Breeding crops for water limited environments: an overview from a water and nitrogen perspective

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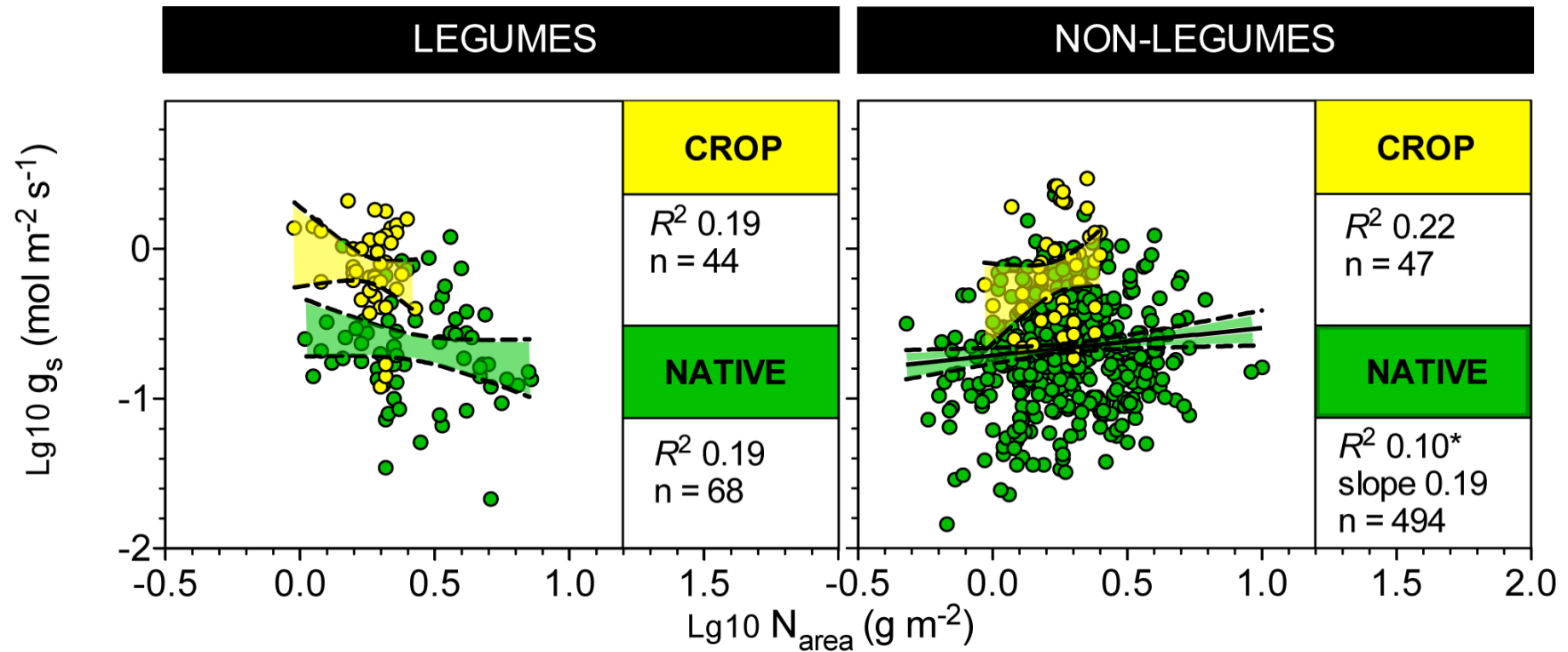SYDNEY

› The use of traits to guide plant breeding has a long and successful history.

› Photosynthesis related traits have been foci for decades, owing to (potentially) direct links to yield.

› Water use efficiency has, for at least the last 20 years, become a focus owing to drying climates in many traditional crop-growing regions. A simple definition: WUE=carbon gain/water loss.

› Australian researchers have been central players in many research programs.

› Our interest lies in the interaction of nitrogen with WUE at the leaf/plant scale

› Will remain critical in future

› Understanding driver(s) is essential

- Many direct (A, g_s) but also indirect (e.g. internal [CO_2]) influences

- Some well described processes

- Many still poorly described processes – for example, mesophyll conductance has 'exploded' as a research topic in recent years, but, so far, has <u>not</u> been shown to be of greater importance than stomatal conductance to WUE.

