Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Plant diversity consistently increased yield in the multisite LegacyNet experiment

James O'Malley, John Finn, Carsten Malisch, Caroline Brophy, the LegacyNet consortium

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ADAPT

Taighde Éireann
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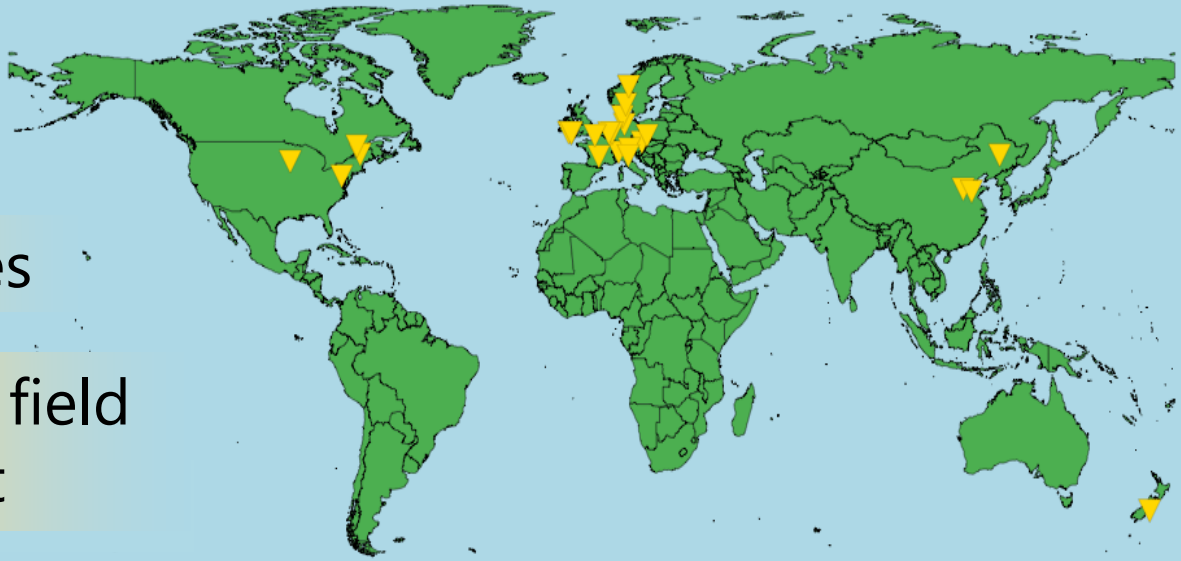
LegacyNet

The LegacyNet network of experiments

26 sites

15 countries

1 common field experiment



6 forage species:
2 grasses,
2 legumes,
2 herbs

Grassland
⬇
Follow-on crop

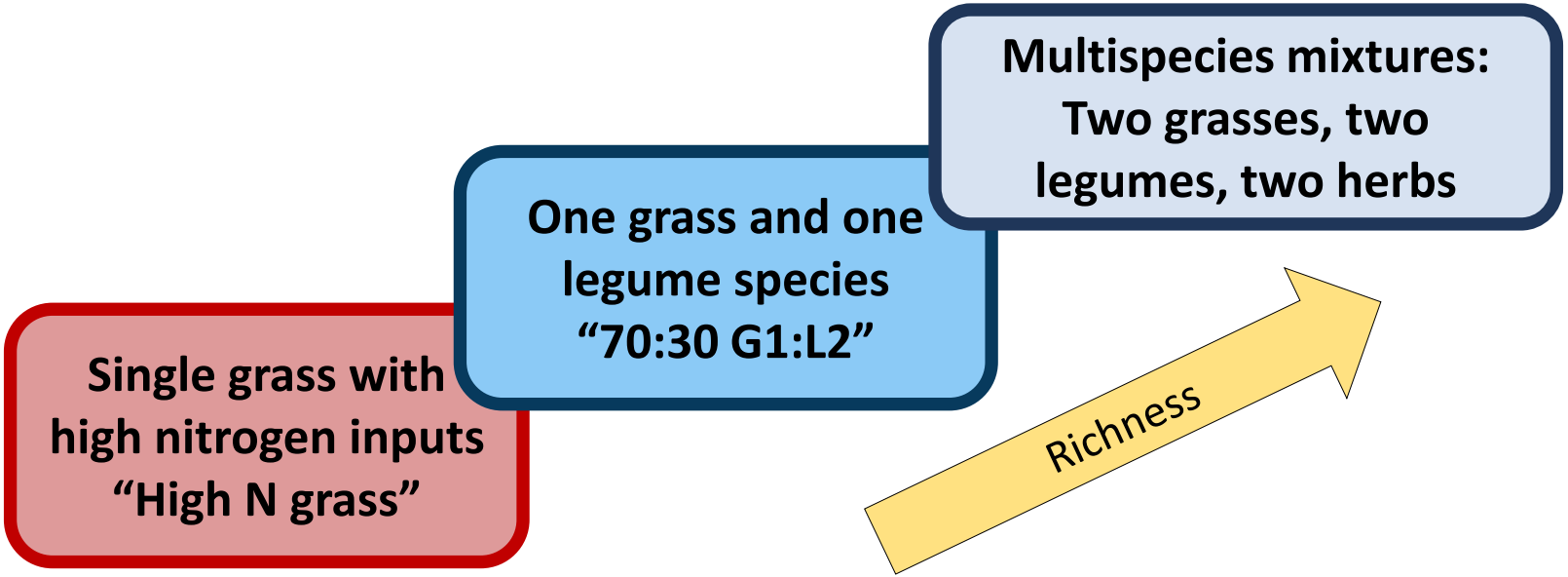
108.7
kg N ha^{-1}
on average

47 plots:
Monocultures and mixtures up to six species

5 plots:
Grass monocultures

260.5
kg N ha^{-1}
on average

Can we improve the sustainability of productive grasslands *while* maintaining or improving agronomic performance?



