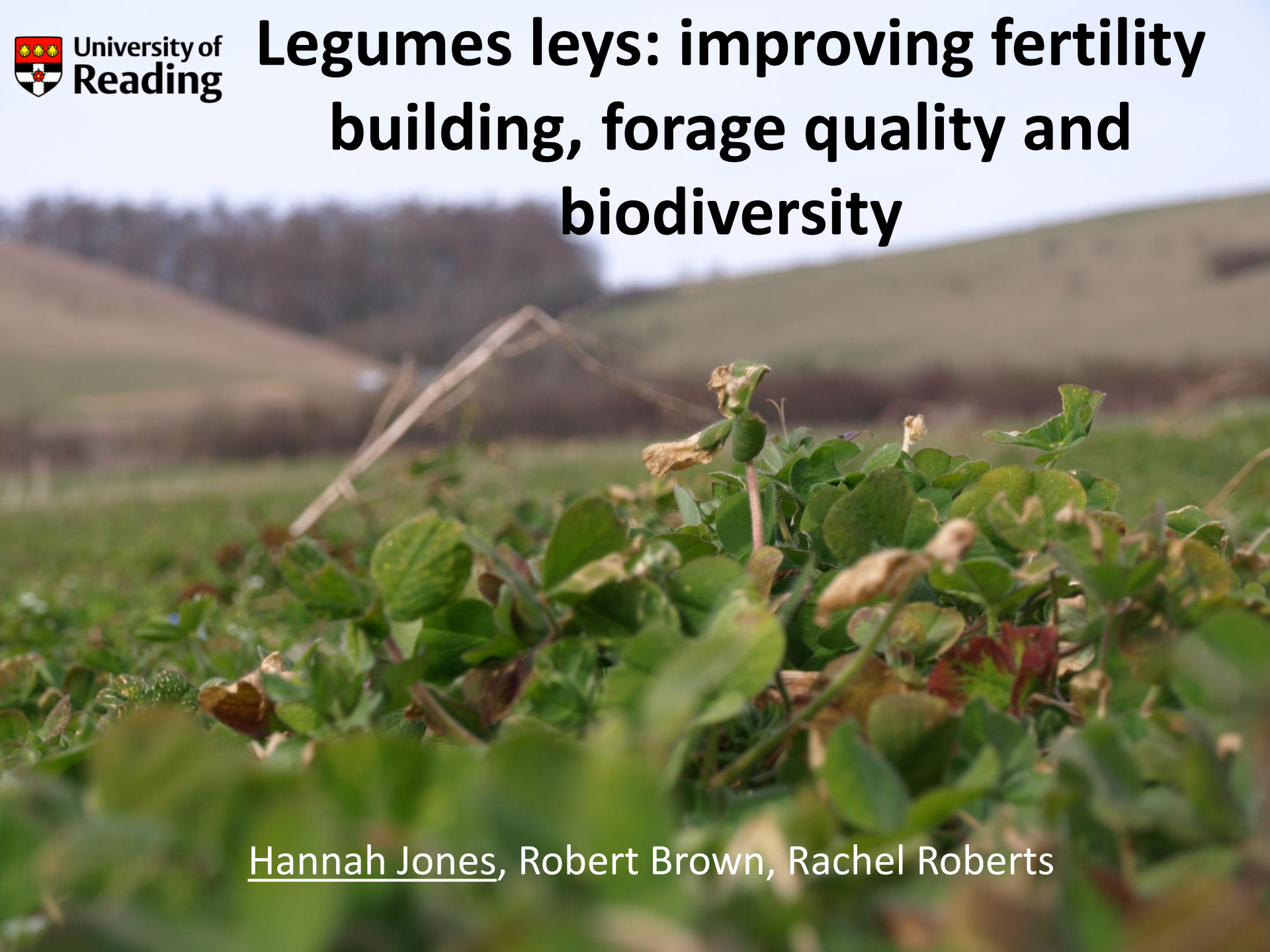
University of Reading

Legumes leys: improving fertility building, forage quality and biodiversity



Hannah Jones, Robert Brown, Rachel Roberts

Agronomic

First year N fixation
Silage/ Hay
Early grazing
3 year longevity
Deep rooting
Weeds suppressive
Low bloat risk
Spring or autumn sowing

