

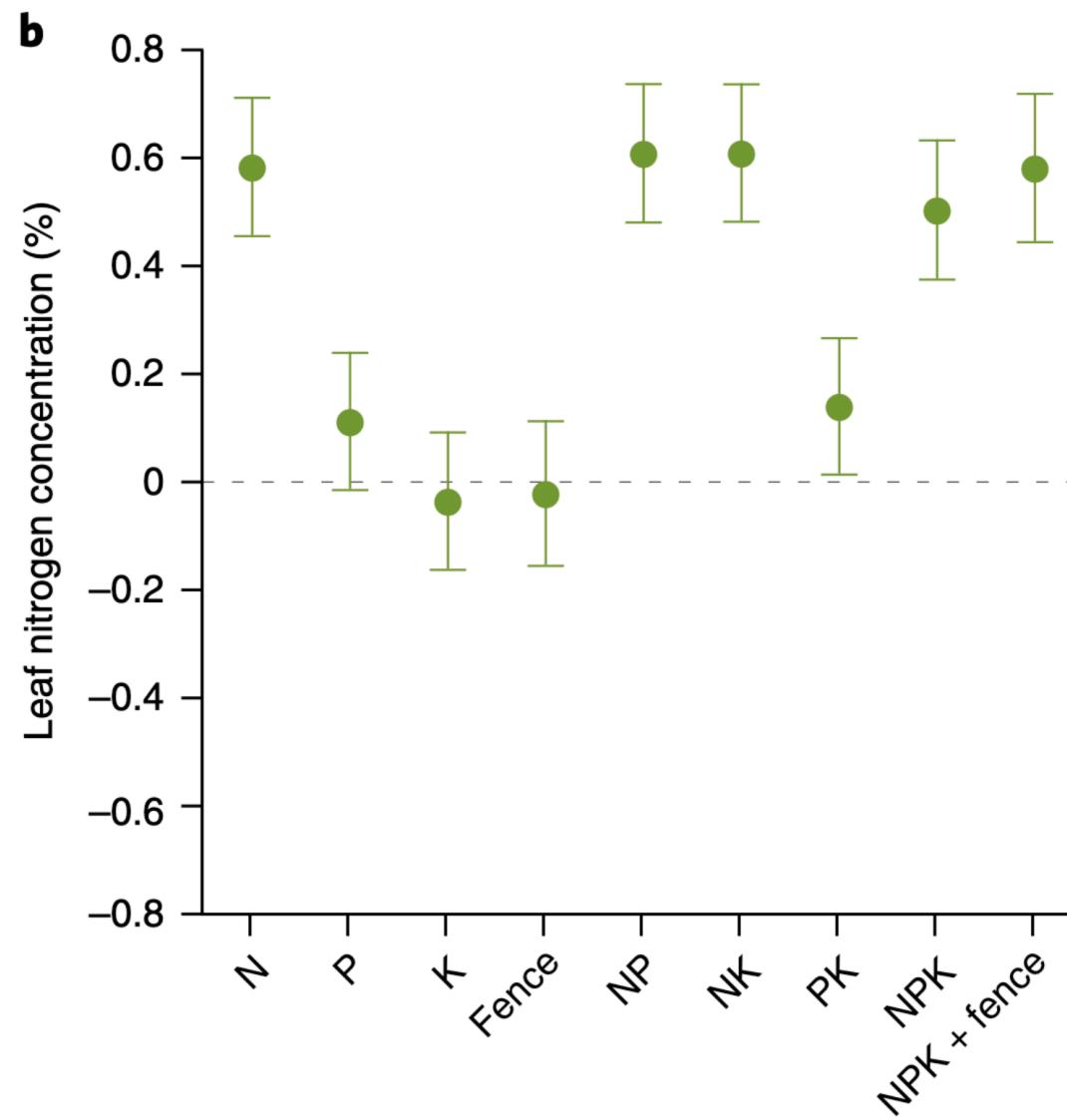


# **Leaf nitrogen is driven by the unit cost of nitrogen and water use in Texan grasslands**

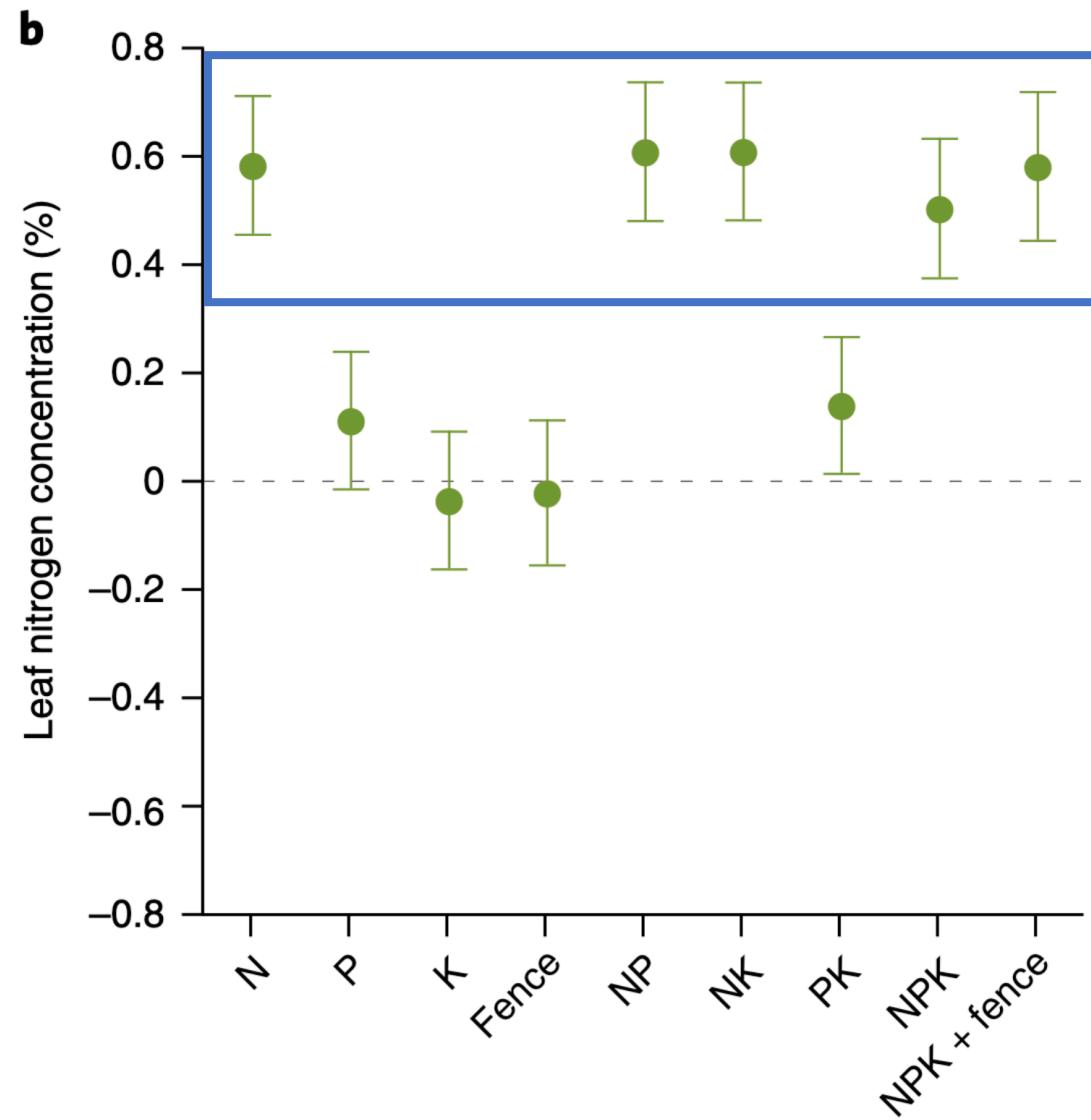
Evan A. Perkowski; Nicholas G. Smith