Science

Multispecies grasslands produce more yield from lower nitrogen inputs across a climatic gradient

JAMES O'MALLEY, JOHN A. FINN, CARSTEN S. MALISCH, MATTHIAS SUTER, SEBASTIAN T. MEYER, GIOVANNI PERATONER, MARIE-NOËLLE THIVIERGE, DIEGO ABALOS, PAUL R. ADLER, [...], AND CAROLINE BROPHY +21 authors Authors Info & Affiliations

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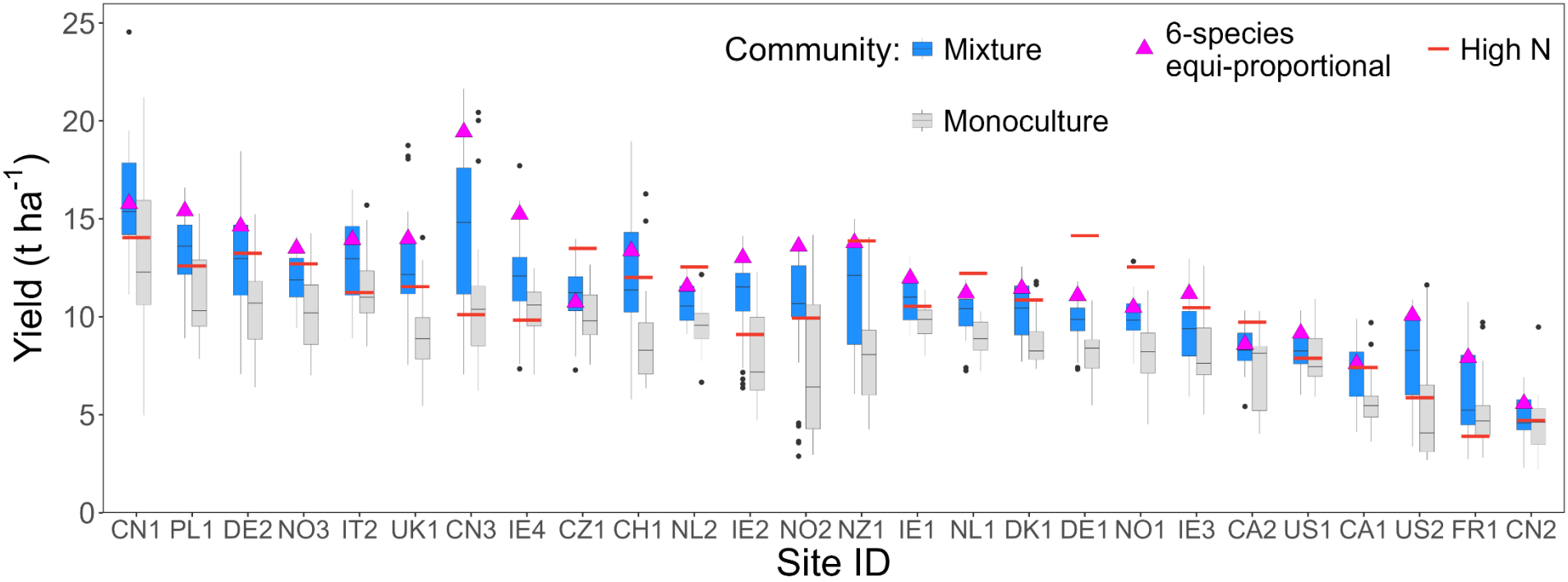

Community:
Mixture
Monoculture
6-species equi-proportional
High N
Yield (t ha-1)
0
5
10
15
20
25
CN1 PL1 DE2 NO3 IT2 UK1 CN3 IE4 CZ1 CH1 NL2 IE2 NO2 NZ1 IE1 NL1 DK1 DE1 NO1 IE3 CA2 US1 CA1 US2 FR1 CN2
Site ID

Modelling

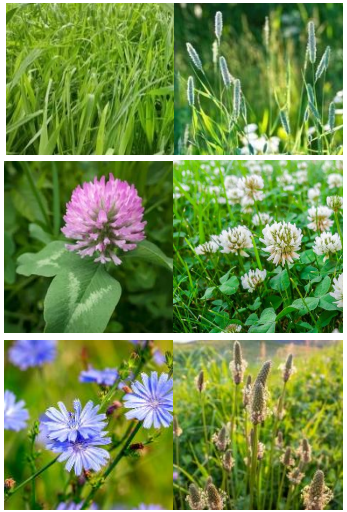
Nonlinear mixed effects diversity interactions model

$$Yield = \text{Identity effects} + \text{Interaction effects} + \text{High N effect} + \text{Temperature effects} + \varepsilon$$

Modelling

$$Yield = \text{Identity effects} + \text{Interaction effects} + \text{High N effect} + \text{Temperature effects} + \varepsilon$$

