

# Multi-species mixtures increase yields & drought resilience, with lower nitrogen inputs

*John Finn, Guylain Grange, Saoirse Cummins, Eamon Haughey, Dominika Krol, Caroline Brophy, Matthias Suter, Laura Kirwan, John Connolly, Andi Luescher*  
*@johnfinn310*

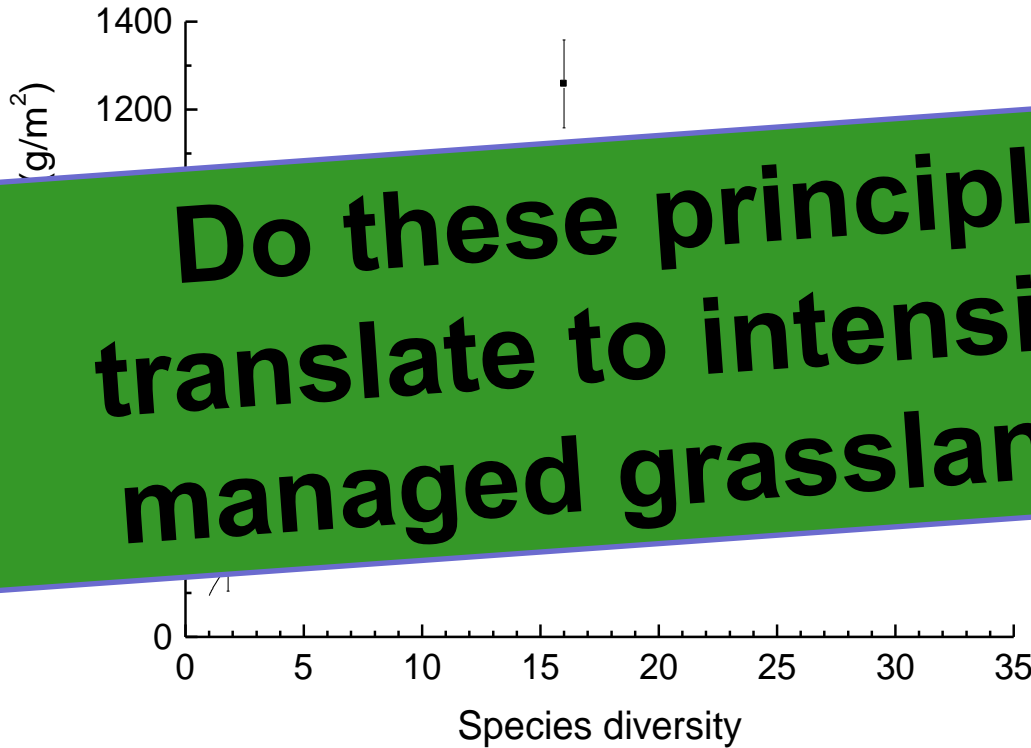


## Overview

1. Effects of mixtures on yield and weeds
2. How do mixture yields respond to lower rates of N fertiliser?
3. Can mixtures mitigate drought effects?
4. Next steps



**Aboveground biomass declines with loss of plant species richness  
...but semi-natural grassland, no fertiliser**



**Do these principles  
translate to intensively  
managed grasslands?**



(Hector et al., *Science*, 1999).

# COST 852: 'AgroDiversity' expt.

## Objectives

### Agronomic sites

### Species richness (low levels)

1, vs 4 species

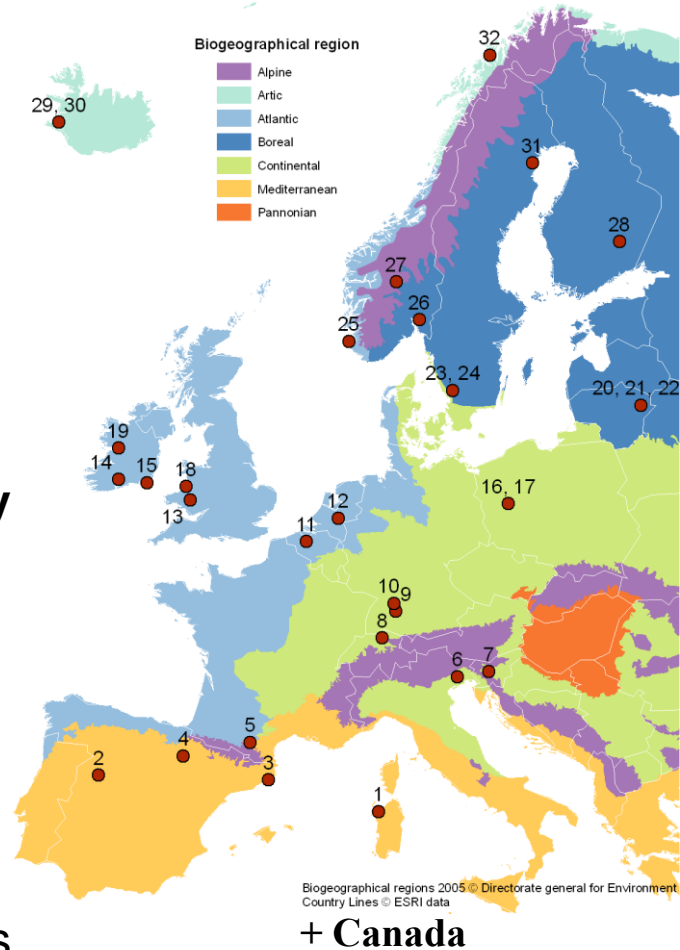
### Species proportions systematically varied across mixtures:

100, 25:25:25:25





70:10:10:10, 40:40:10:10

## Methods

Simplex design, 31 sites, 17 countries  
= 930 plots



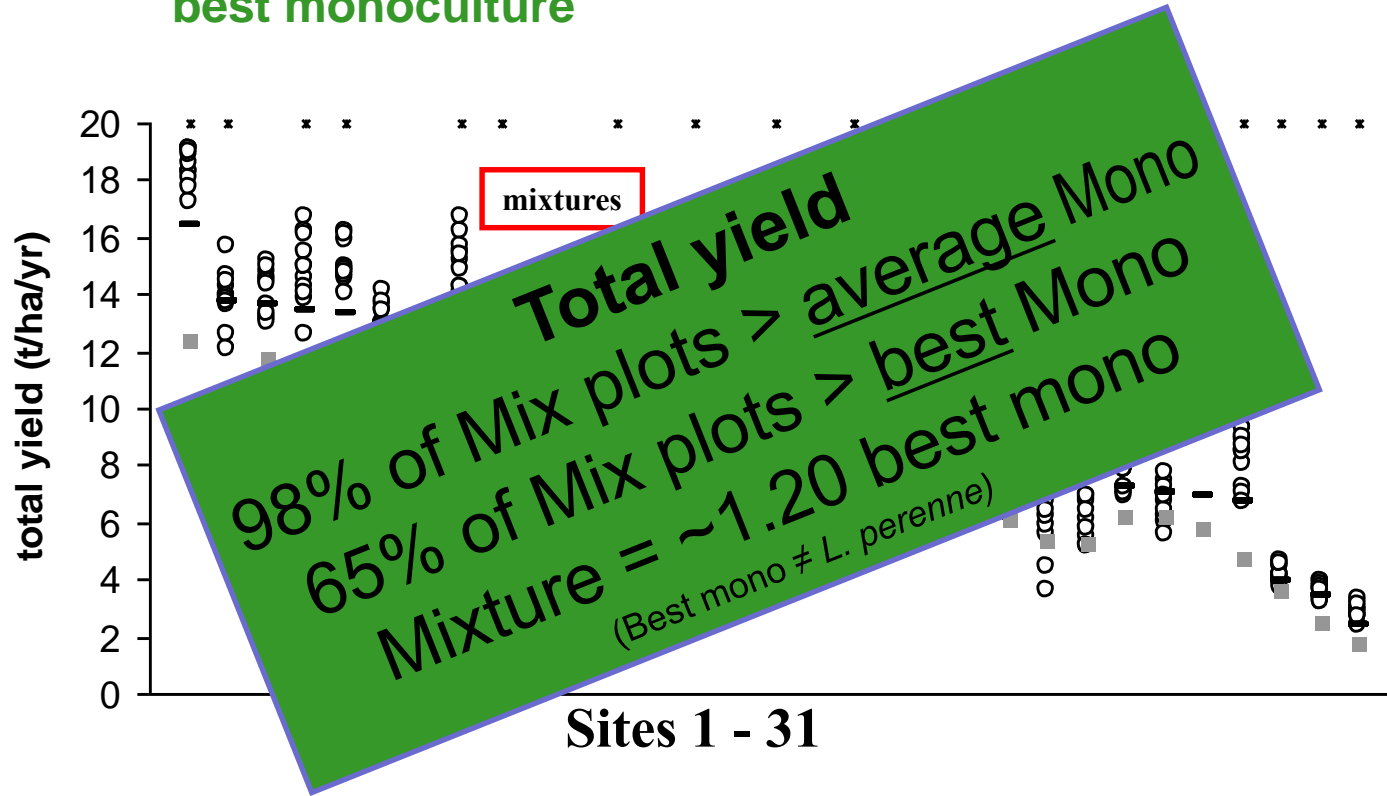
# Functional types:

	Grass	Legume
Fast	 <p>Perennial ryegrass</p>	 <p>Red clover</p>
Slow	 <p>Cocksfoot</p>	 <p>White clover</p>

# RESULTS



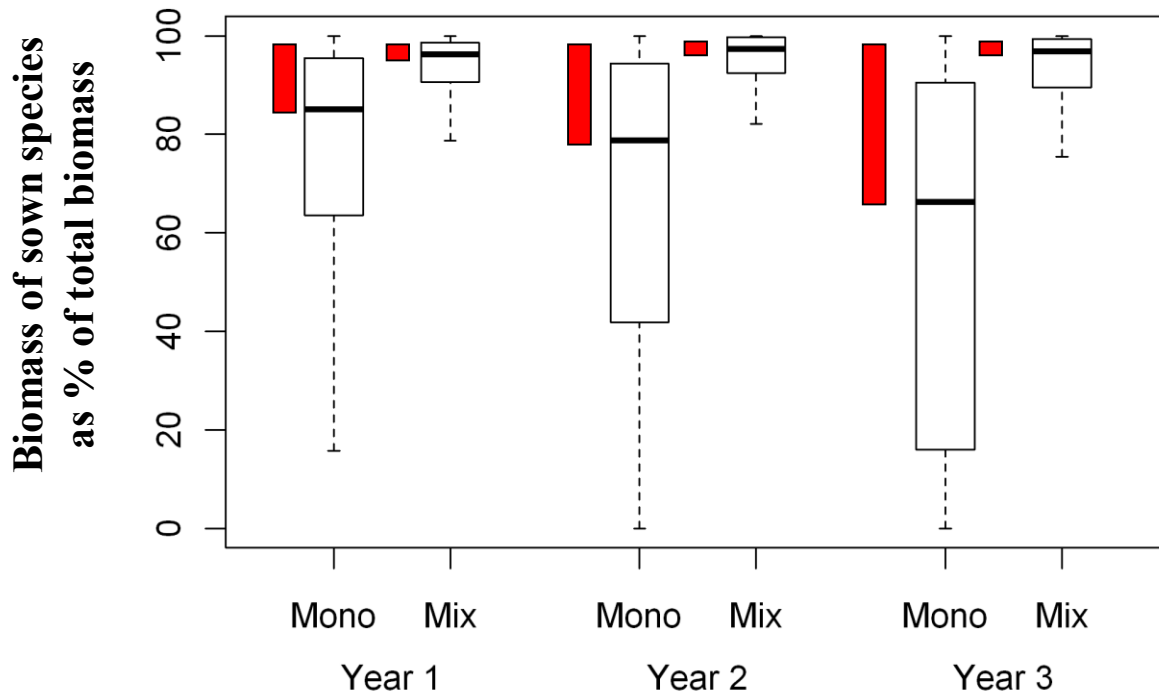
## Annual total yield of mixtures generally exceeded best monoculture