# Soil nitrogen generally increases leaf nitrogen

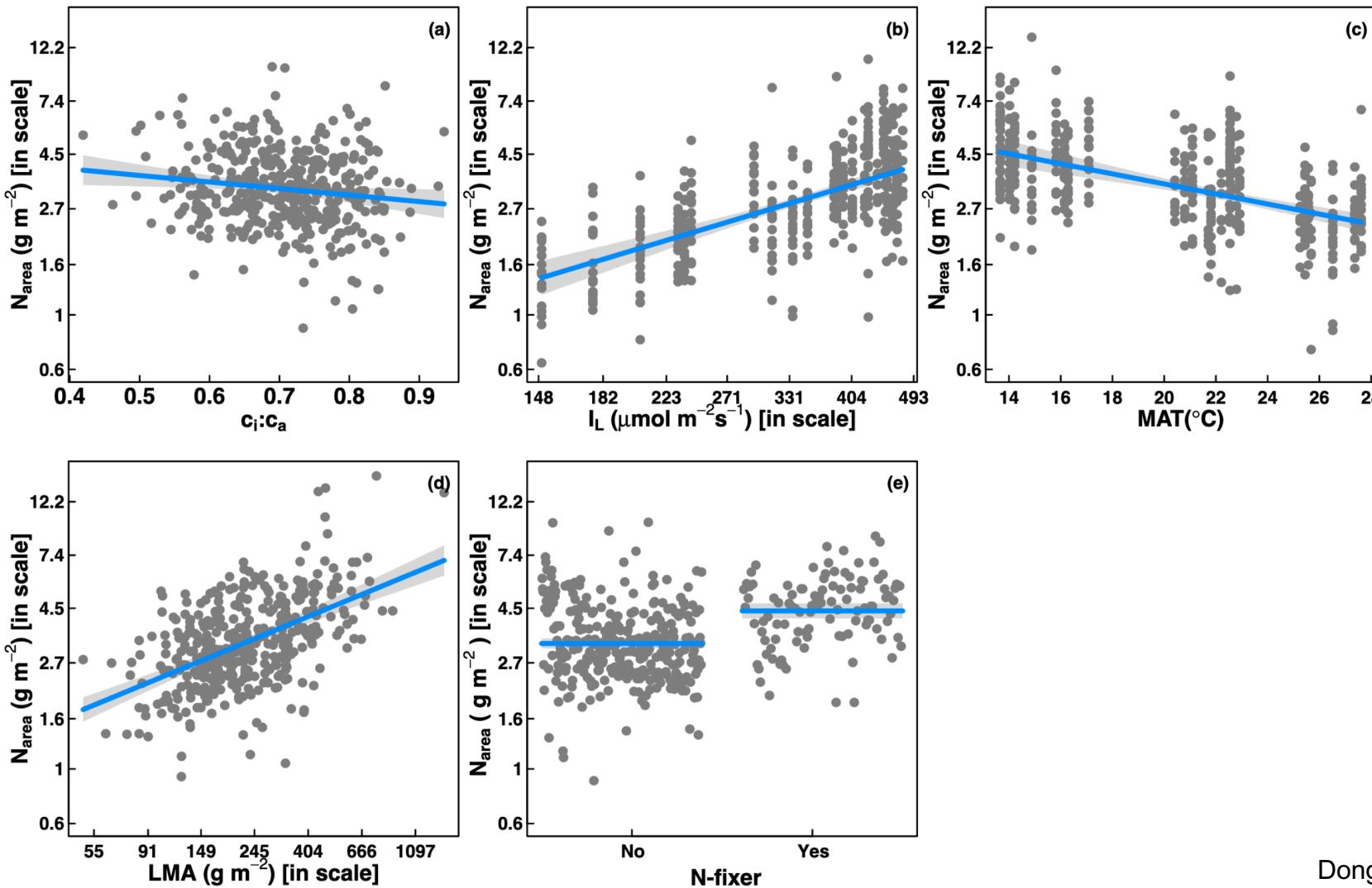


# Soil nitrogen generally increases leaf nitrogen



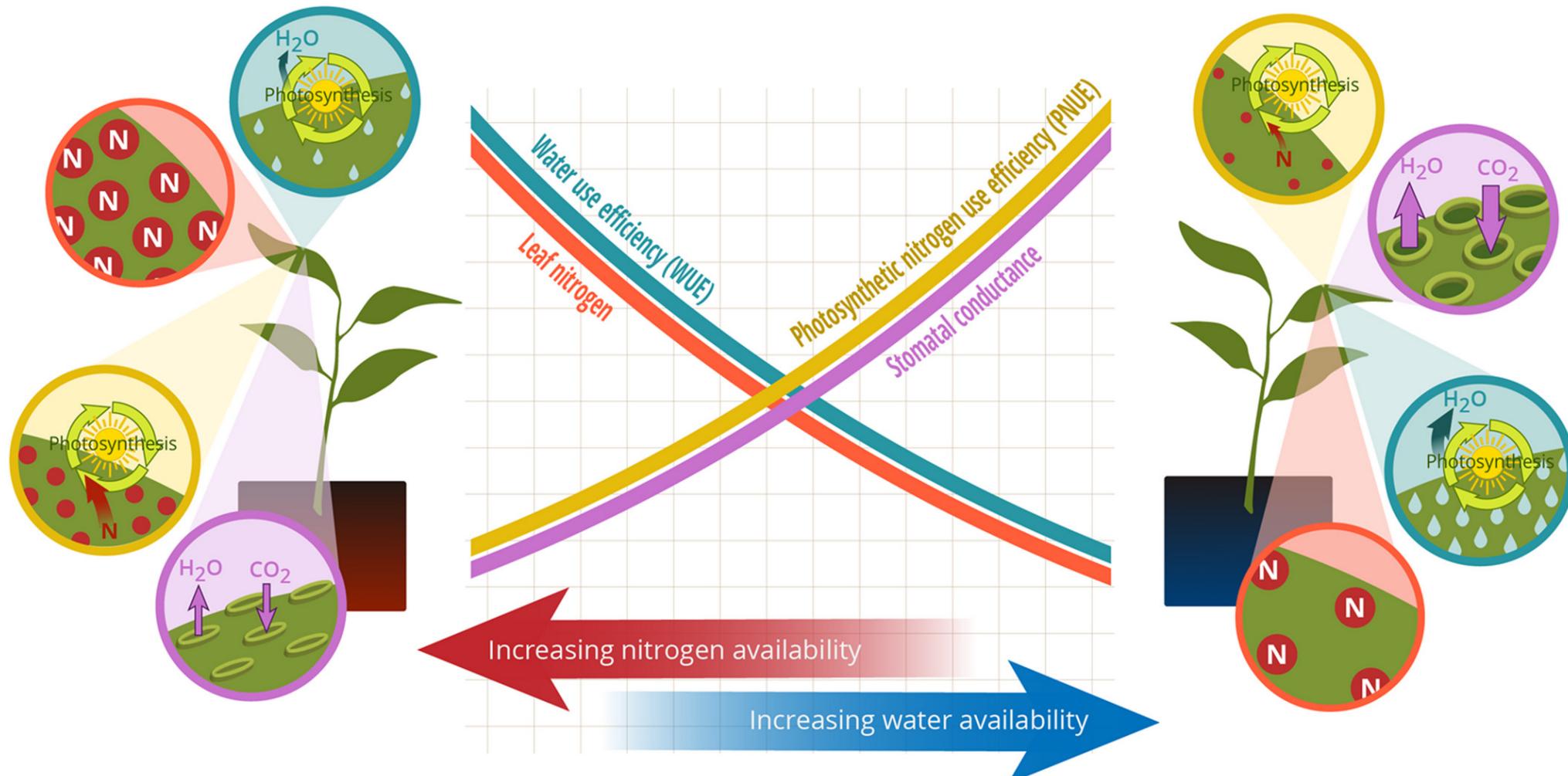
Plots that receive  
nitrogen have higher  
leaf nitrogen content