Species specific contributions to yield



Grasses x 2

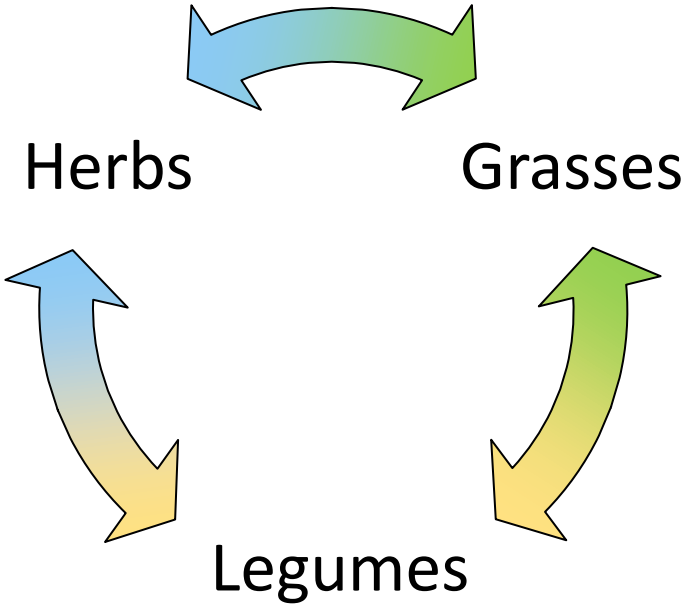
Legumes x 2

Herbs x2

Vary randomly across sites

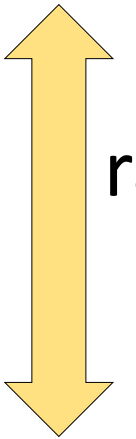
Modelling

$$Yield = \text{Identity effects} + \text{Interaction effects} + \text{High N effect} + \text{Temperature effects} + \varepsilon$$



Contribution of **interactions** between species to yield

Driven by functional group membership



Vary randomly across sites

Modelling

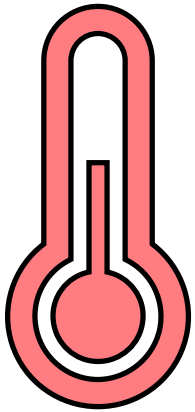
$$Yield = \text{Identity effects} + \text{Interaction effects} + \text{High N effect} + \text{Temperature effects} + \varepsilon$$

Yield of the high N grass monoculture

Vary randomly across sites

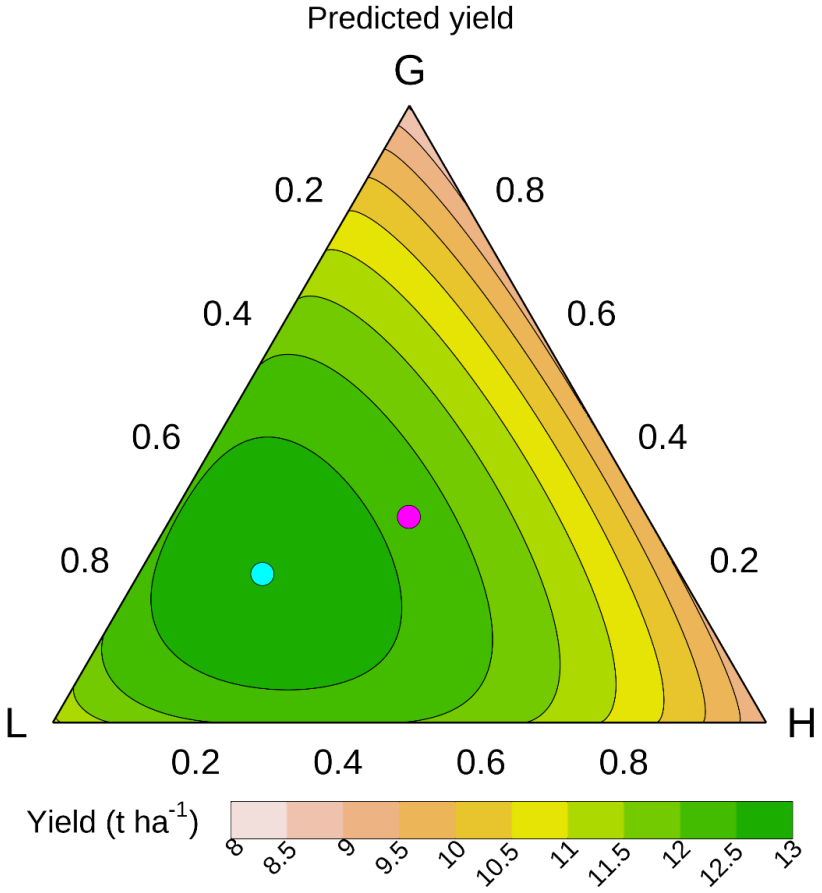
Modelling

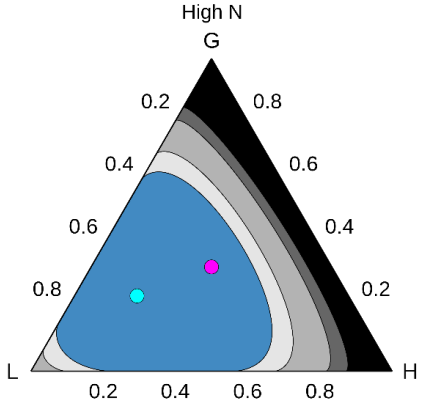
$$Yield = \text{Identity effects} + \text{Interaction effects} + \text{High N effect} + \text{Temperature effects} + \varepsilon$$