Total annual yield (includes weeds) at each of 31 sites.  
Horizontal lines = best-performing monoculture  
boxes = mean monoculture performance (Finn et al. 2013, J Appl Ecol)

# Mixtures are considerably more resistant to weed pressure

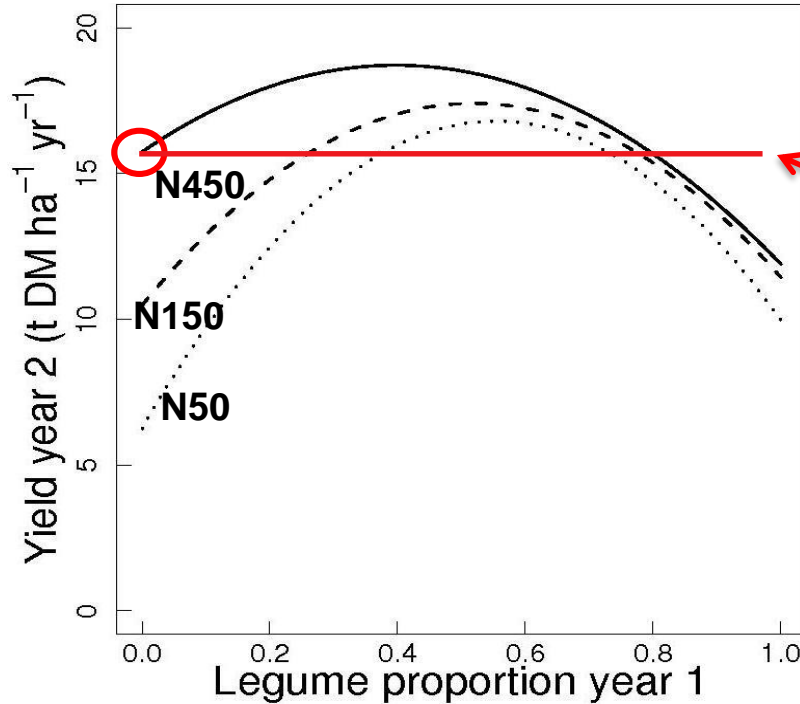
Red bars = proportion of weeds in yield



Mixture = ~4% weeds,  
Monocultures = 15% year 1; 32% year 3  
(Finn et al. 2013, J Appl Ecol)

# How do mixture yields respond to lower rates of N fertiliser?

# Balanced grass/legume mixtures at N50 can be as productive as grass monocultures at N450



Higher nitrogen  
fertiliser reduced  
legume % in  
swards

Grass only  
450 kg/ha N

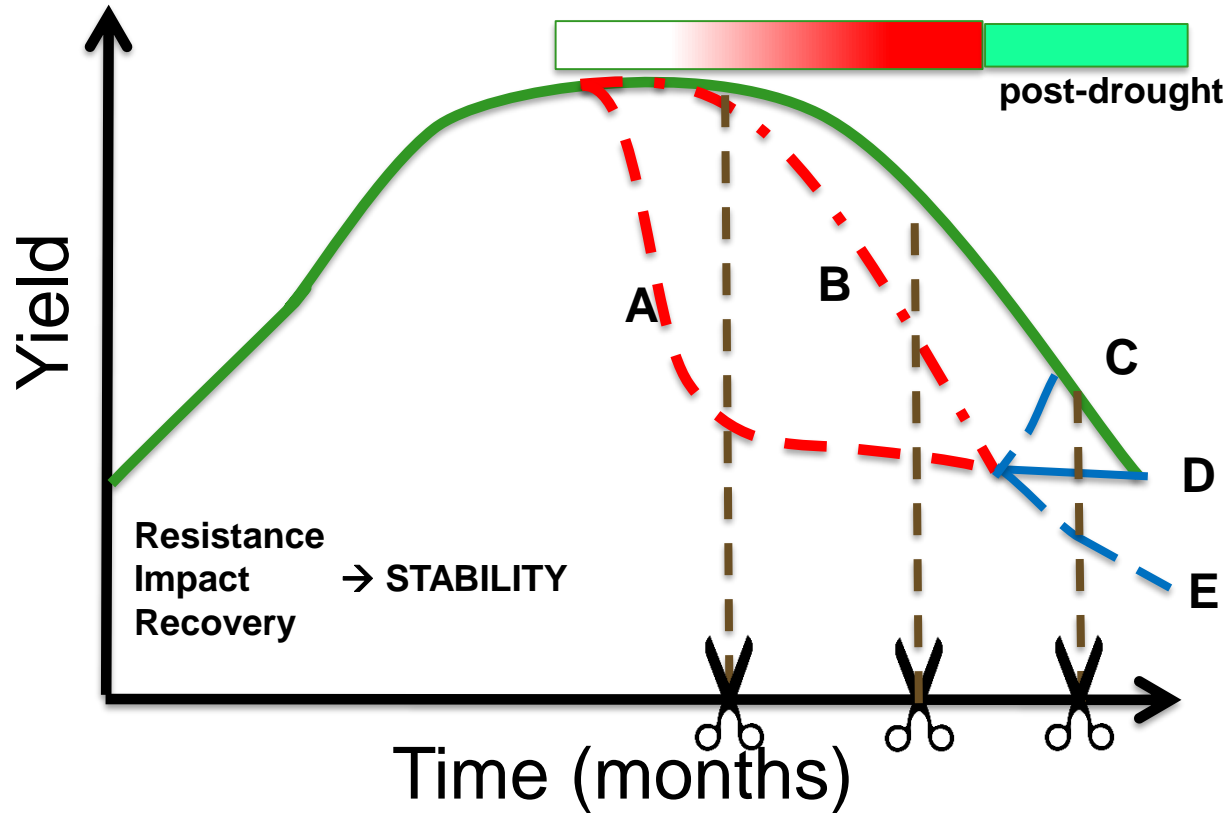
From: Nyfeler *et al.* 2009. J. Applied Ecology