# But, leaf nitrogen can be predicted independent of soil nitrogen

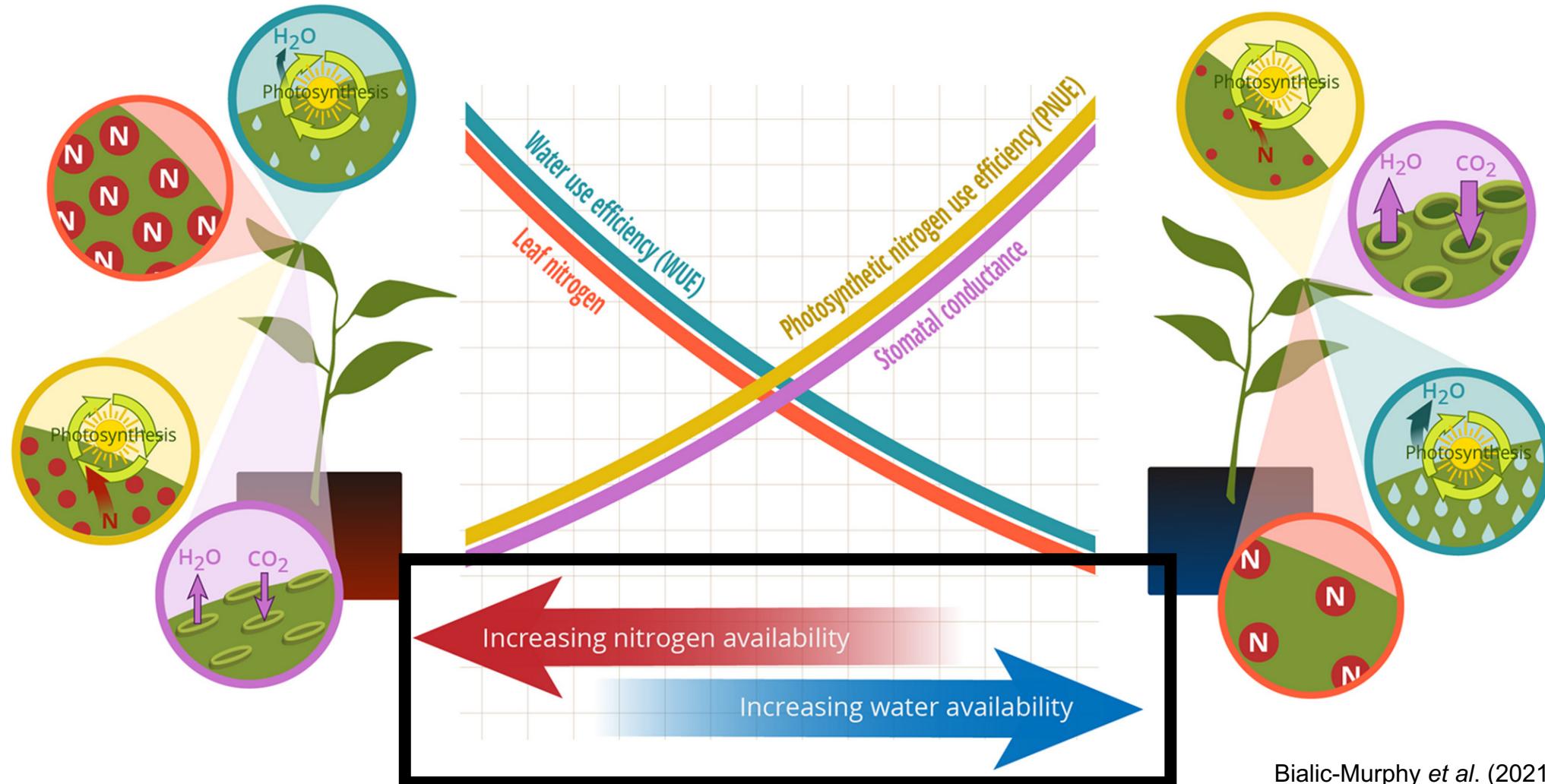


Leaf N is likely a product of interactions between climatic and edaphic factors

# Photosynthetic ‘least-cost’ theory



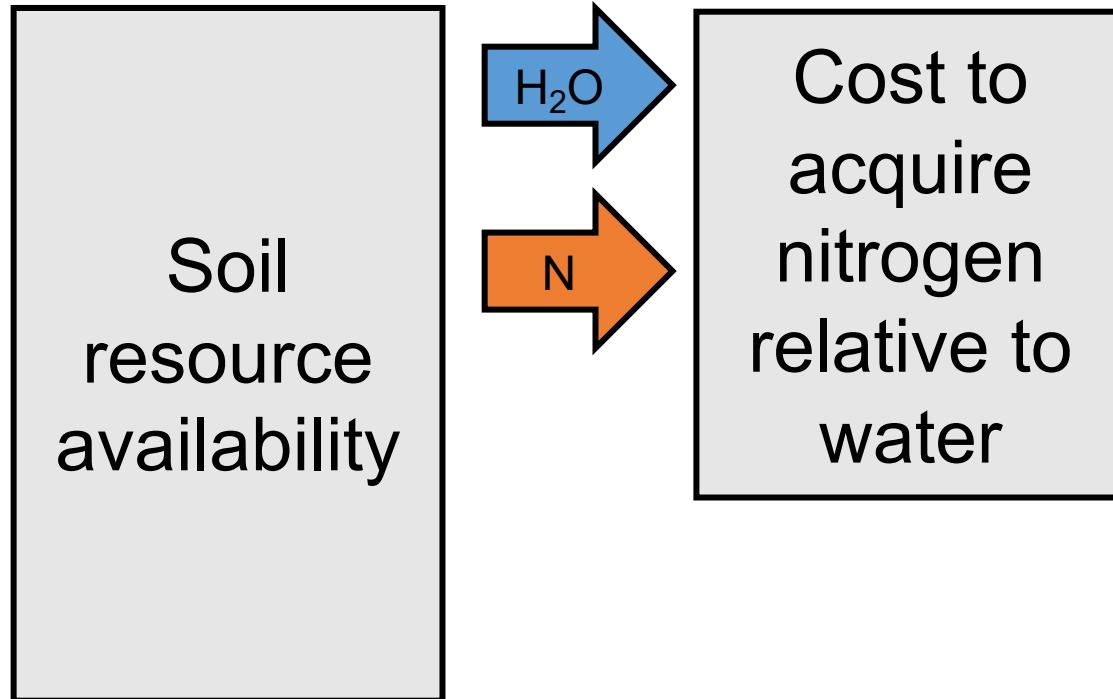
# Photosynthetic ‘least-cost’ theory: leaves acclimate to changing climatic and edaphic environments via summed cost of resource use (nitrogen and water)



Soil N should **decrease**, and soil moisture should **increase** the cost of acquiring nitrogen relative to water

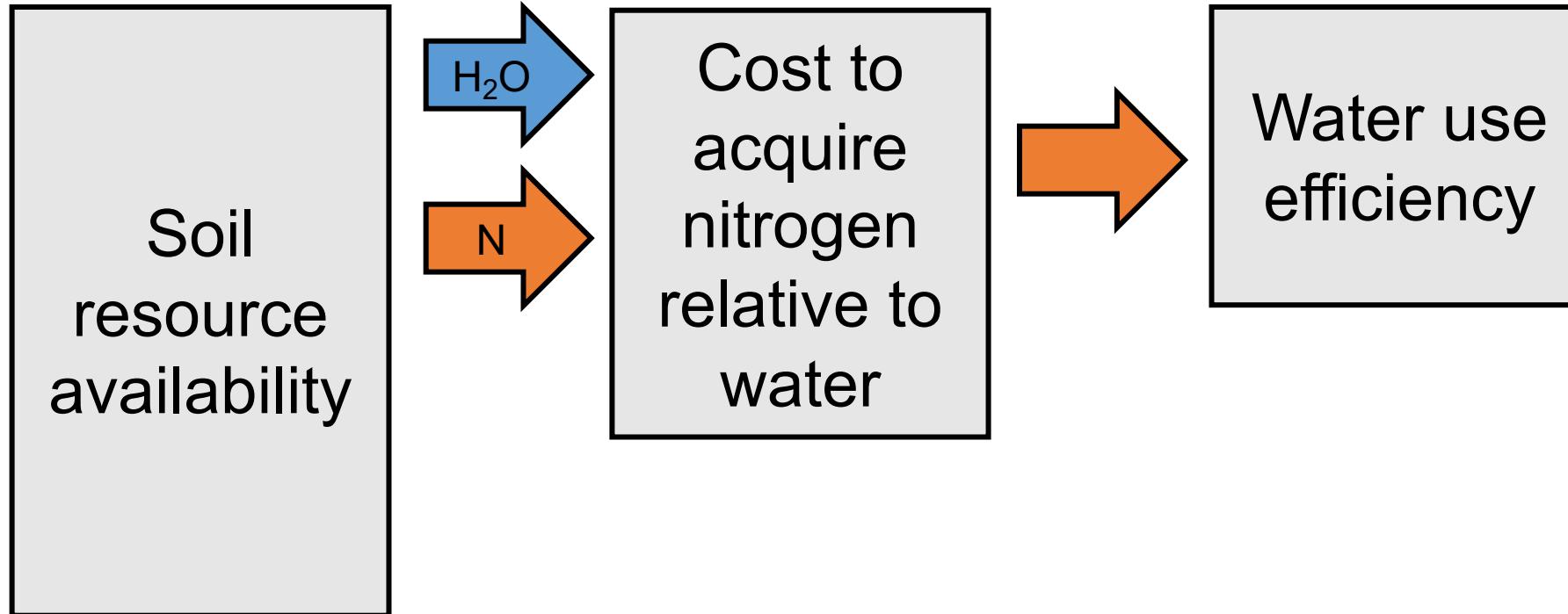
Positive effect

Negative effect



Increasing costs of acquiring nitrogen relative to water should **decrease** water use efficiency

