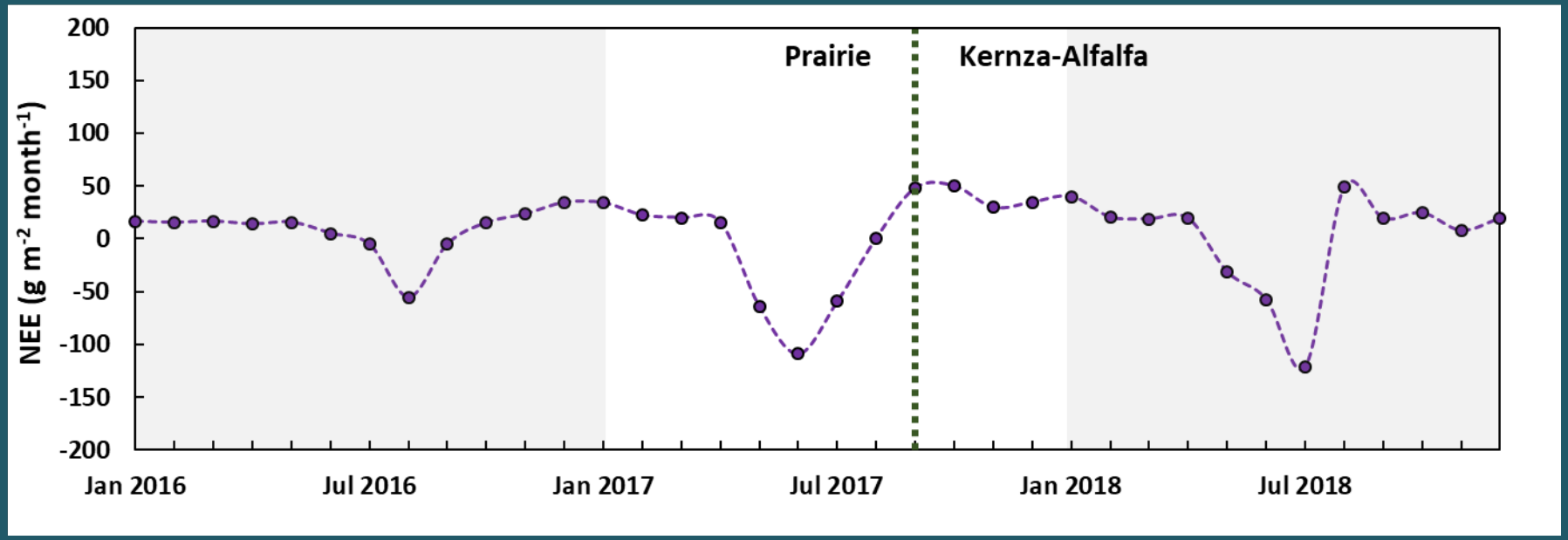
- Letters indicate differences among treatments within a given year (shared letter=no significant difference).
- All treatments declined in ANPP over time
- KK+NP had significantly higher yield than KK in all years except 2013.
- KA had lower ANPP than N-fertilized treatments in 2014, but otherwise had intermediate ANPP throughout the study.

# Mulching Experiment – ANPP




| Mixed Model Type 3 Tests of Fixed Effects | | | | |
|---|---|---|---|---|
| **Effect** | Num DF | Den DF | F Value | Pr > F |
| **Treatment** | 3 | 12 | 2.52 | 0.1073 |
| **Year** | 4 | 47 | 34.32 | <0.0001 |
| **Treatment*Year** | 12 | 47 | 1.79 | 0.0770 |

- No significant treatment or treatment*year interaction effects
- ANPP in all treatments dropped significantly between 2013-2014, was stable for 3 years, then significantly dropped again in 2017.