Environmental

Drought tolerance
Flood tolerance
High biomass
Frost tolerant
Low/high pH tolerant
High organic matter
Enhance biodiversity
Reduces N leaching from residues

Each legume species has its strengths and its weaknesses

August 2013

HGCA

Project Report No. 513

Using legume-based mixtures to enhance the nitrogen use efficiency and economic viability of cropping systems

by

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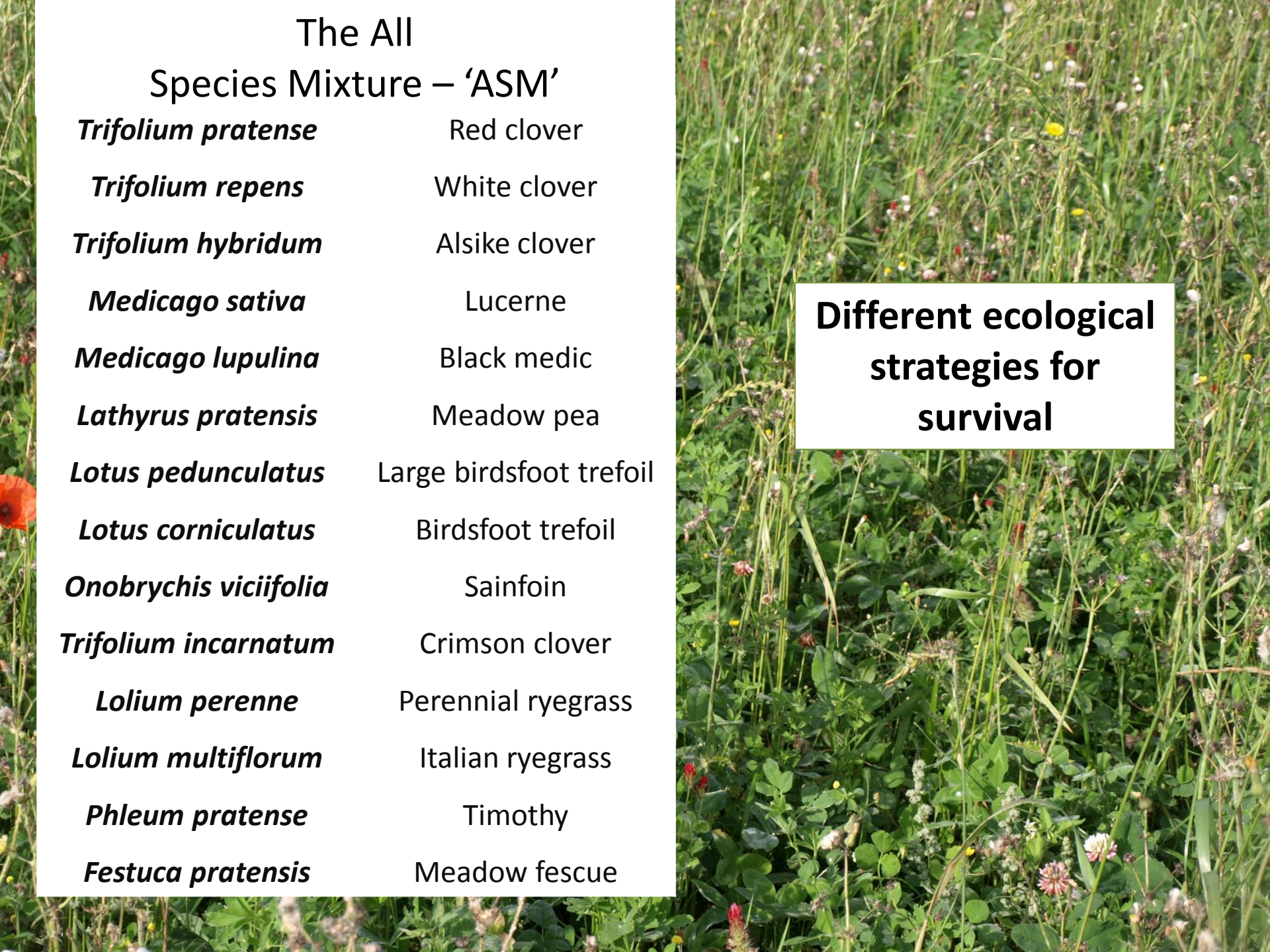
The All Species Mixture – 'ASM'