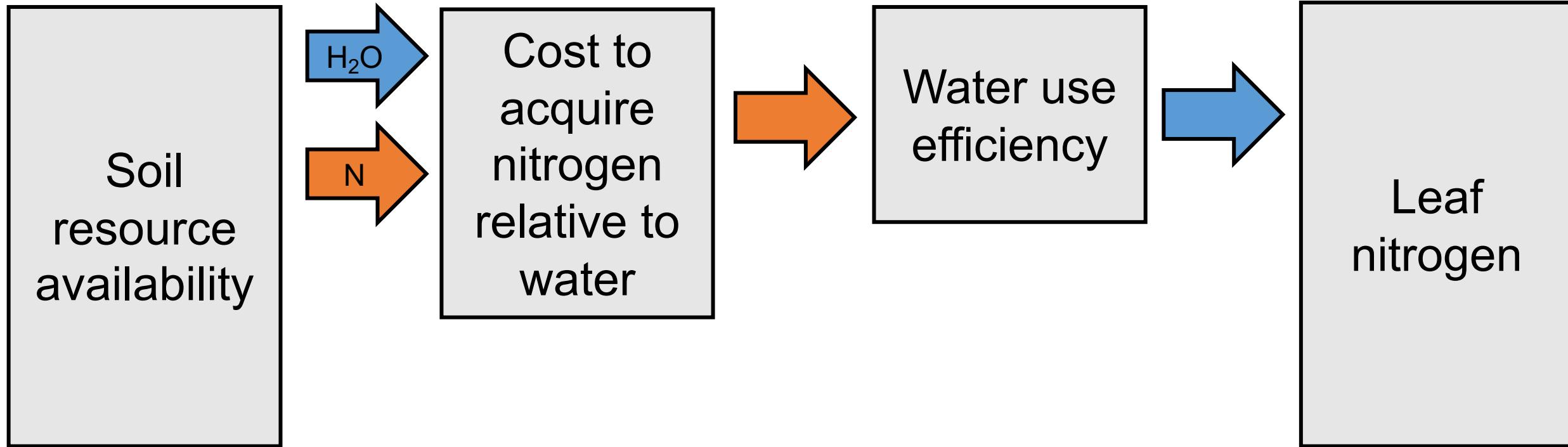
Positive effect  
Negative effect



Increasing water use efficiency should  
**increase** leaf N

Positive effect

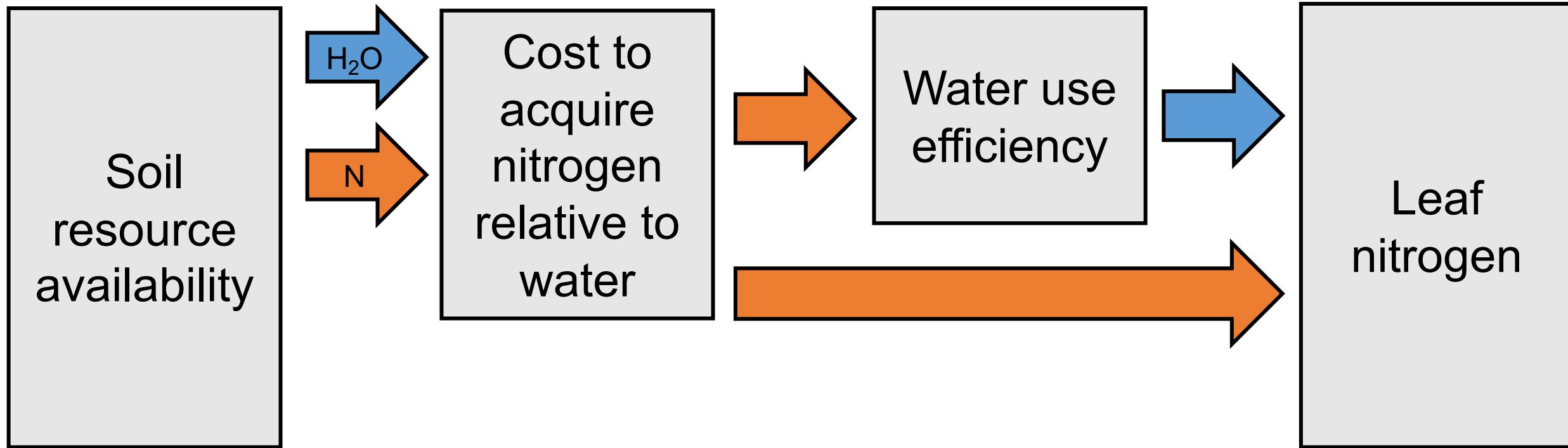
Negative effect



However, leaf N could be independent of water use efficiency...

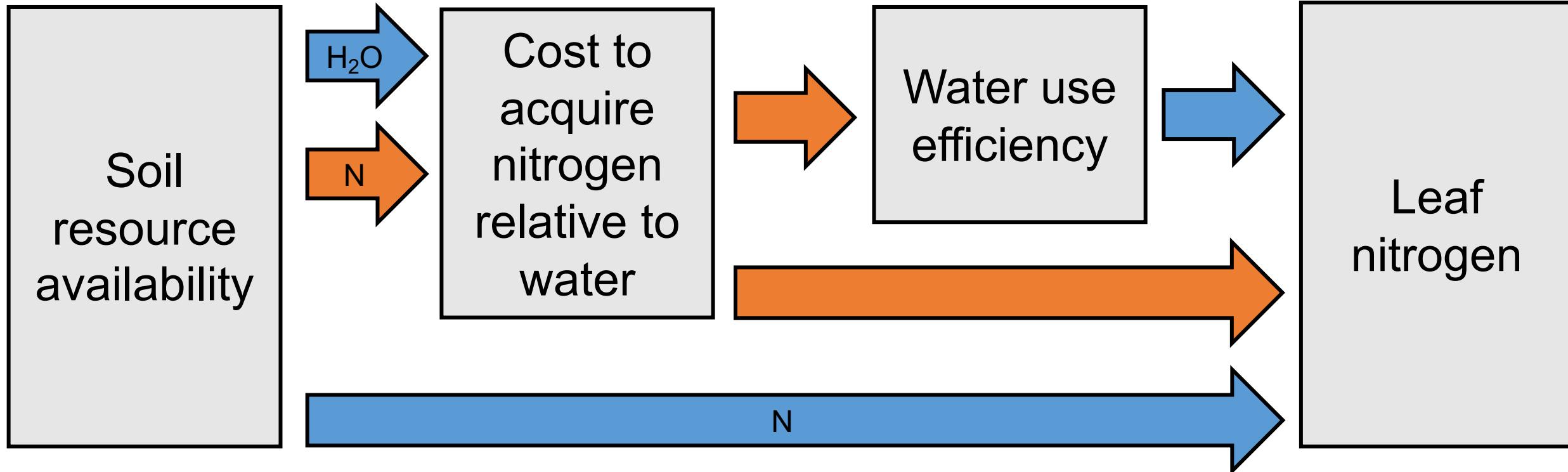
Positive effect

Negative effect



... and may be independent of the cost to acquire nitrogen relative to water

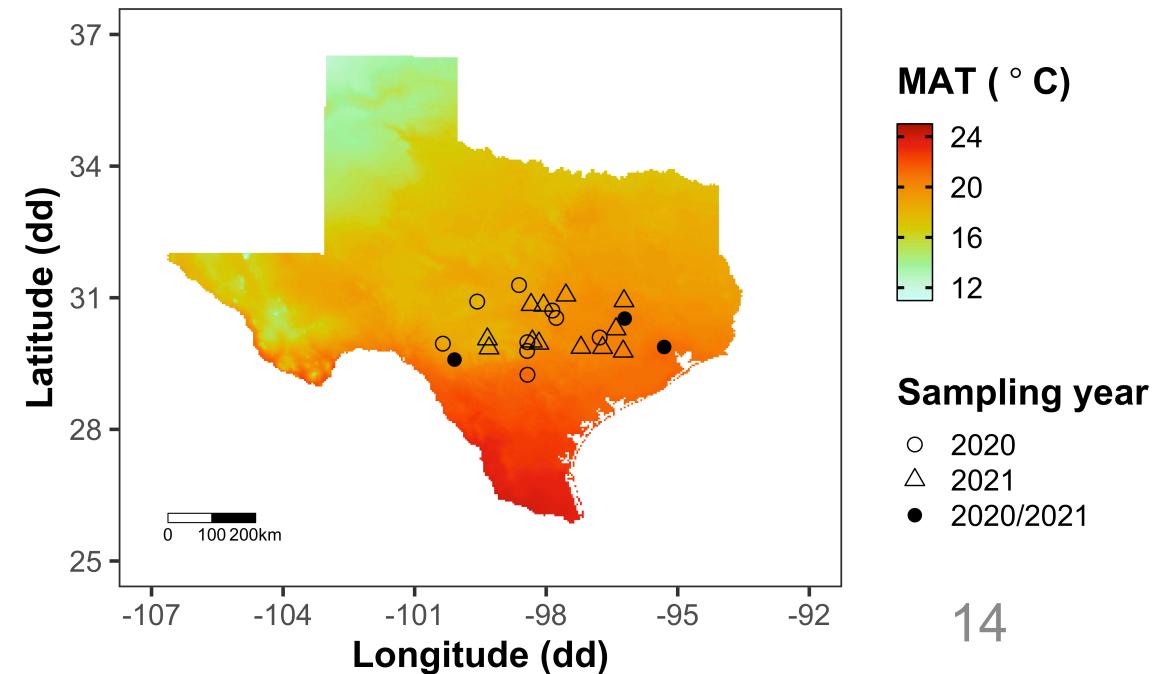
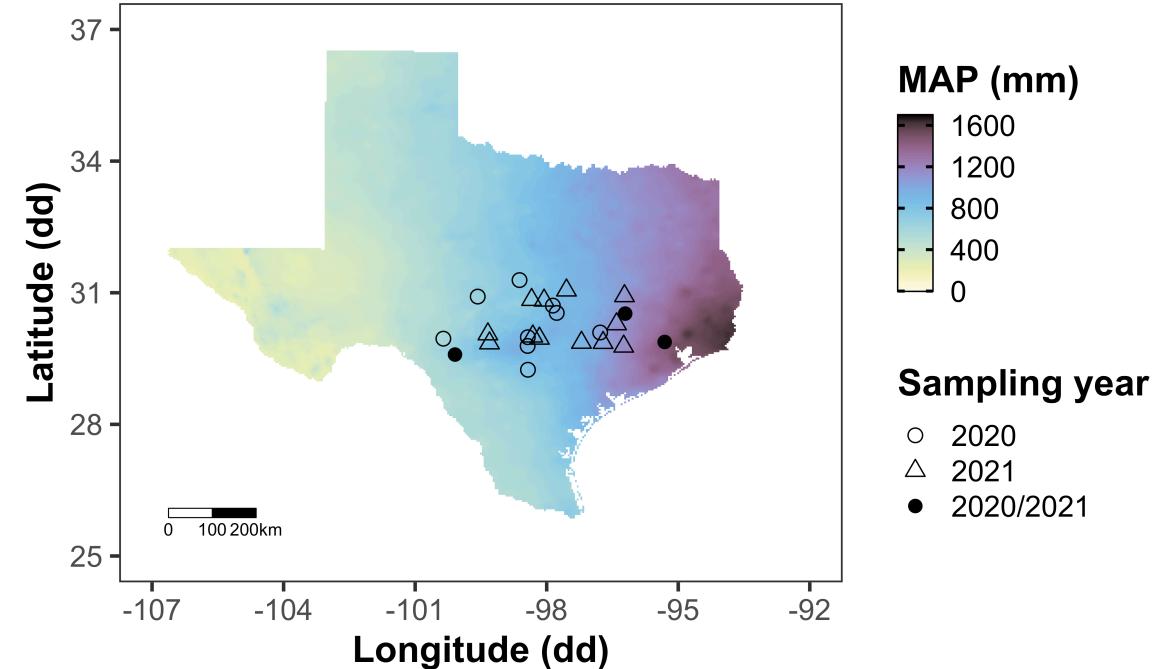
Positive effect  
Negative effect



We currently lack empirical studies that directly test patterns expected from photosynthetic least-cost theory