de Oliveira, Brunsell, Crews and Kemp unpublished

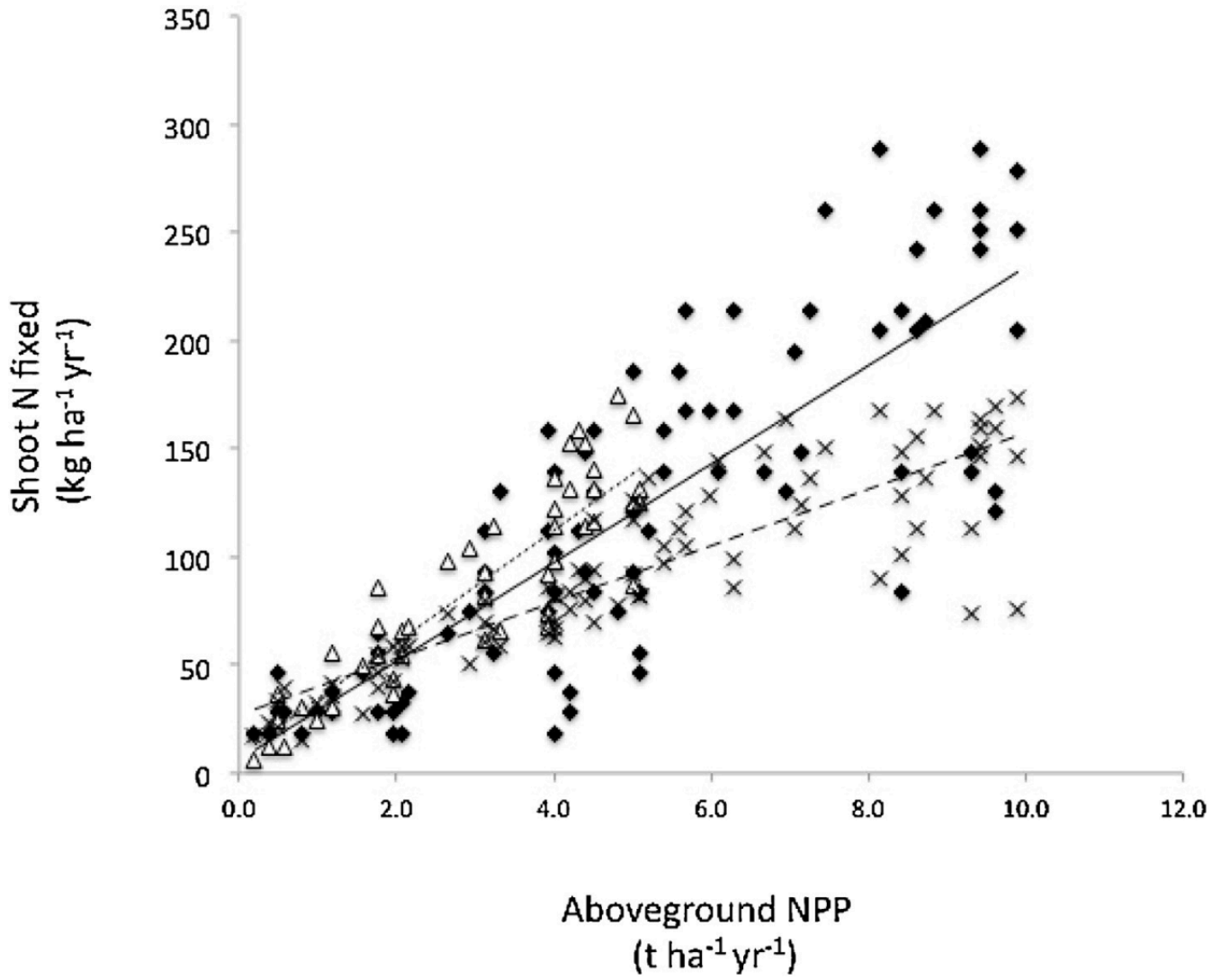



**Fig. 4.** The amounts of shoot N fixed as a function of aboveground net primary productivity (ANPP) in perennial forage legumes (solid diamonds, n = 83, y = 22.81x + 6.21, $R^2$ = 0.68), annual forage legumes (open triangles, n = 46, y = 26.01x + 8.37, $R^2$ = 0.78), and annual crop legumes (Xs, n = 123, y = 13.06 + 26.92, $R^2$ = 0.75). Perennial forage data from Carlsson and Huss-Danell (2003), annual forage data from Unkovich et al. (2010), and annual crop legume data from Peoples et al. (2009a).