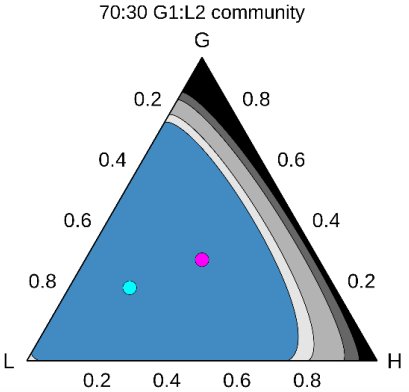


Average daily temperature across the experimental period for each site

Multispecies mixtures outperformed two widely used conventional practices





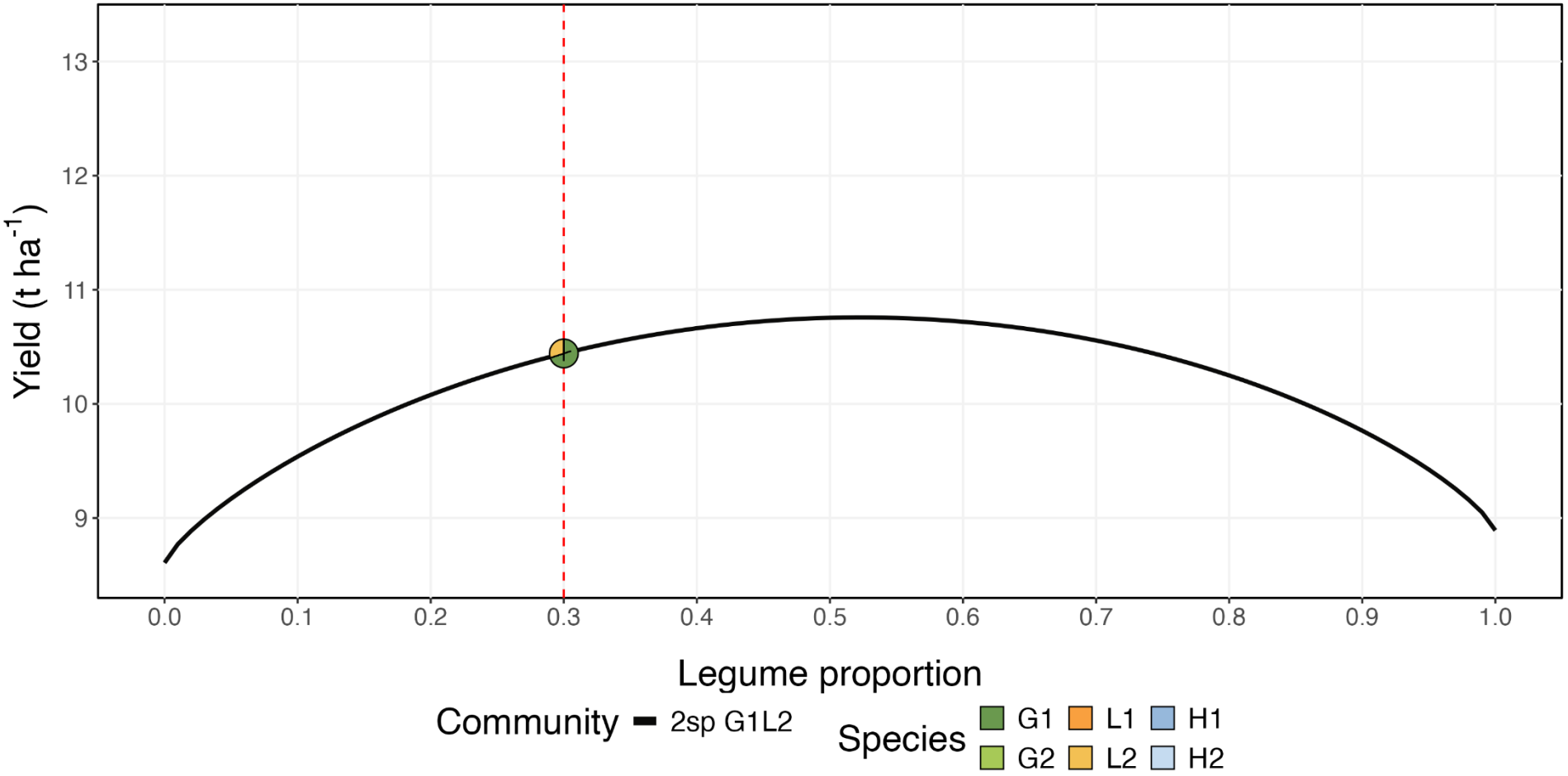


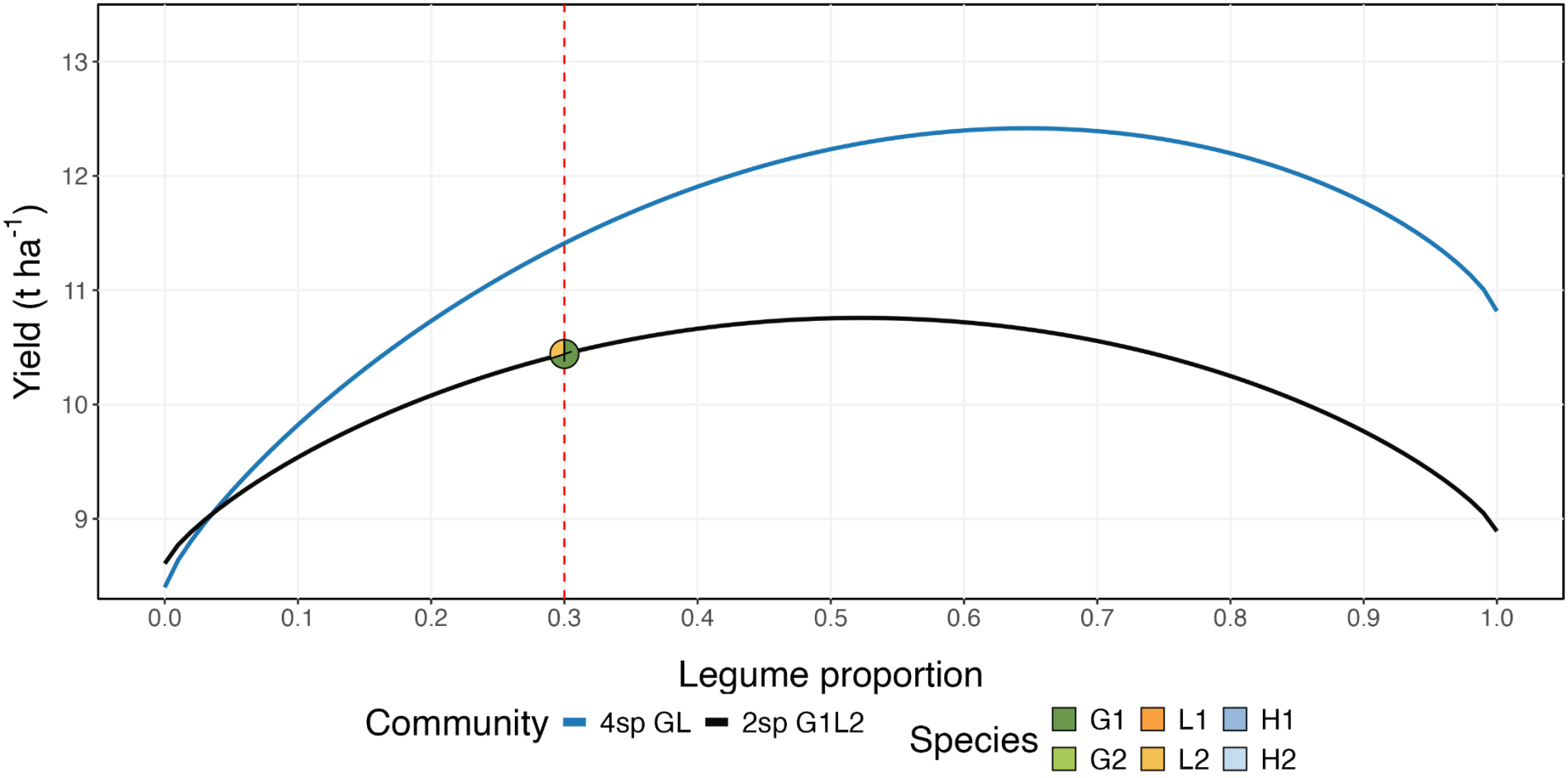
SE range: < -2 | [-2 , -1) | [-1, 1) | [1, 2) | ≥ 2