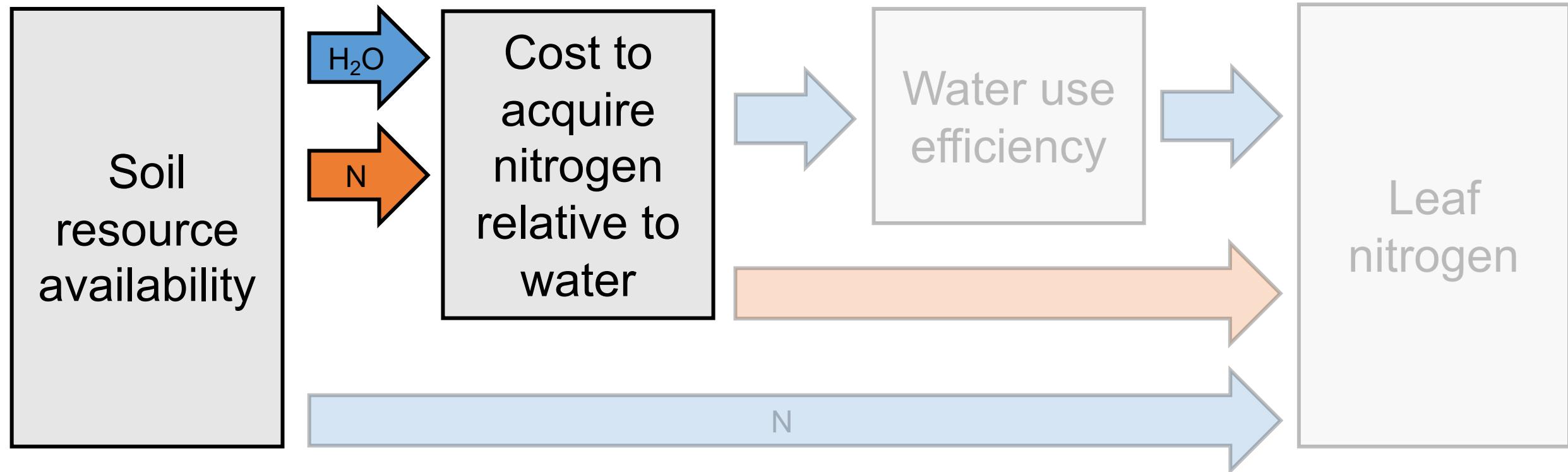
# Study sites, collection methods, traits

- 24 sites
  - 12 in 2020
  - 15 in 2021 (3 same from 2020)
- 3 leaves of 5 most dominant species at each site
  - Leaf N
  - Leaf water use efficiency ( $\delta^{13}\text{C}$ )
- Composite soil sample
  - $[\text{NO}_3\text{-N}]$



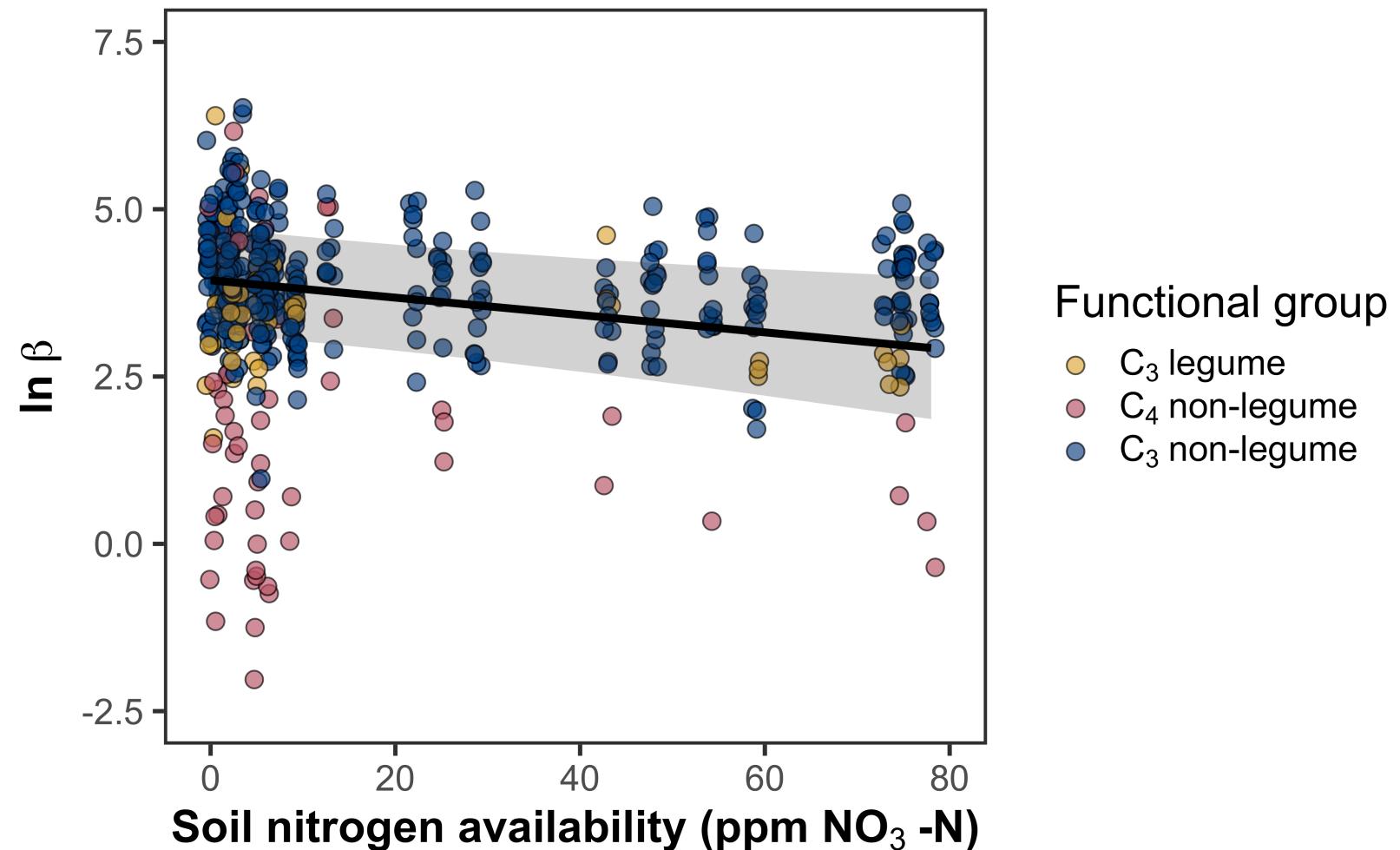
Positive effect

Negative effect



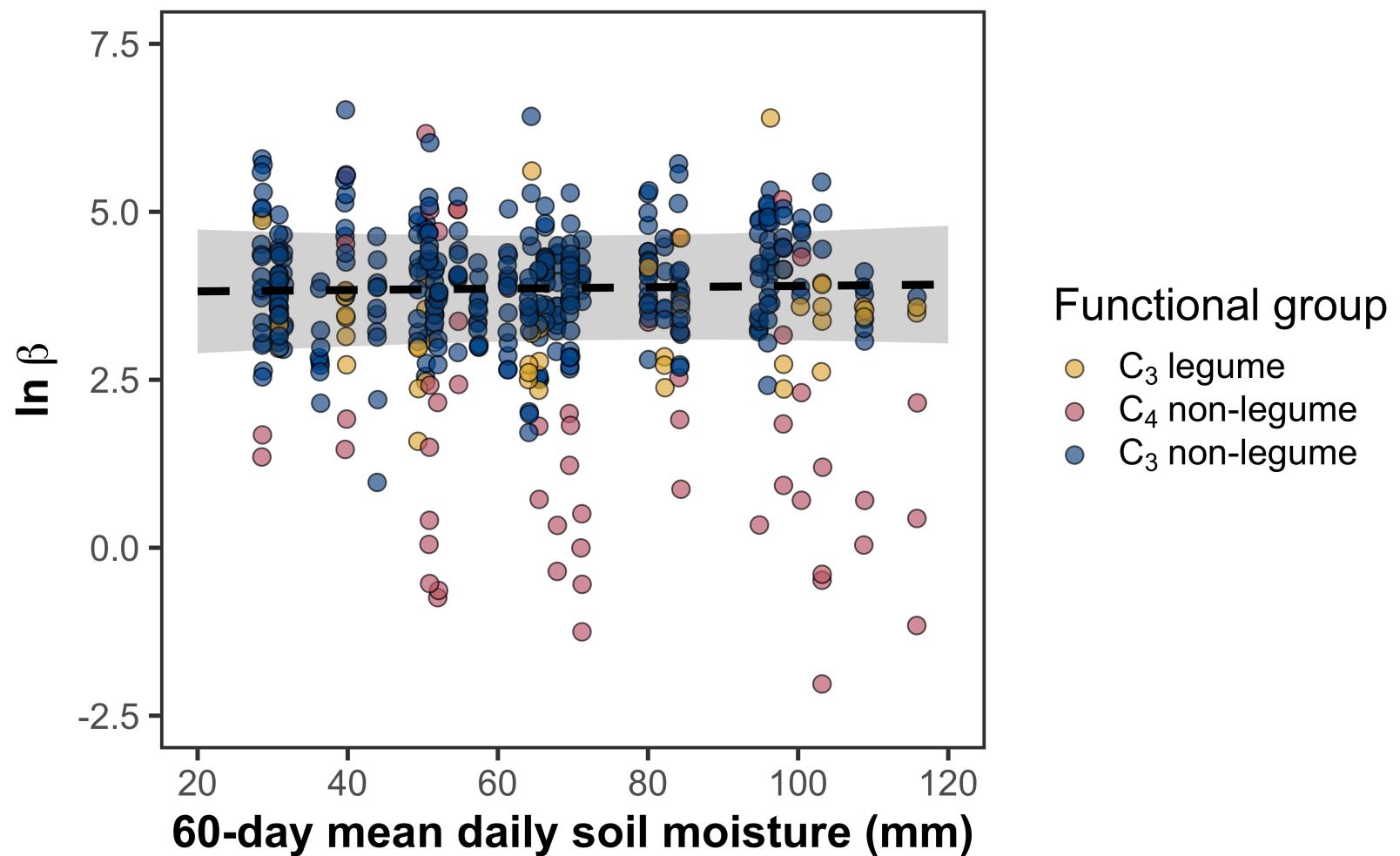
Soil nitrogen availability **decreases** the cost of acquiring nitrogen relative to water