# Can mixtures provide 'insurance' against drought?



# How will drought affect yield?





## What are the effects of diversity?



# Can mixtures better resist and recover from environmental stresses than monocultures (EU AnimalChange)?

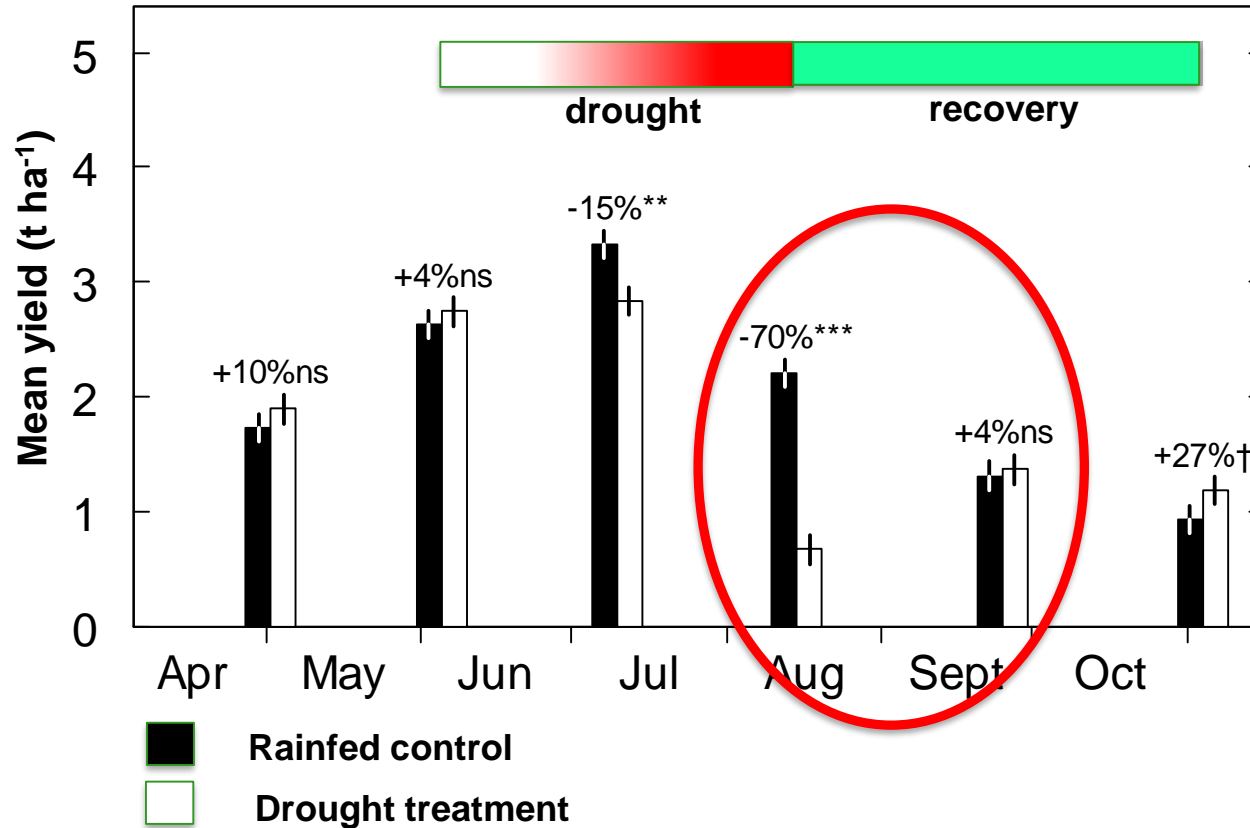


## 4 species

	Shallow-rooting (SR)	Deep-rooting (DR)
Non-fixing	 <i>L. perenne</i>	 <i>C. intybus</i>
N <sub>2</sub> fixing	 <i>T. repens</i>	 <i>T. pratense</i>

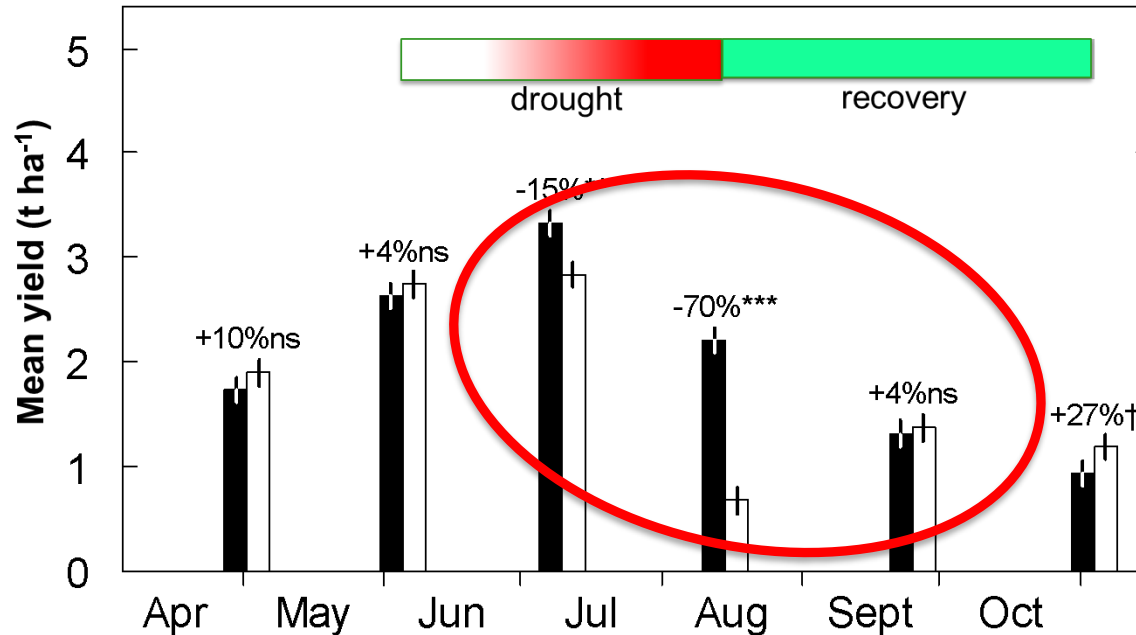
- Ireland (Teagasc) + Switzerland (Agroscope)
- Species: functional traits
- 1, 2, 4 species
- 36 main plots, rain shelter for **9 weeks** on 3m x 5m sub-plot
- 150 (IE), 200 (CH) kg N ha<sup>-1</sup>
- mowing