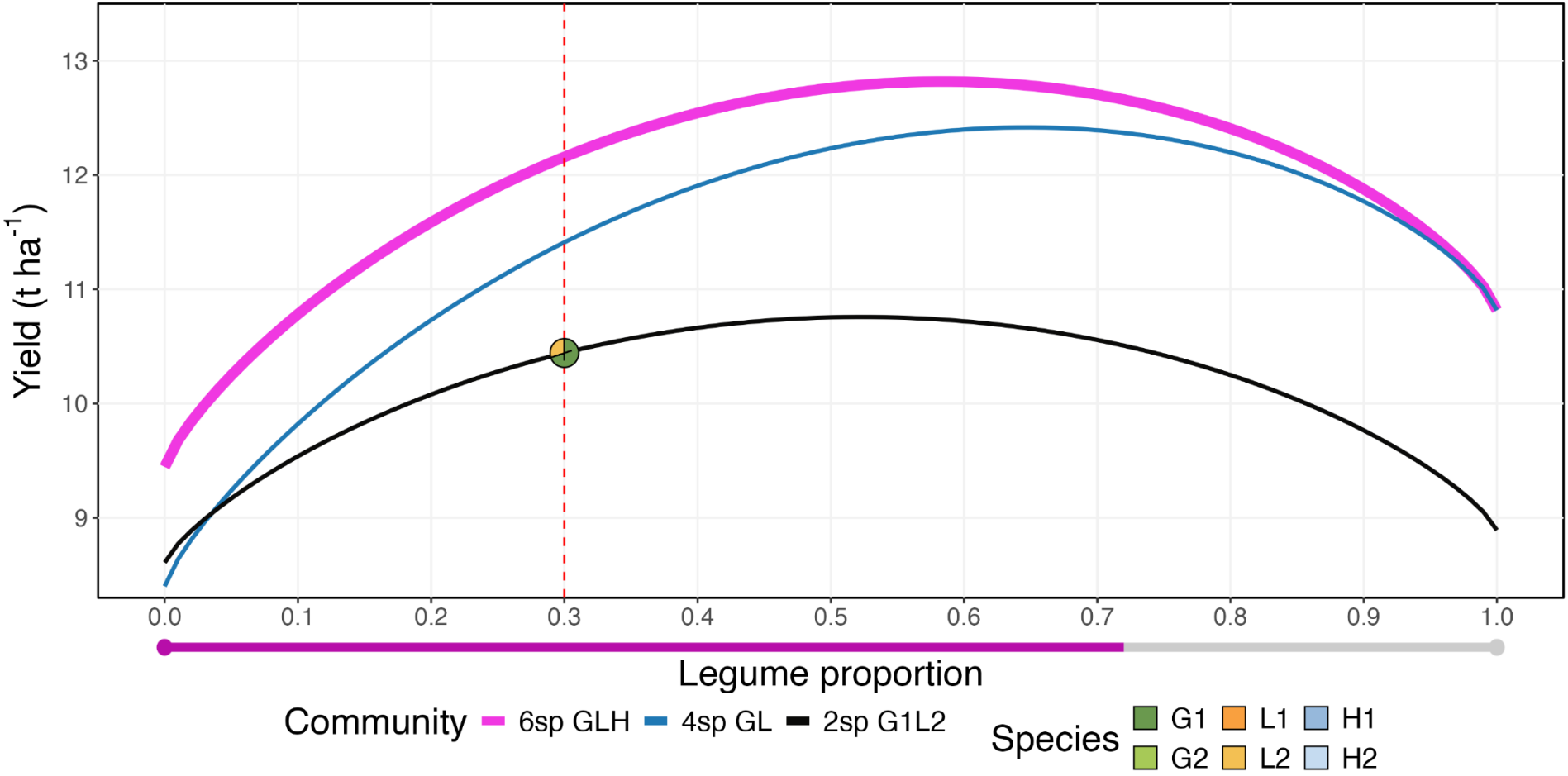
Legumes are important

But they are not everything!

When sown with the same proportion of legumes, six-species mixtures > four-species grass-legume > two-species grass-legume (up to about 70% sown legume)