Cost of acquiring  
nitrogen relative  
to water



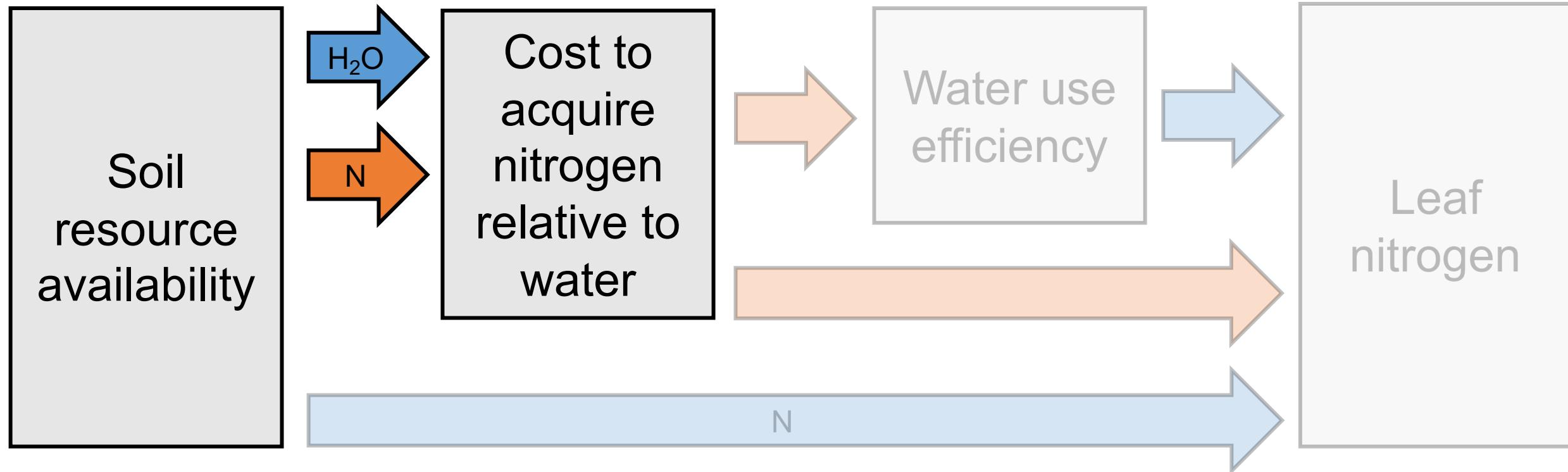
# Soil moisture does not change the cost of acquiring nitrogen relative to water