# Drought effects were severe; but grassland species very resilient once soil moisture restored (all plots)

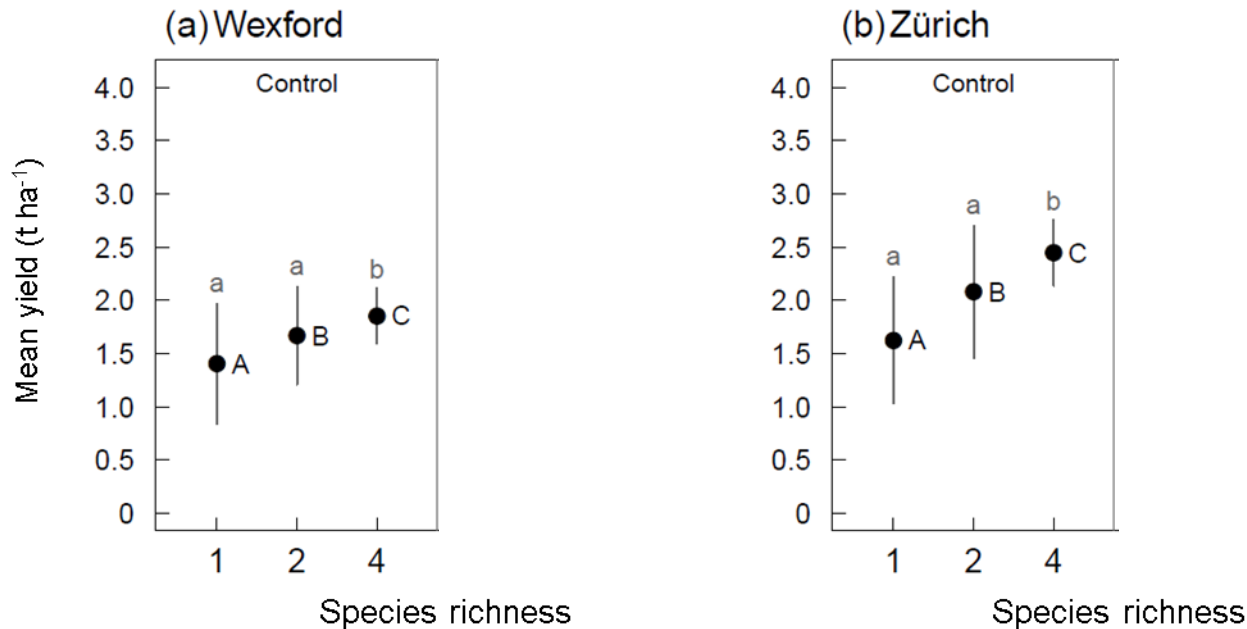


# What is the effect of species diversity?

Examined yields across three harvests (mid-drought, end-of-drought and recovery) and two years, Ireland and Switzerland.

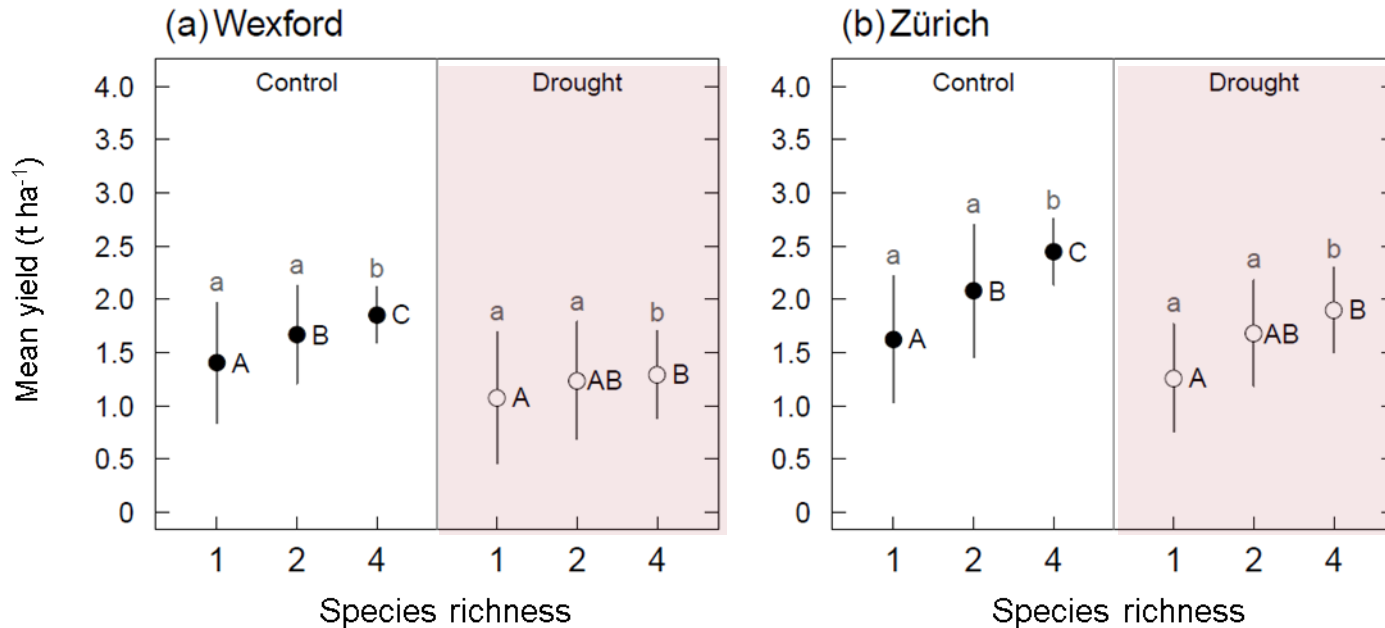


# Species diversity increased mean yield & reduced yield variation = yield stability



Effects of drought and species richness on average harvest yield and yield variance under rainfed control and drought conditions. Means across six harvests: three harvests X two years. (Haughey et al. 2018, *Nature Scientific Reports*)