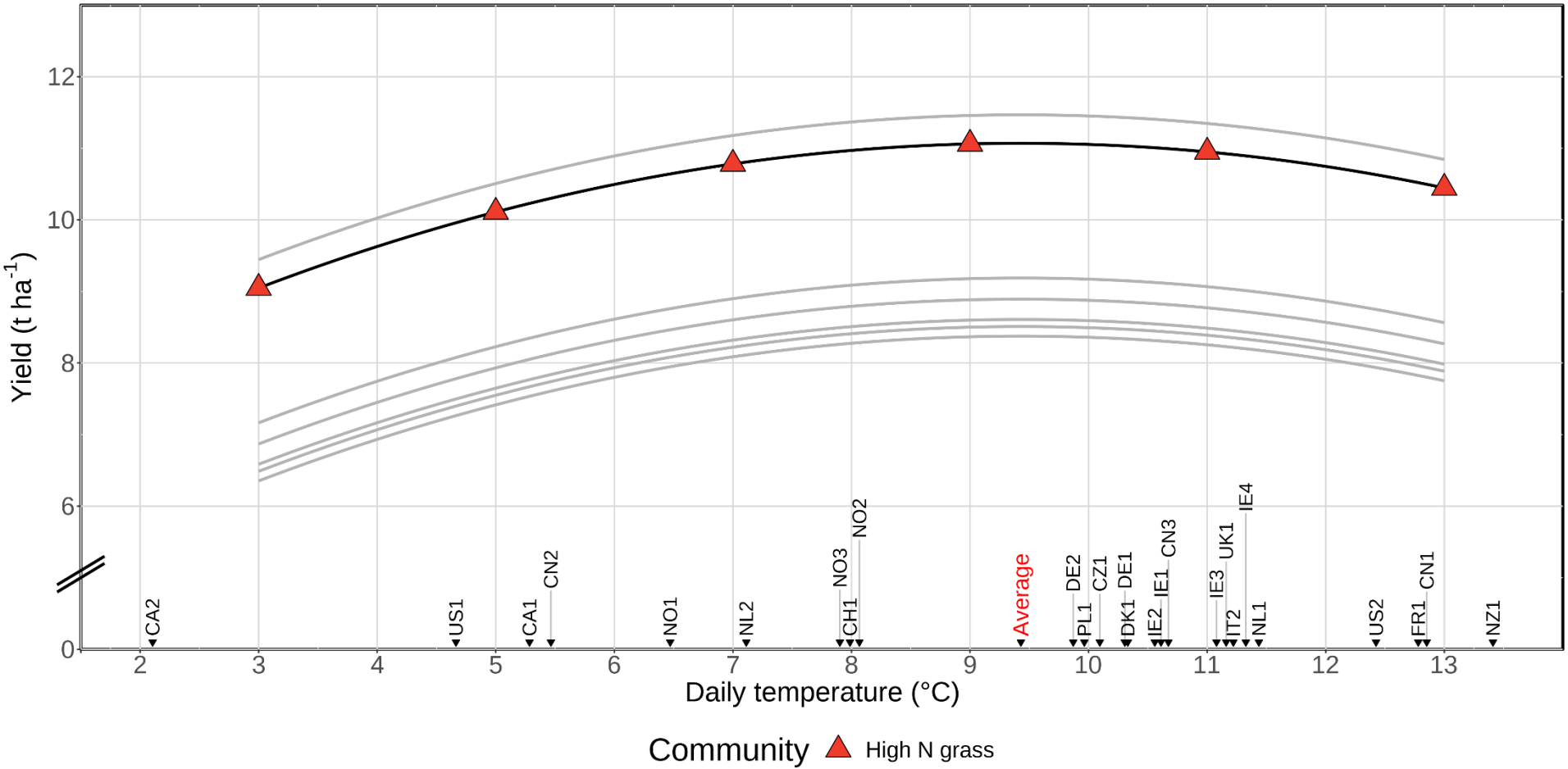

Yield (t ha-1)
13
12
11
10
9
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Legume proportion
Community
2sp G1L2
Species
G1
L1
H1
G2
L2
H2

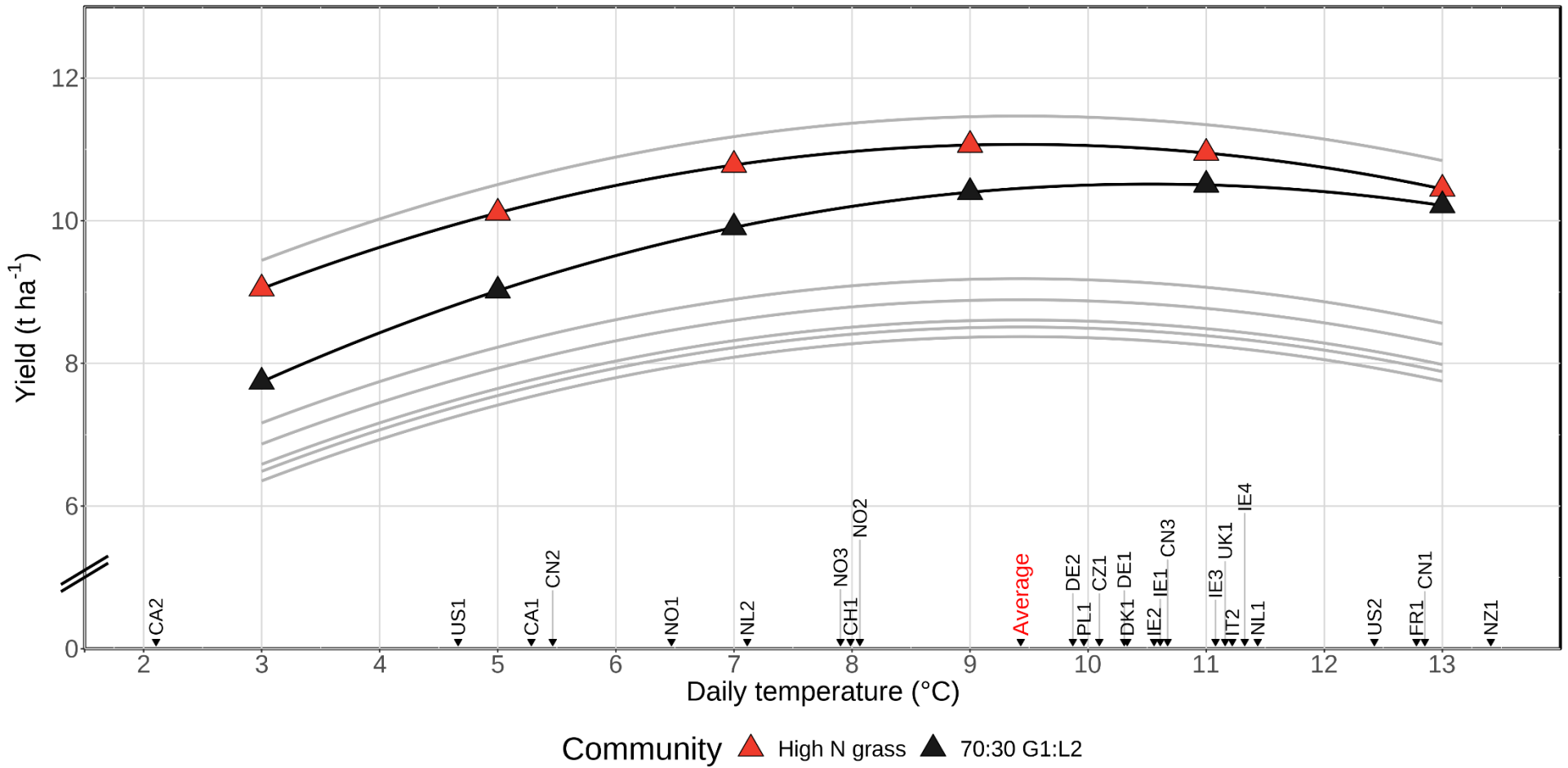

Yield (t ha-1)
13
12
11
10
9
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Legume proportion
Community
4sp GL
2sp G1L2
Species
G1
L1
H1
G2
L2
H2