Trifolium pratense	Red clover
Trifolium repens	White clover
Trifolium hybridum	Alsike clover
Medicago sativa	Lucerne
Medicago lupulina	Black medic
Lathyrus pratensis	Meadow pea
Lotus pedunculatus	Large birdsfoot trefoil
Lotus corniculatus	Birdsfoot trefoil
Onobrychis viciifolia	Sainfoin
Trifolium incarnatum	Crimson clover
Lolium perenne	Perennial ryegrass
Lolium multiflorum	Italian ryegrass
Phleum pratense	Timothy
Festuca pratensis	Meadow fescue



Different ecological strategies for survival

LegumeLINK project results – **Engineering an ecosystem to deliver multiple services.** Storkey et al, 2014 (in press)

Grass + Legume = A good combination of….

- Early season productivity
- Regrowth after cutting
- Weed suppressive
- Support insect diversity
- Good wheat yield after incorporation
- Residue composition reduces diffuse pollution

The success of a legume is pre-determined by root nodulation

	Control		
Legume	Number of plants assessed over 10 farm sites	Plants nodulated	Mean no. nodules ±1 SE
Black medic	84	22 (26%)	2.9 ±0.41
Lucerne	85	22 (26%)	2.2 ±0.33
Red clover	87	84 (97%)	5.6 ±0.36
White clover	85	85 (100%)	4.8 ±0.31

Rhizobia species specificity to legumes within the ASM

Root system of lucerne, showing healthy pink root nodules, and numerous small ineffective nodule (white arrows)

Host legume	Rhizobia species	Bacterial strain code
White clover	*Rhizobium leguminosarum* bv. *trifolii*	RCR221*
Red clover		
Alsike clover		
Crimson clover		RCR226
Black medic	*Sinorhizobium meliloti*	RCR2011*
Lucerne		
Sainfoin	*Rhizobium gallicum* bv. *gallicum*	RCR3007
Birdsfoot trefoil	*Mesorhizobium loti*	RCR3002
Large birdsfoot trefoil		RCR3209
Meadow pea	*Rhizobium leguminosarum* bv. *viciae*	RCR1001*

Good, mediocre and bad lucerne rhizobia

E. meliloti

E. medicae

S.fredii

	pH	*E. meliloti*	*E. medicae*	*S. fredii*	No. nodules black medic	No. nodules lucerne
	4.9	-	-	-	0	0
	5.3	-	-	-	0	0
	5.5	4	-	-	2	7
	5.9	-	-	14	34	40
	6.0	-	2	8	16	3
	6.4	-	-	-	0	1
	6.7	8	21	-	56	59
	7.0	7	11	-	47	60
	7.1	2	10	-	30	16
	7.3	4	2	-	27	7

9 lucerne plants selected per site

Lucerne (and black medic) can nodulate with three different rhizobium species found in farm soils

E. meliloti is the best, *E. medicae* is effective, but *S. freddii* is highly detrimental

E.meliloti is effective at low pH, but was not recovered from soils below 6.7, even in other soils inoculated 3 years previously.

pH affects the long term survival of rhizobia in the soil.

Lucerne + *E. meliloti* are acid tolerant, but not independently so

In a diverse legume mixture which includes a significant proportion of black medic, lucerne and white clover….