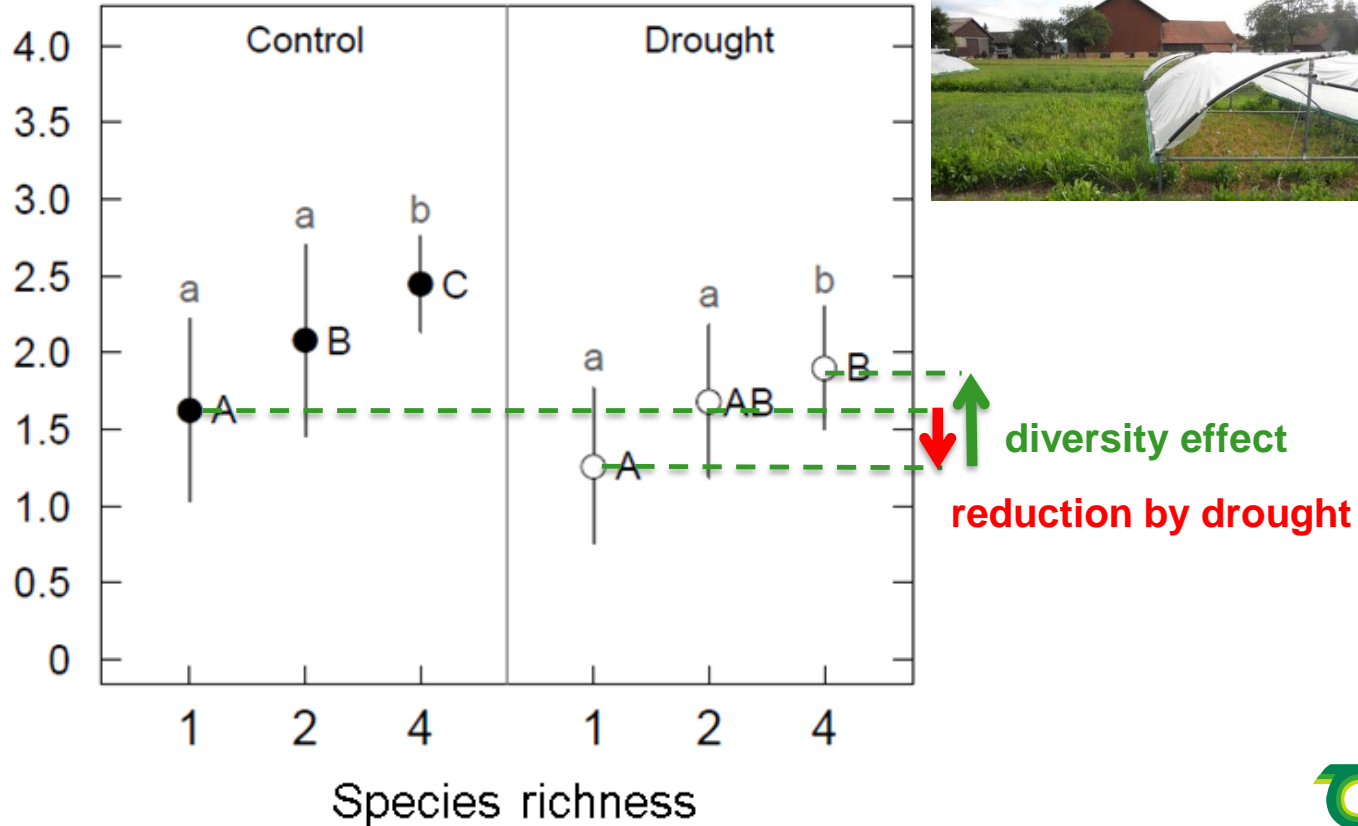
# Species diversity increased mean yield & reduced yield variation = yield stability ...even under drought



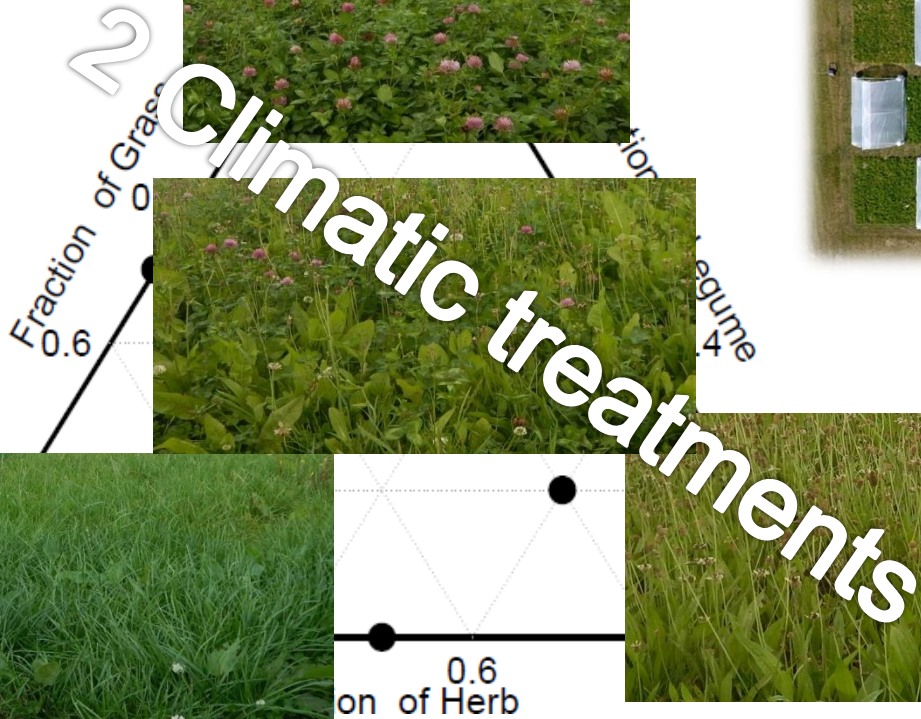
Effects of drought and species richness on average harvest yield and yield variance under rainfed control and drought conditions. Means across six harvests: three harvests X two years. (Haughey et al. 2018, *Nature Scientific Reports*)