› We combined meta-analysis with experimental analysis to re-examine the Q: "Which is more important to WUE, A, or g_s ?
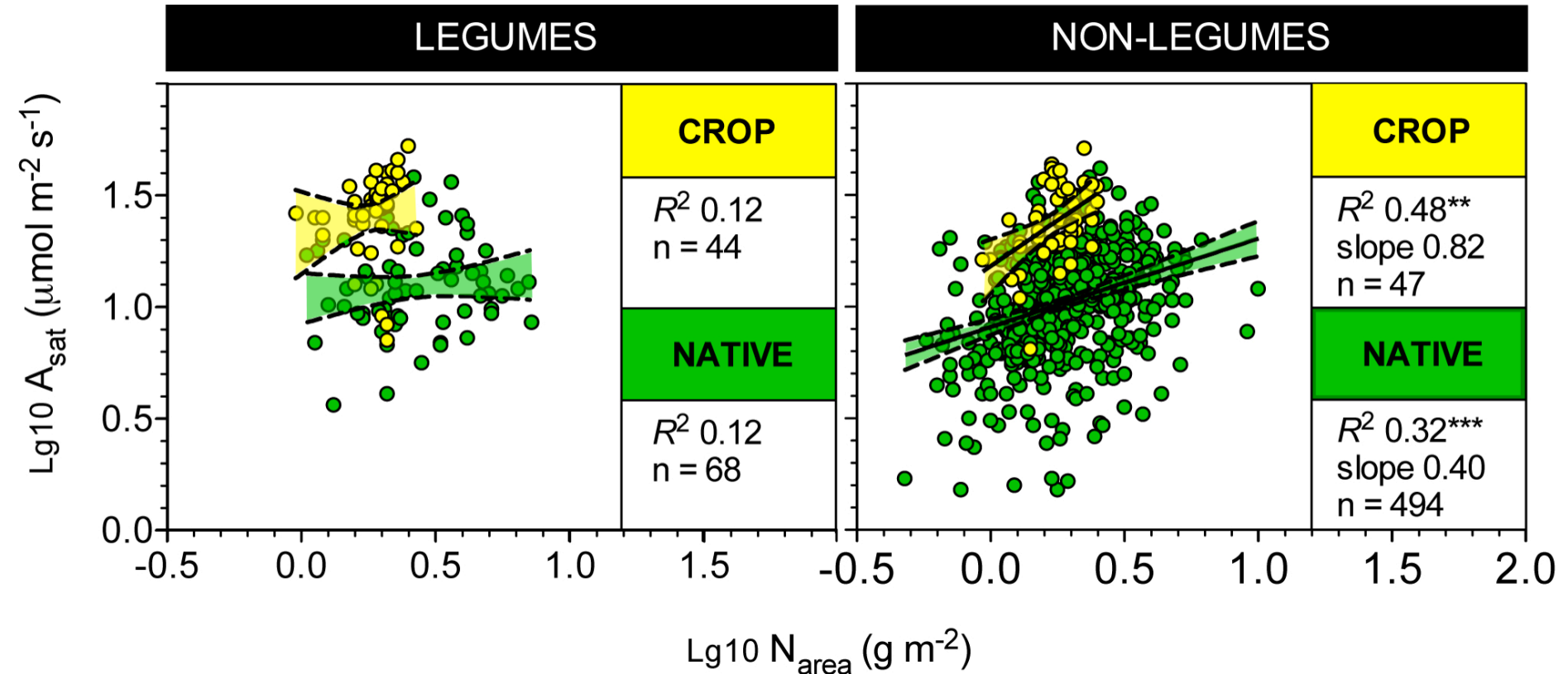
Global meta-analysis of leaf N_{area} vs A_{sat}

Adams, Turnbull, Buckley *et al.* unpublished data

LEGUMES | **NON-LEGUMES**

Plot axes: y-axis $Lg10\ g_s\ (mol\ m^{-2}\ s^{-1})$, x-axis $Lg10\ N_{area}\ (g\ m^{-2})$