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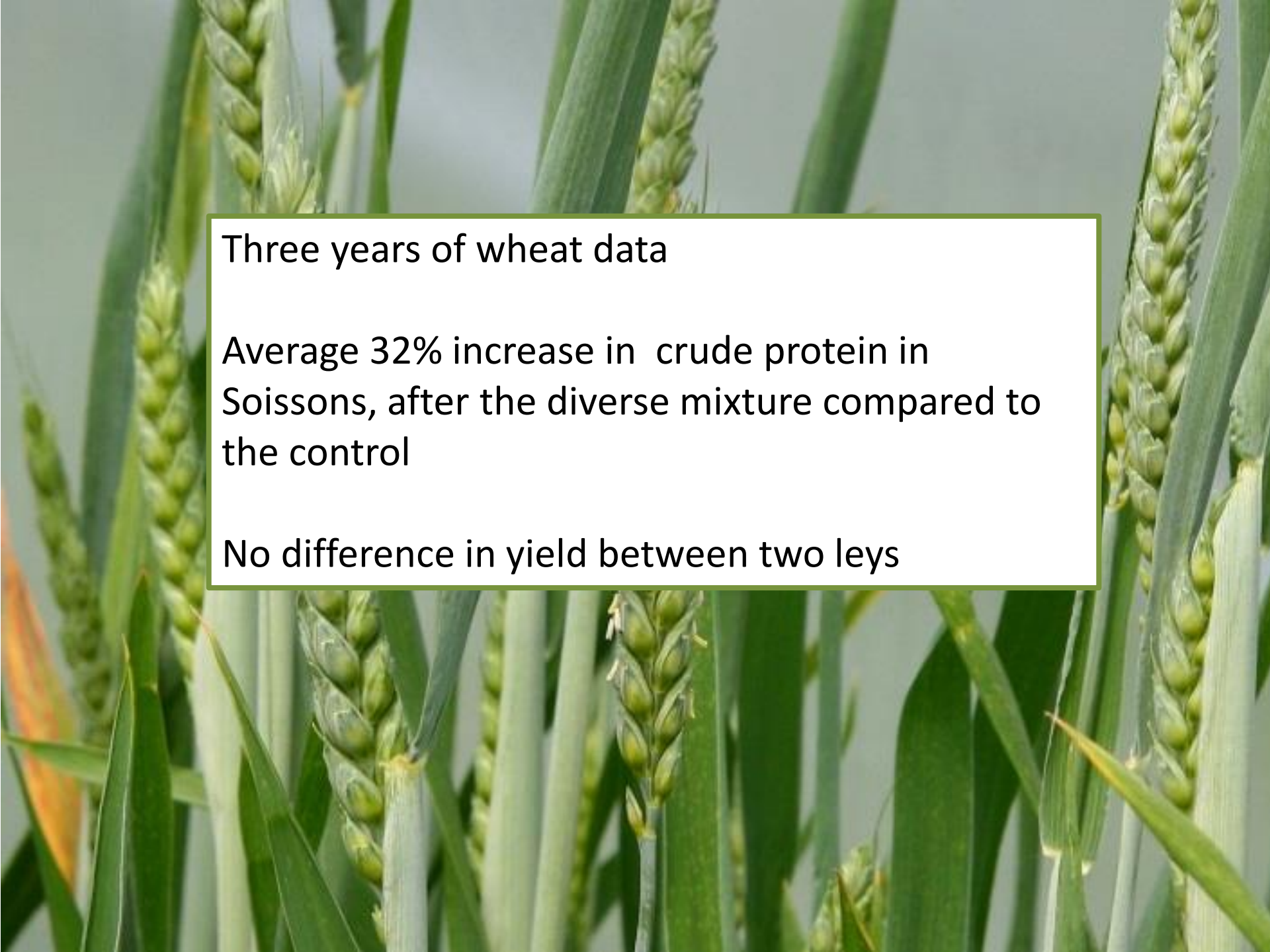
Lolium multiflorum	Italian ryegrass
Phleum pratense	Timothy

The ‘Control’

Trifolium pratense	Red clover
Dactylis glomerata	Cocksfoot
Trifolium repens	White clover
Dactylis glomerata	Chicory



Three years of wheat data

Average 32% increase in crude protein in Soissons, after the diverse mixture compared to the control

No difference in yield between two leys

At mid-stem extension, the control *probably* provided more nitrogen compared to the diverse mixture

But

At harvest N is significantly higher after the diverse mixture compared to the control