# Mixtures mitigated drought effects on yield

(4-species mixtures under drought treatment attained or exceeded average monoculture yields under rainfed conditions)



# Johnstown expt. (6 species)







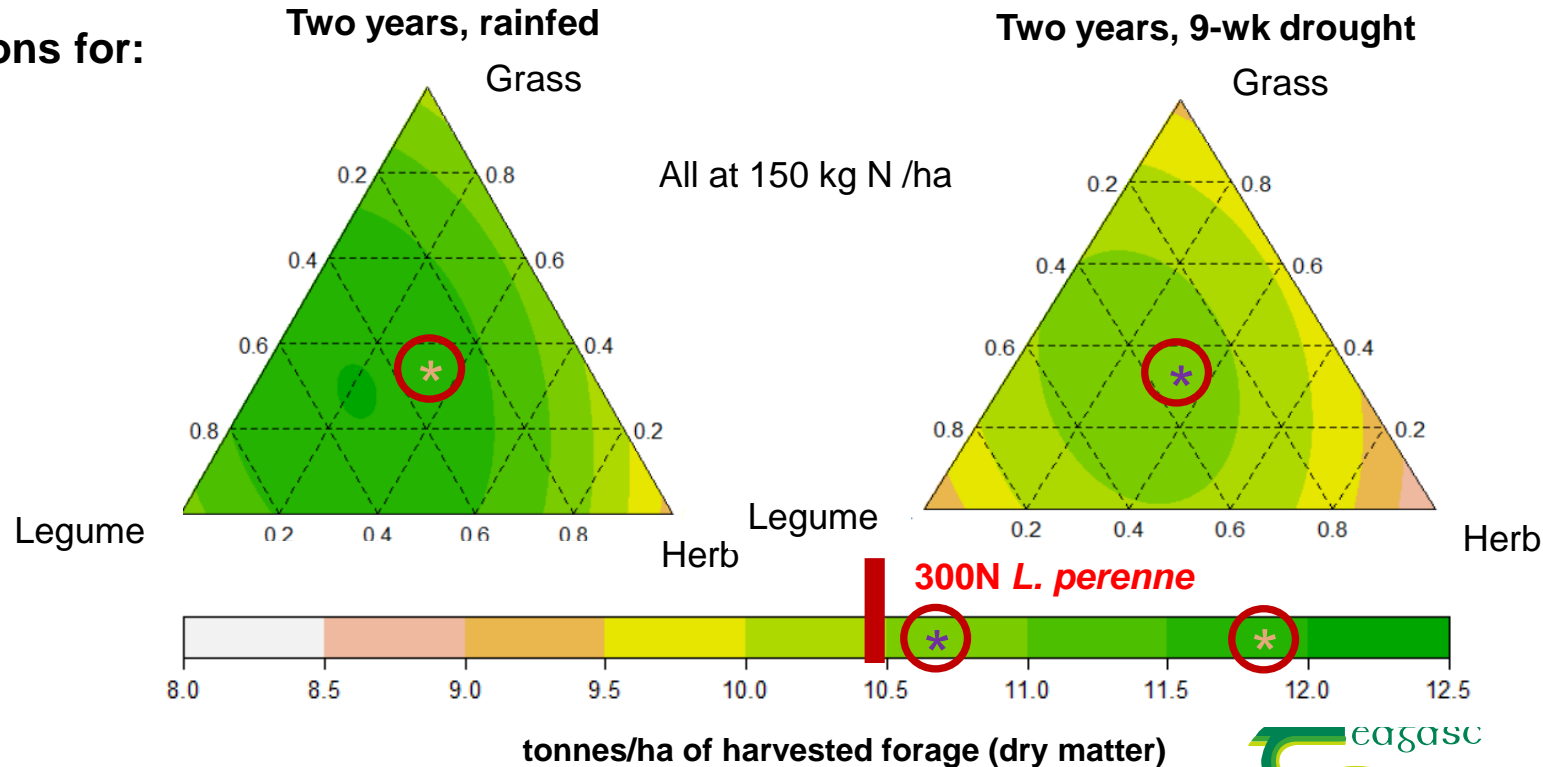
# Drought experiment, 6 species

Grange et al (accepted) J App. Ecology

Cummins et al (in review)