LEGUMES:
CROP — R^2 0.19, n = 44
NATIVE — R^2 0.19, n = 68

NON-LEGUMES:
CROP — R^2 0.22, n = 47
NATIVE — R^2 0.10*, slope 0.19, n = 494

Global meta-analysis of leaf N_{area} vs g_s

Adams, Turnbull, Buckley *et al.* unpublished data

Barley

Applied N
8mM   4mM   2mM   1mM   0

Broadbean

Applied N

| 8mM | 4mM | 2mM | 1mM | 0 |

Canola

Applied N
8mM   4mM   2mM   1mM   0

Wheat

Applied N

| 8mM | 4mM | 2mM | 1mM | 0 |

Soybeans

Applied N

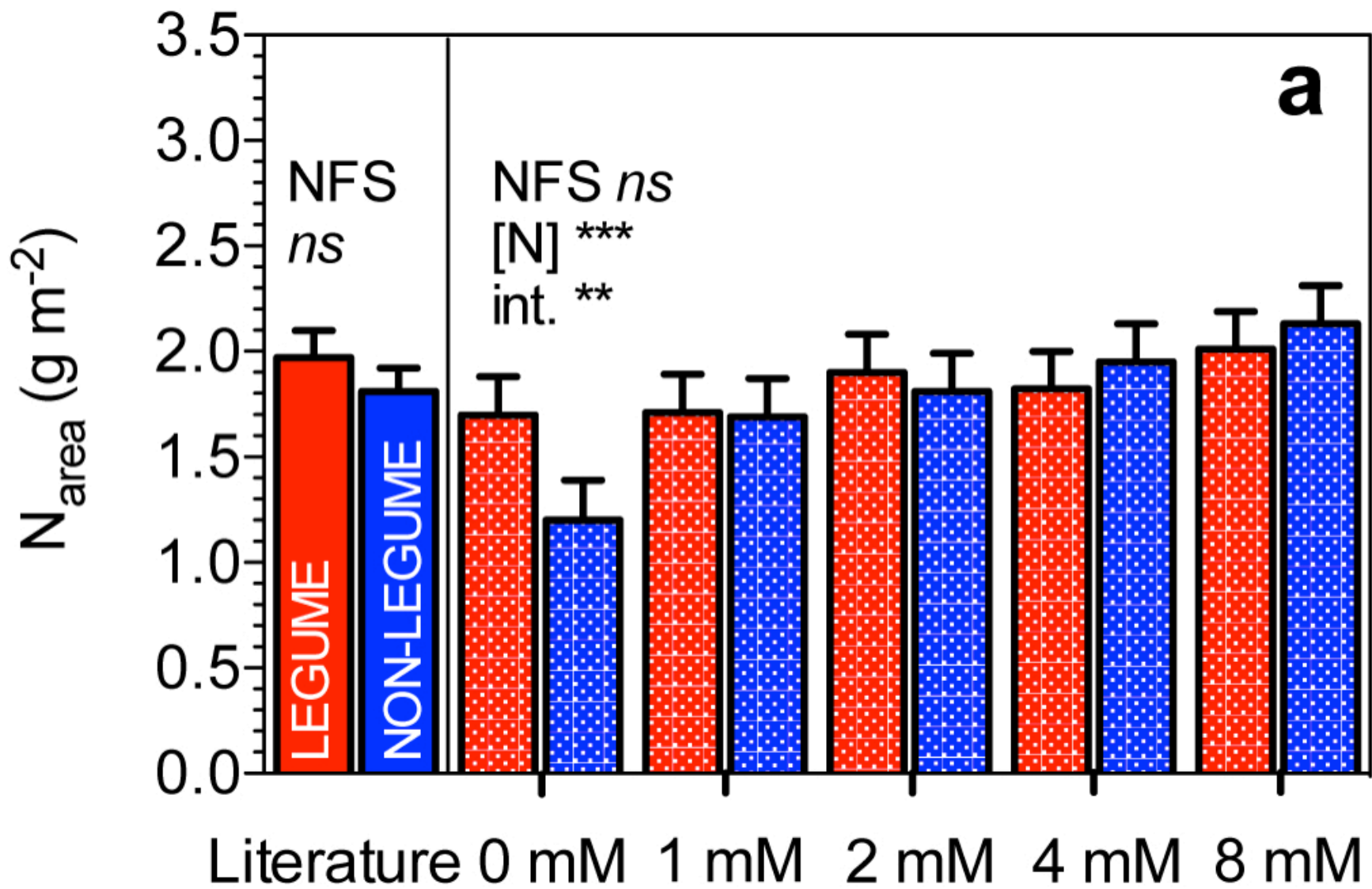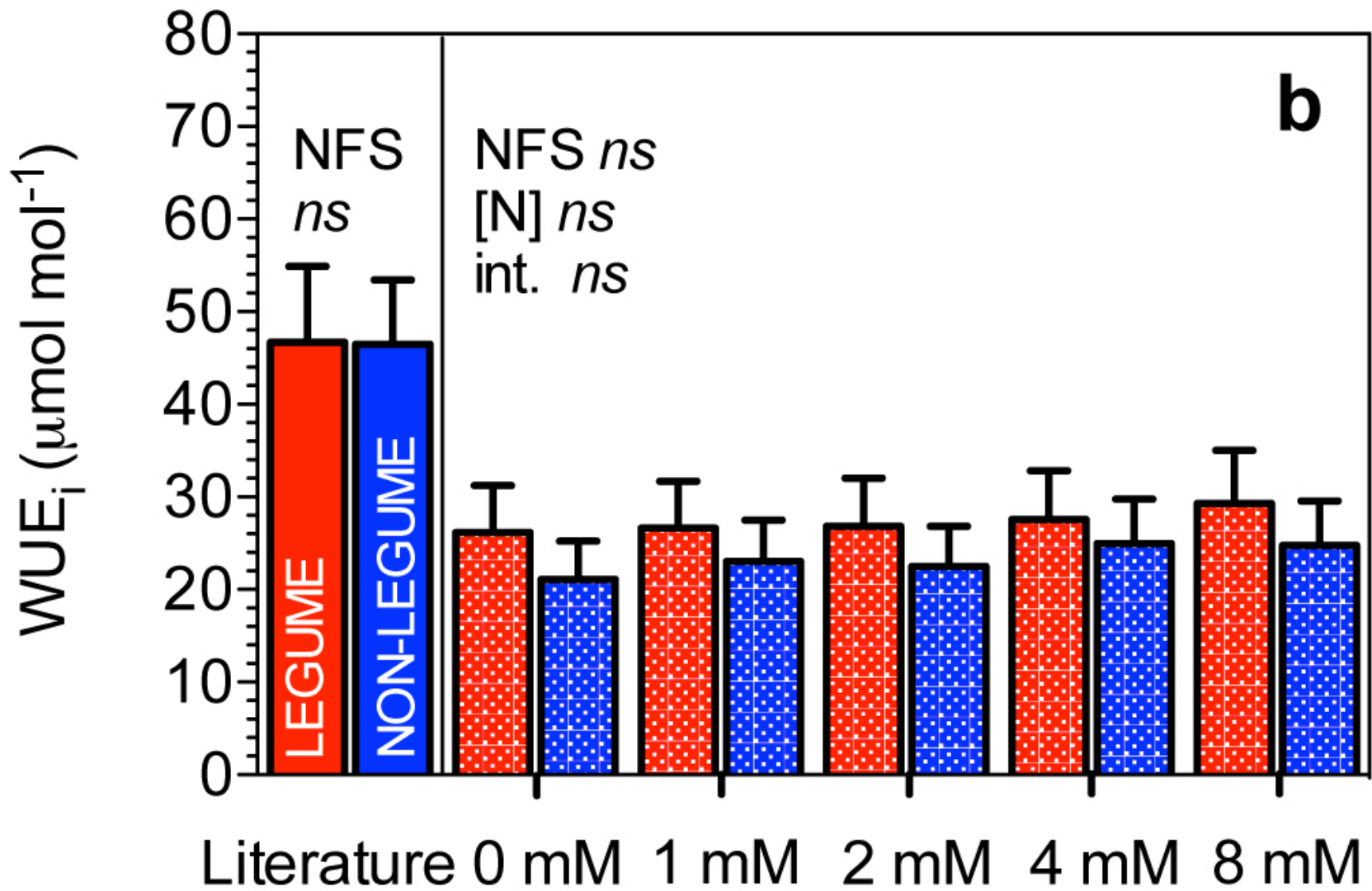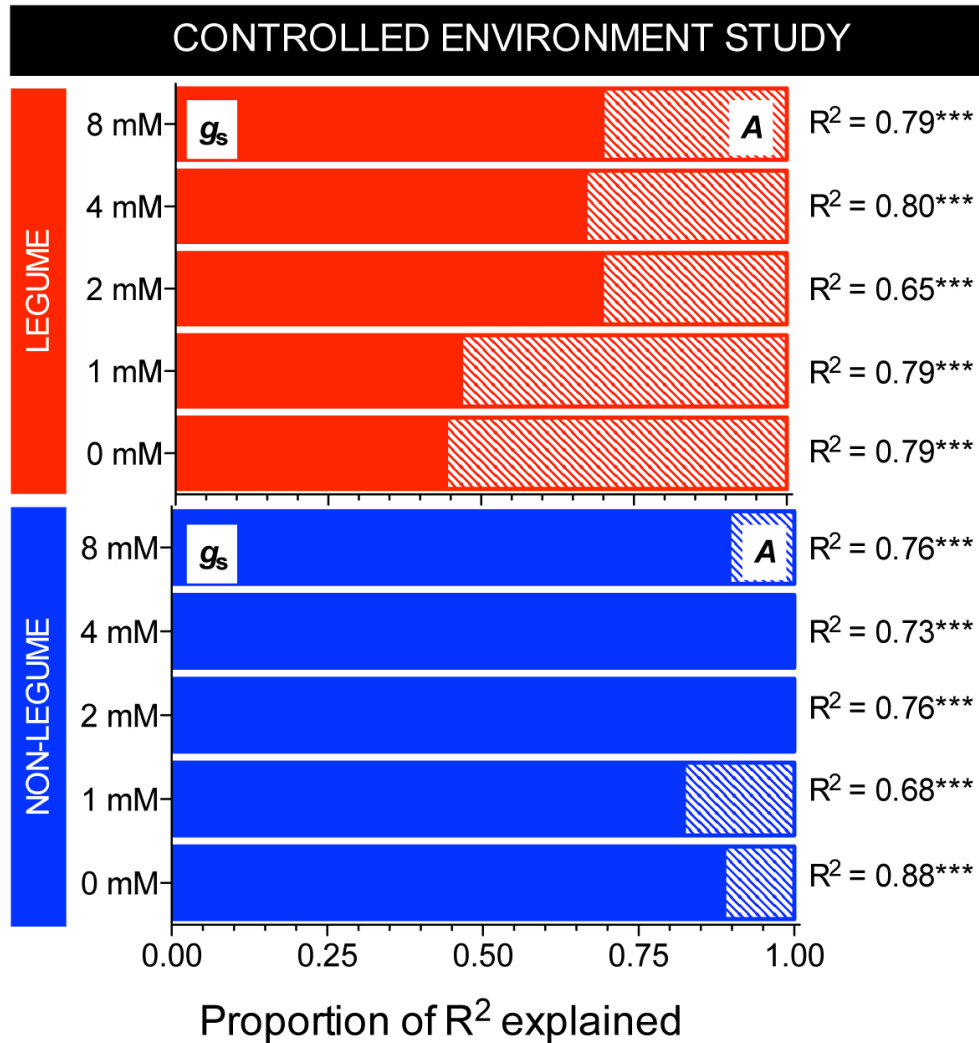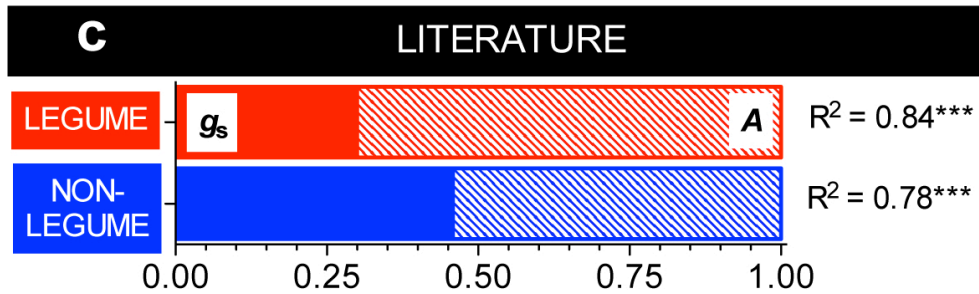| 8mM | 4mM | 2mM | 1mM | 0 |