Cost of acquiring  
nitrogen relative  
to water



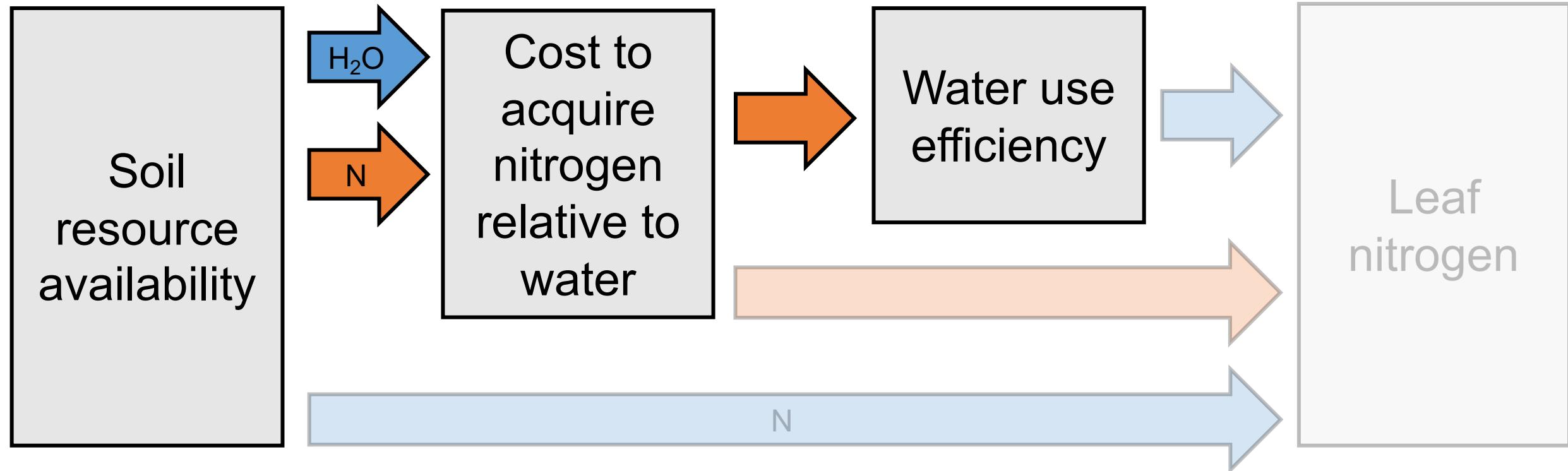
Positive effect

Negative effect



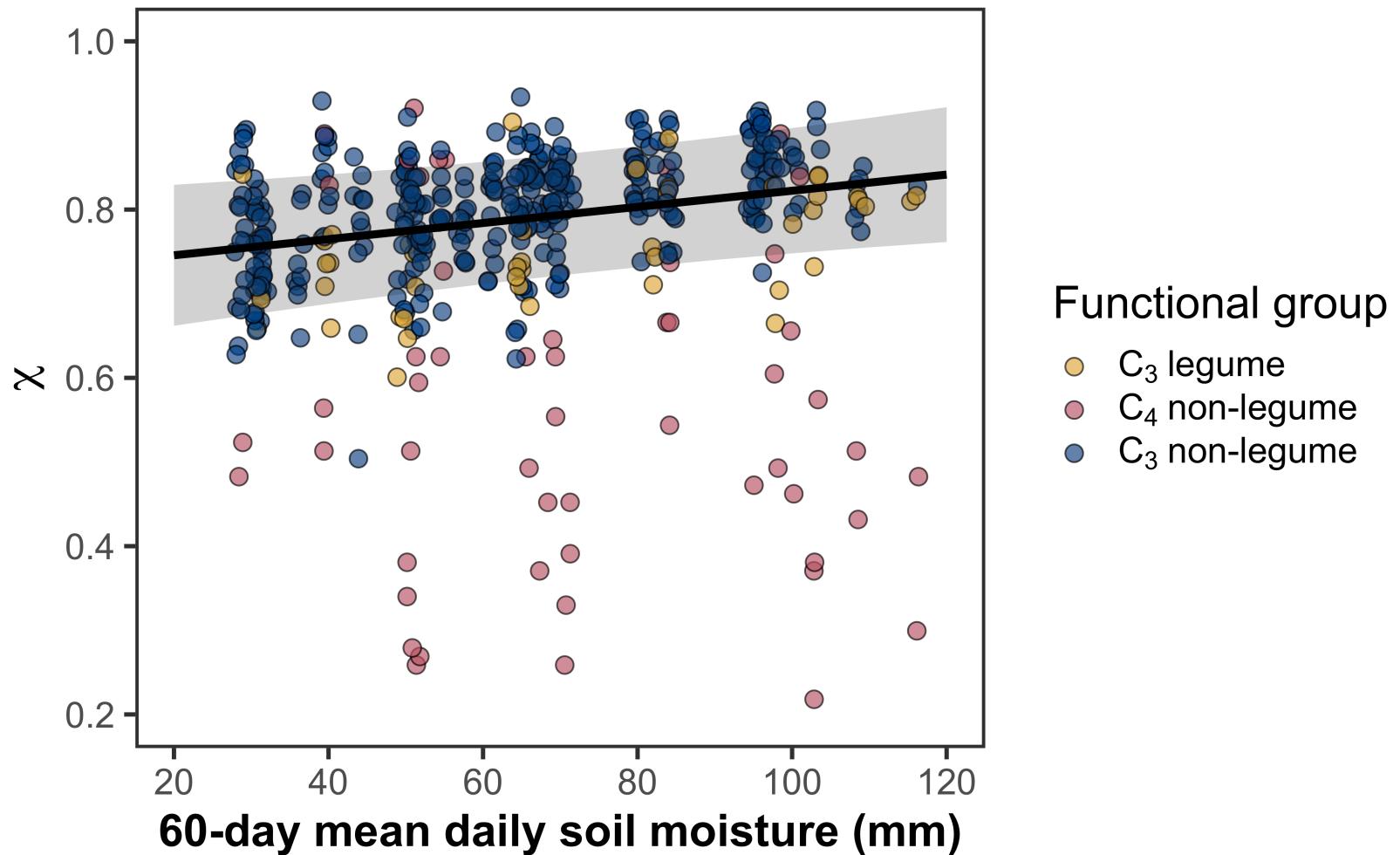
Positive effect

Negative effect



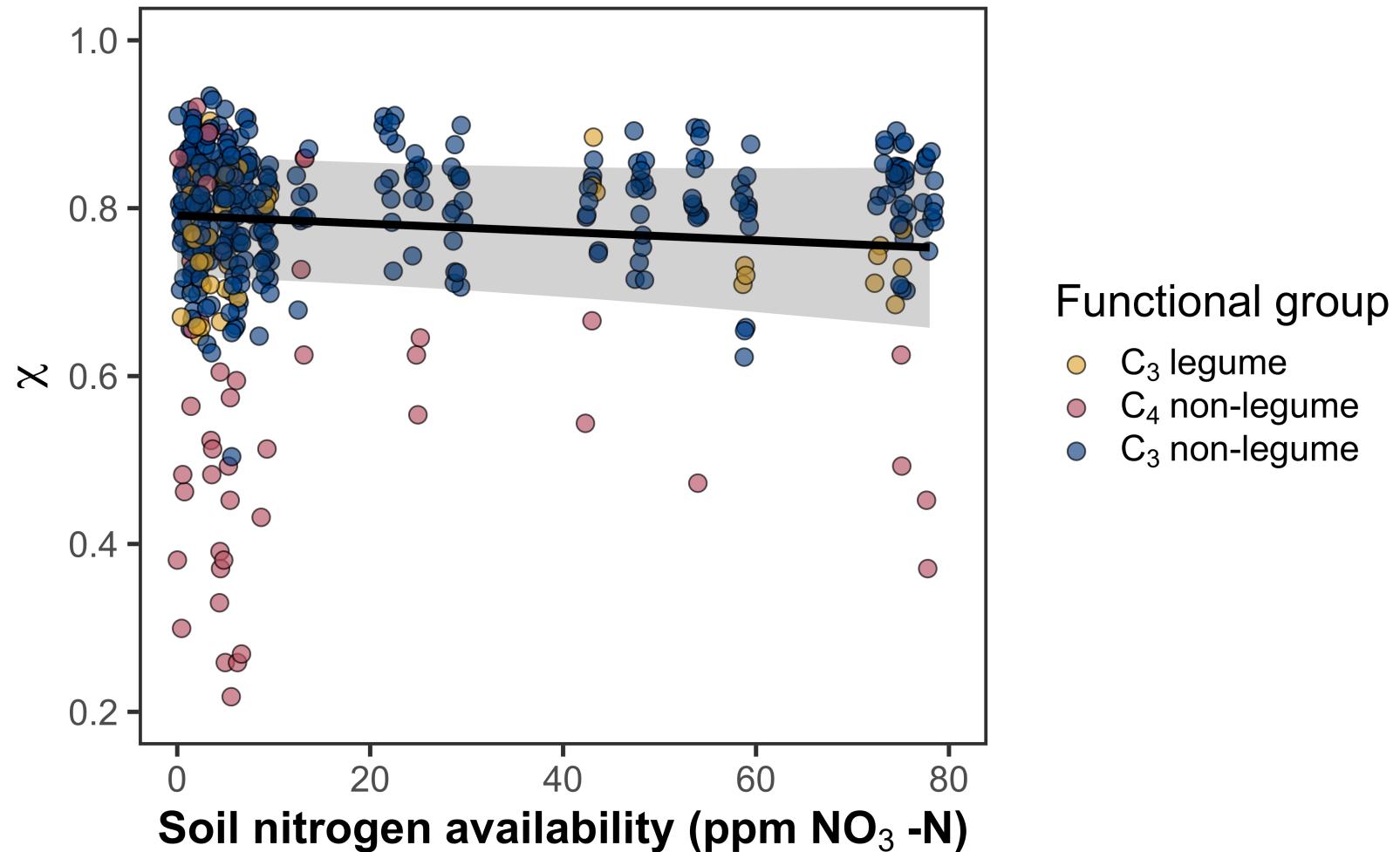
# Soil moisture **decreases** water use efficiency

Increasing  
WUE



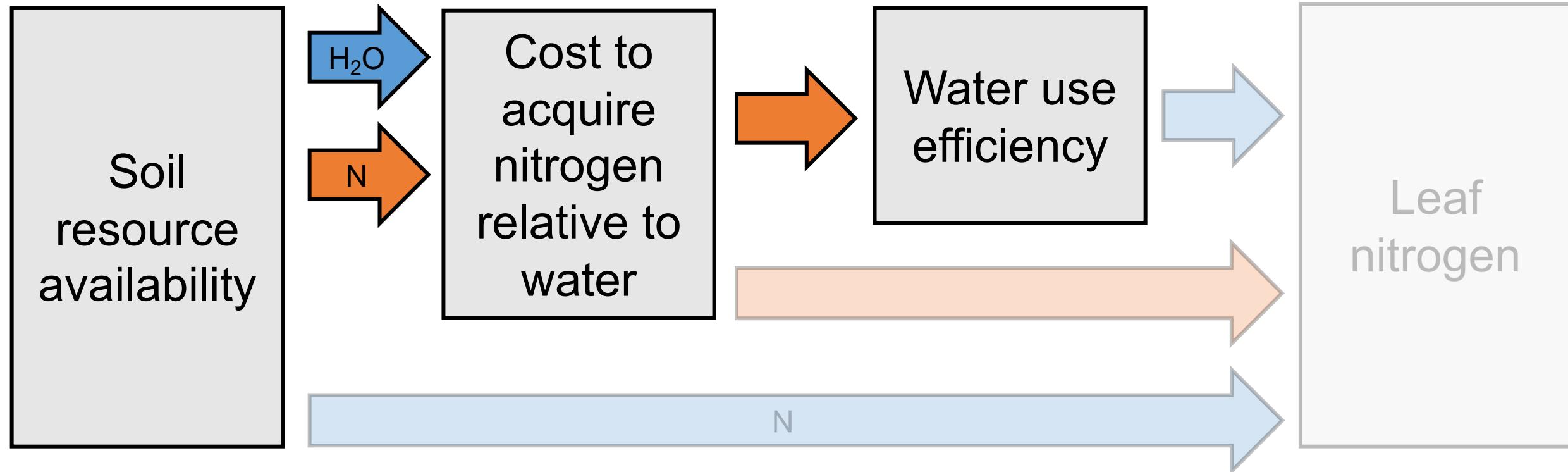
# Soil nitrogen availability **increases** water use efficiency