## Positive indications for:

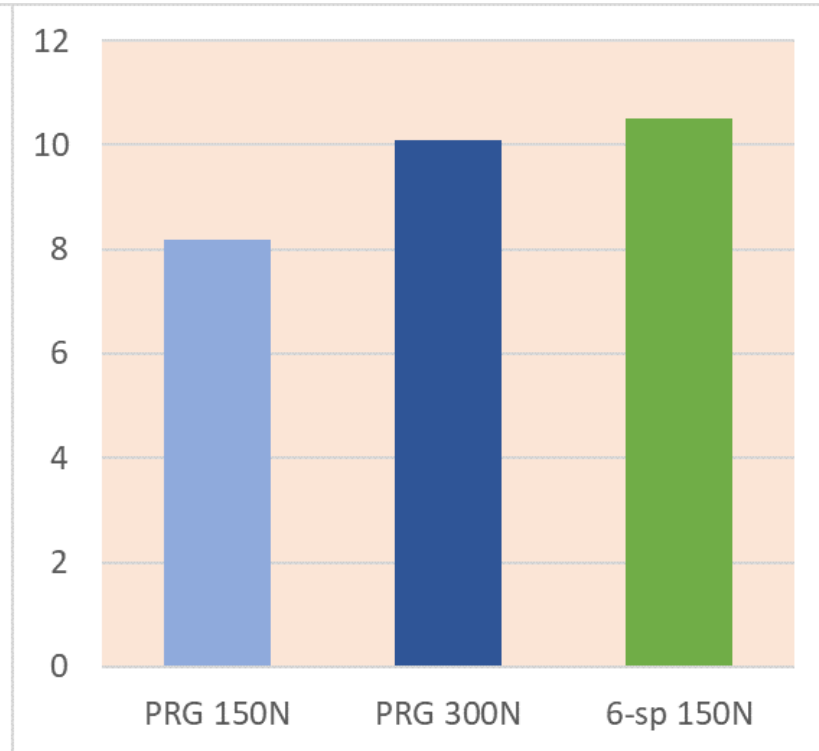
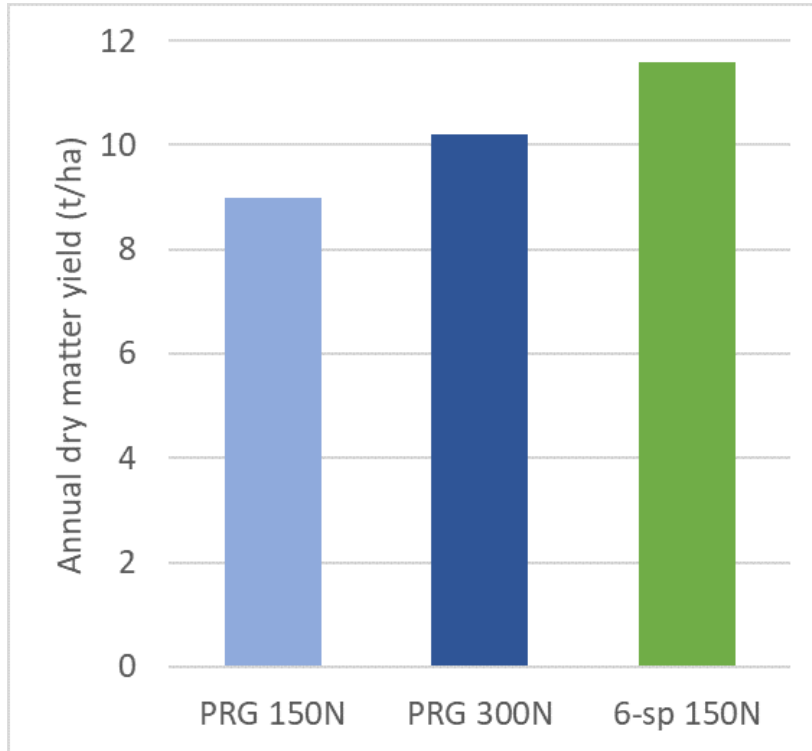
- Emissions
- Invasion
- N content



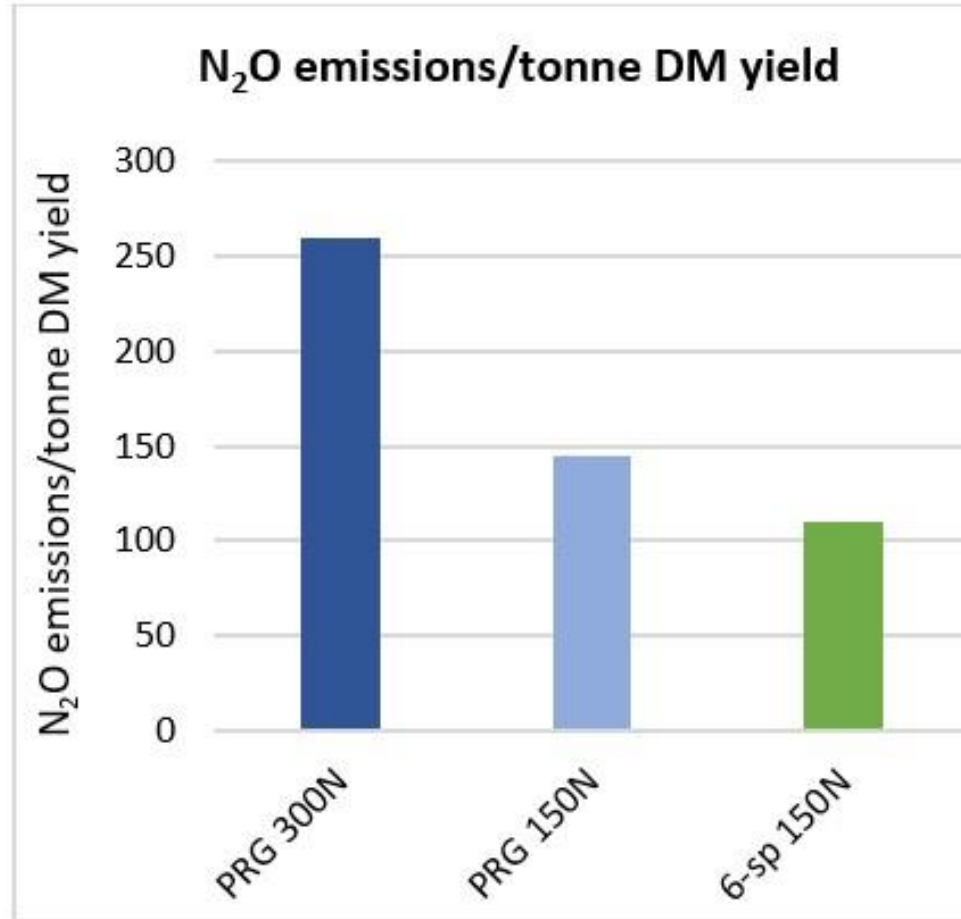
# Higher yields from 6-species mix (2018)

rainfed (control)

experimental drought



# N<sub>2</sub>O emissions intensity: lower from mixtures



(Cummins et al., in review)

# Conclusions

- Diversity matters: strategic selection of species important for mixture design
- Mixtures benefit: yields, weed resistance, protein self-sufficiency, nitrogen efficiency, yield stability under drought, N<sub>2</sub>O emissions intensity
- Legume % is important to achieve mixture benefits



# Next steps

- Grazing trials
- Soil fertility effects
- Soil C sequestration
- Anaerobic digestion



More at: <https://farmecol.blogspot.com/>