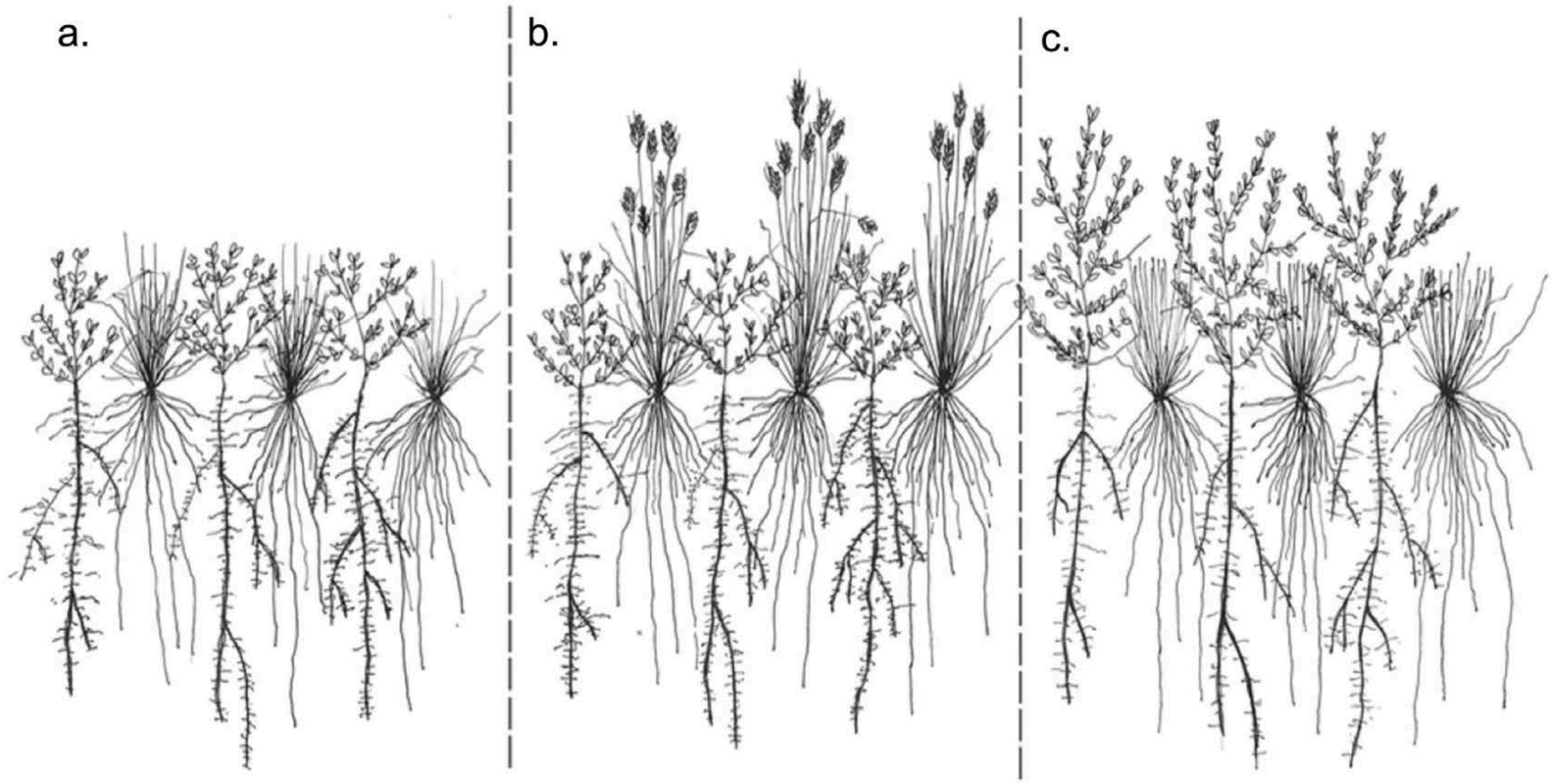



**Fig. 1.** Example of a perennial grain-legume intercrop through a growing season. (a) **Spring**. The two species break winter dormancy producing similar aboveground biomass. (b) **Early summer**. The canopy of the grain crop overshadows and suppresses the legume. **Late summer**. Following grain harvest, light reaches the legume inducing a surge of growth and $N_2$ fixation. Livestock grazing or mowing may be employed to manage biomass accumulation.