Chickpea

Applied N
8mM   4mM   2mM   1mM   0

Also sunflower, and lupin

b

NFS
ns

NFS *ns*
[N] *ns*
int. *ns*

LEGUME

NON-LEGUME

WUE$_i$ (μmol mol^{-1})

80
70
60
50
40
30
20
10
0

Literature   0 mM   1 mM   2 mM   4 mM   8 mM
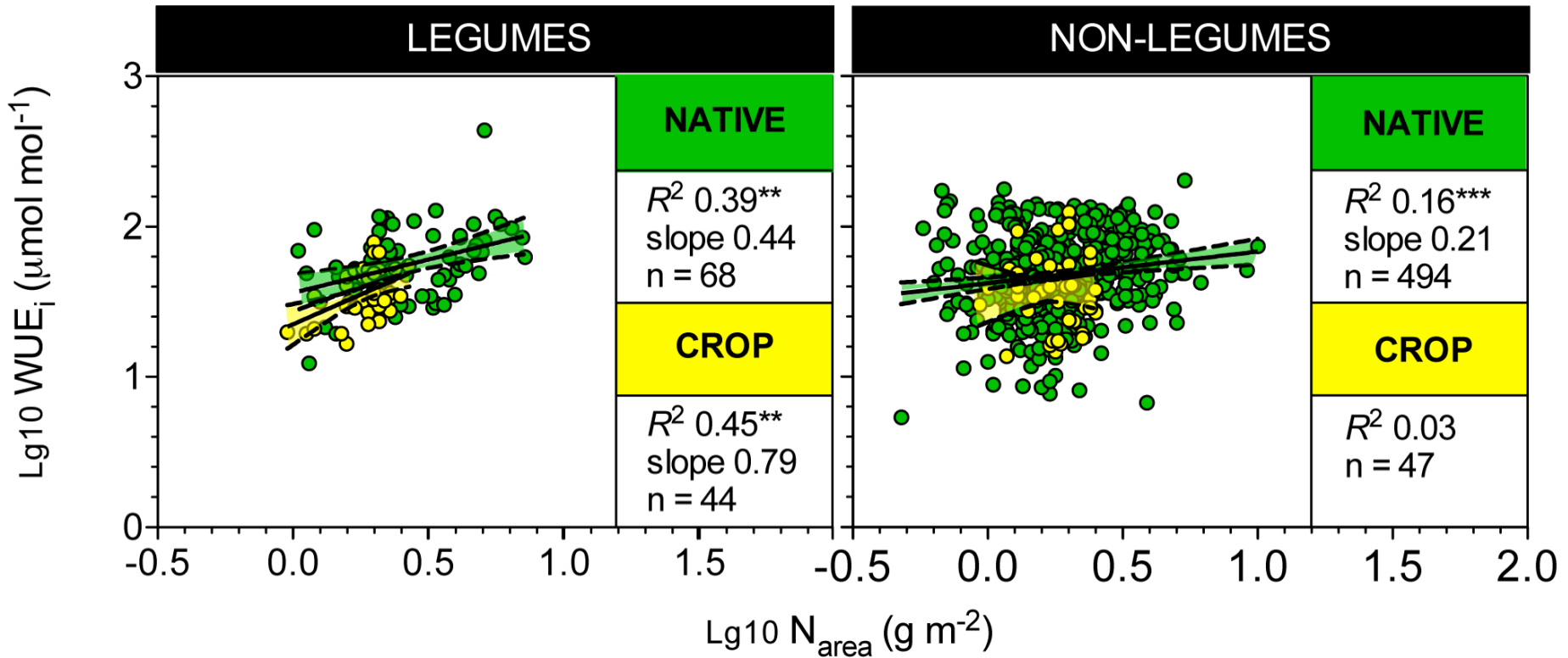
Global meta-analysis of leaf N_{area} vs WUE_i

Adams, Turnbull, Buckley *et al.* unpublished data

› Identifying traits for selection is obviously important

› Modifying those traits via breeding is the basis of increased yield and quality

› Legumes and non-legumes differ fundamentally in traits of significance to WUE

  - A_{sat}, for example has a long history of being used as a target for both selection and breeding and GM in cereals

  - g_s, on the other hand, should be the basis for selection of genotypes in legumes

› More research is needed – the interactions of the nutrient cycle with those of carbon and water is not simple, at any scale.

› Dr Tarryn Turnbull (USYD)

› Numerous other Australian and international colleagues

› Australian Research Council