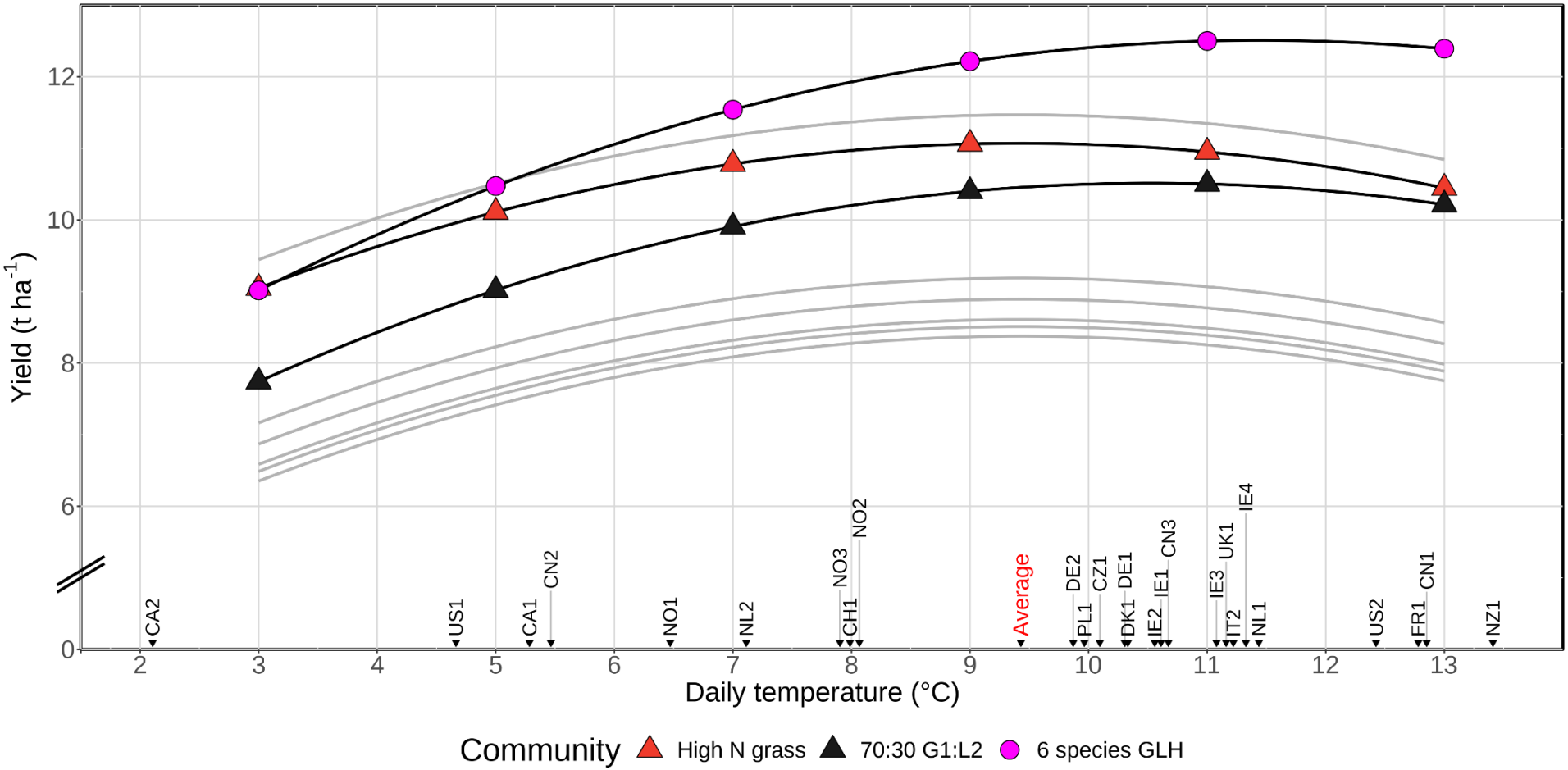

Yield (t ha-1)
13
12
11
10
9
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Legume proportion
Community
6sp GLH
4sp GL
2sp G1L2
Species
G1
L1
H1
G2
L2
H2

Climate adaptation potential of mixtures

At sites with warmer average temperatures, there were increased yield benefits of more diverse, legume-containing grasslands


Yield (t ha-1)
12
10
8
6
0
2
3
4
5
6
7
8
9
10
11
12
13
Daily temperature (°C)
CA2
US1
CA1
CN2
NO1
NL2
NO3
CH1
NO2
Average
DE2
PL1
CZ1
DK1
DE1
IE2
IE1
CN3
IE3
UK1
IT2
IE4
NL1
US2
FR1
CN1
NZ1
Community
High N grass


Yield (t ha-1)
12
10
8
6
0
2
3
4
5
6
7
8
9
10
11
12
13
Daily temperature (°C)
CA2
US1
CA1
CN2
NO1
NL2
NO3
CH1
NO2
Average
DE2
PL1
CZ1
DK1
DE1
IE2
IE1
CN3
IE3
IT2
UK1
NL1
IE4
US2
FR1
CN1
NZ1
Community
High N grass
70:30 G1:L2


Yield (t ha-1)
12
10
8
6
0
2
3
4
5
6
7
8
9
10
11
12
13
Daily temperature (°C)
CA2
US1
CA1
CN2
NO1
NL2
CH1
NO3
NO2
Average
PL1
DE2
CZ1
DK1
DE1
IE2
IE1
CN3
IE3
UK1
IT2
IE4
NL1
US2
FR1
CN1
NZ1
Community
High N grass
70:30 G1:L2
6 species GLH

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