So

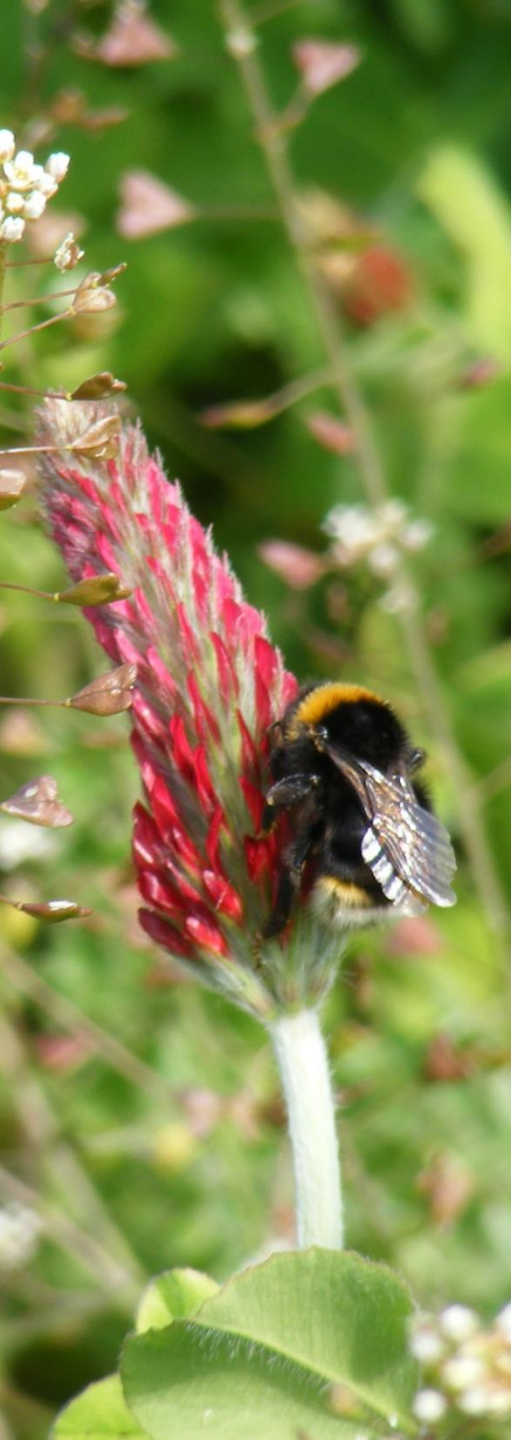
The diverse mixture probably releases more late season N compared to the control

Two years of forage data (but three data sets from leys of different ages)

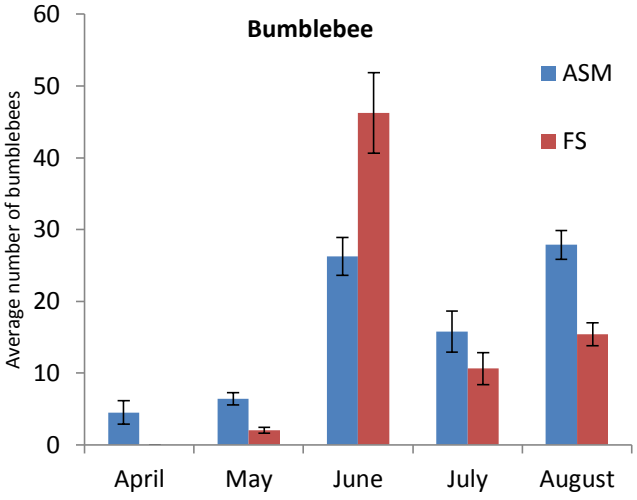
32% increase in crude protein in forage in ASM

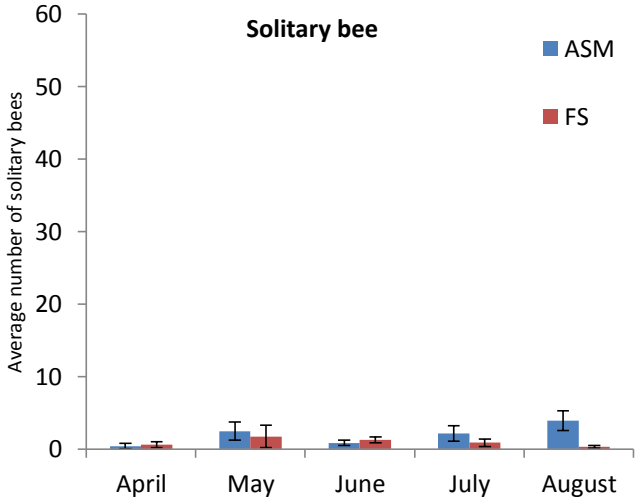
The leys behaved as expected: leafy material (early cuts) had higher protein

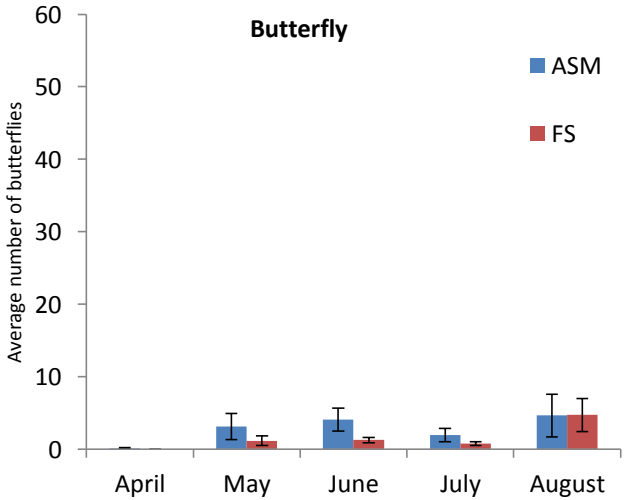
No difference in metabolisable energy between leys, but early cutting better than late cuts

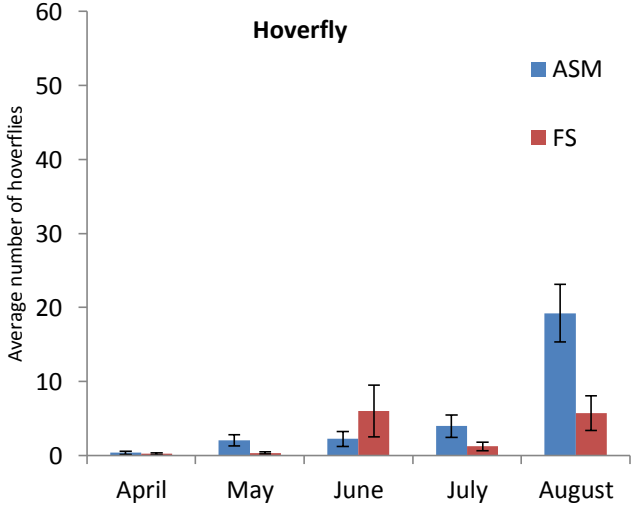


And finally…


Bumblebee
Average number of bumblebees
60
50
40
30
20
10
0
April
May
June
July
August
ASM
FS


Solitary bee
Average number of solitary bees
60
50
40
30
20
10
0
April
May
June
July
August
ASM
FS


Butterfly
Average number of butterflies
60
50
40
30
20
10
0
April
May
June
July
August
ASM
FS


Hoverfly
Average number of hoverflies
60
50
40
30
20
10
0
April
May
June
July
August
ASM
FS

In summary

Diverse mixtures can offer economic advantages

IF

Legume diversity needs to be achieved

THEREFORE

Be vigilant about species presence/chlorosis

Inoculation may be beneficial for lucerne at least, at every sowing time on low pH sites

Cereals

Major advantages for grain protein content

?

Beneficial effects of ploughed in diverse leys *may* be late season

Forage

Promising levels of forage protein from chemical analysis

BUT

Grazing trials are needed to determine suitability for mixed systems

Thanks to…

LegumeLINK consortium and participating farmers

Richard Casebow & Caroline Hadley for their technical expertise

Rachel Roberts

Lawes and RETF funded PhD

Rob Brown

BBSRC CASE studentship with ORC-Elm Farm