Increasing WUE



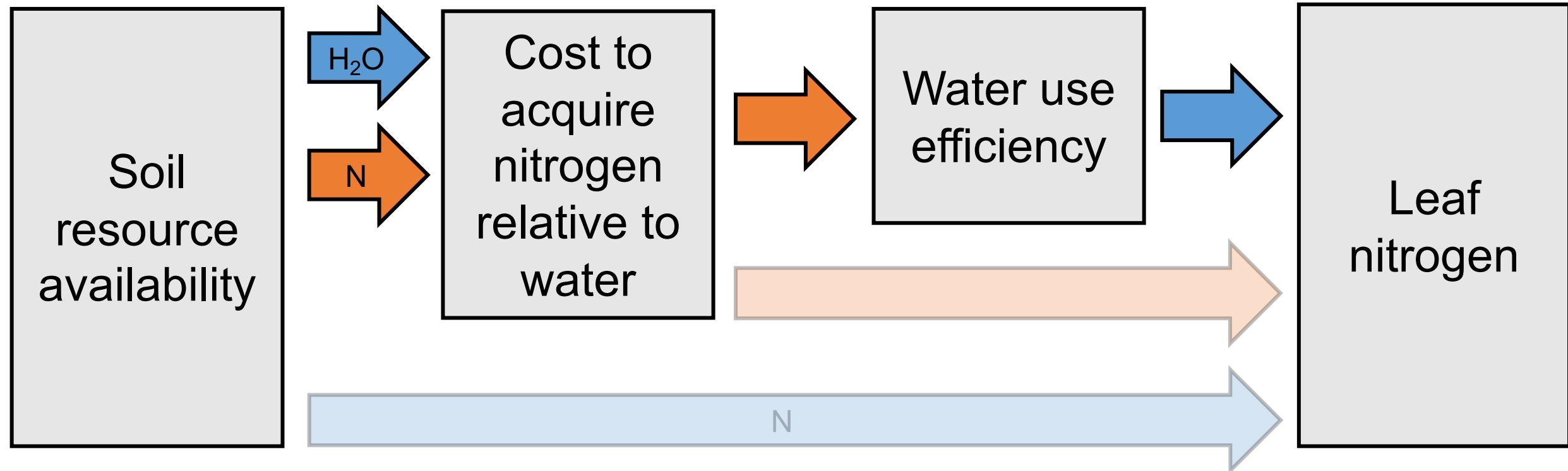
Positive effect

Negative effect

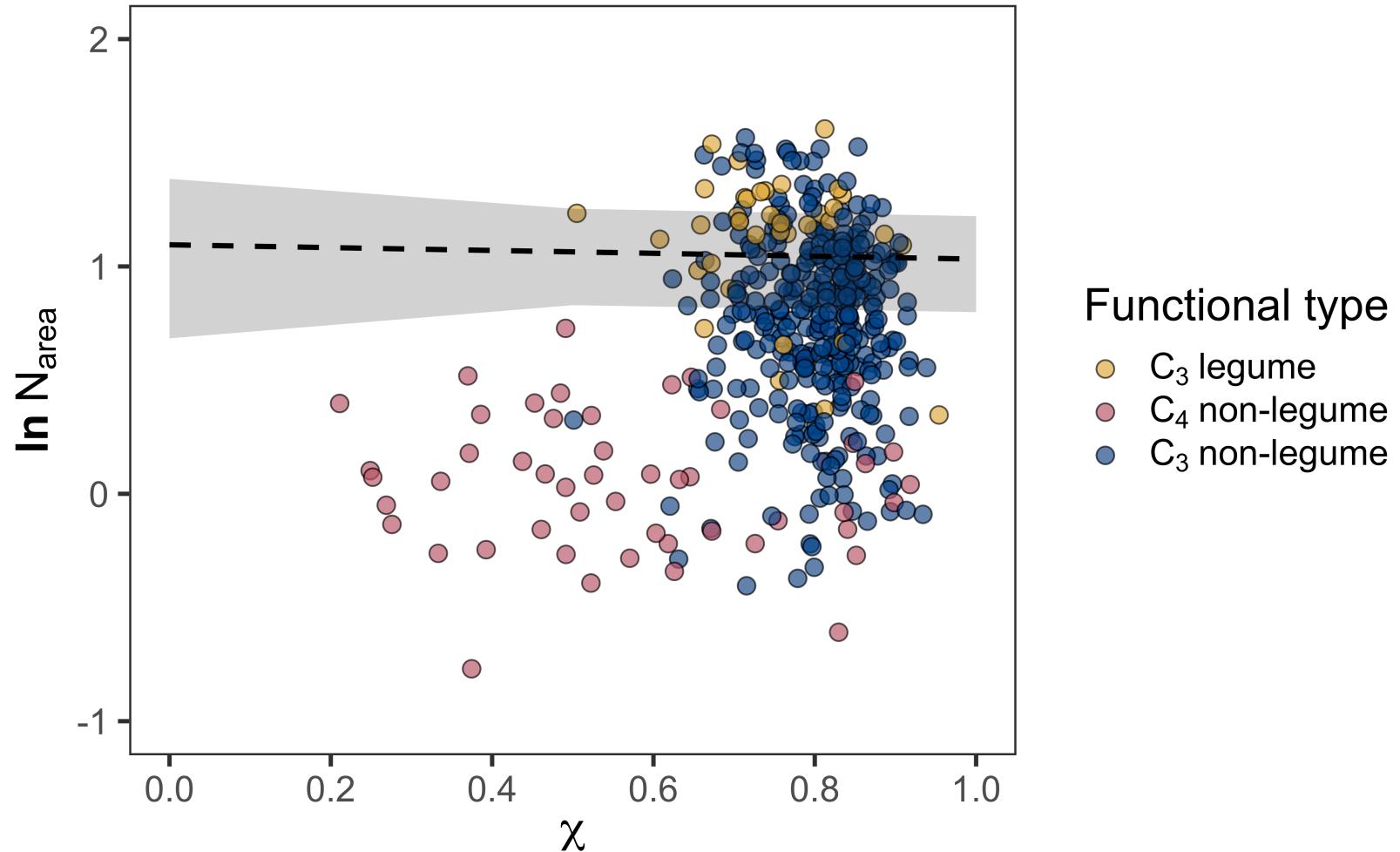


Positive effect

Negative effect

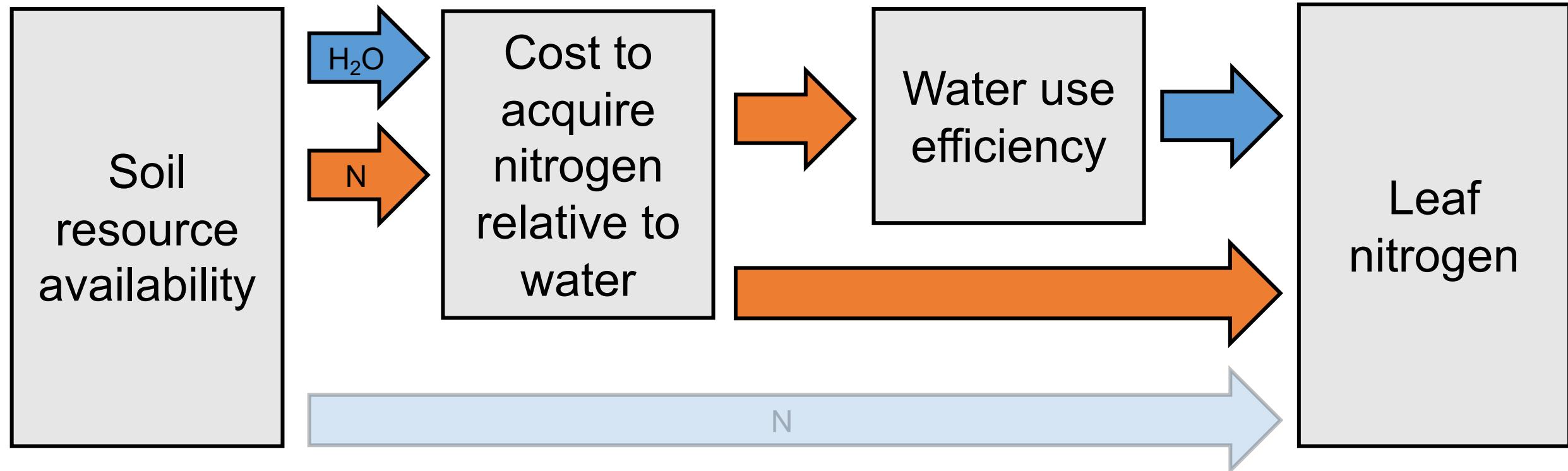


# Water use efficiency does not change leaf nitrogen

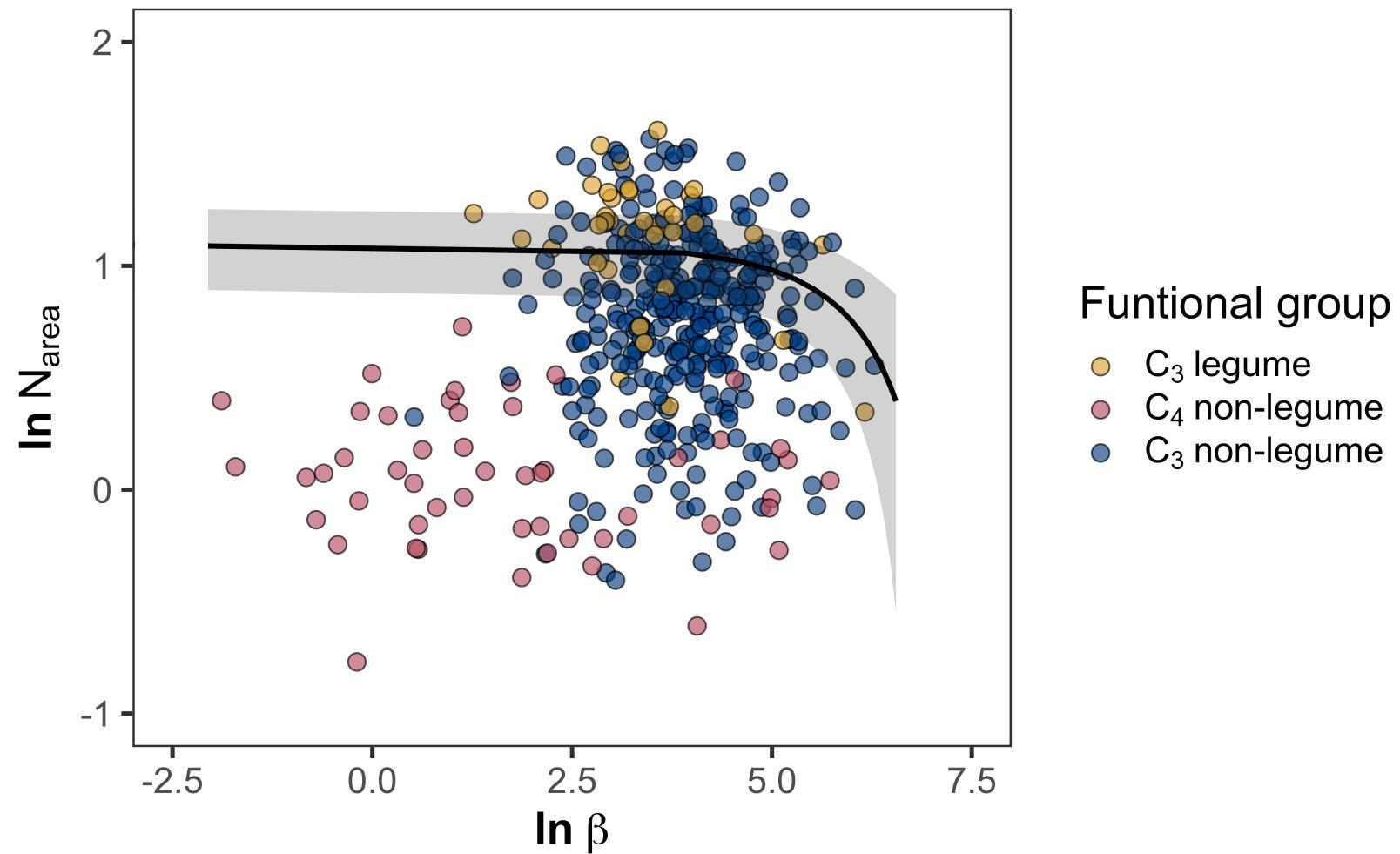


Positive effect

Negative effect

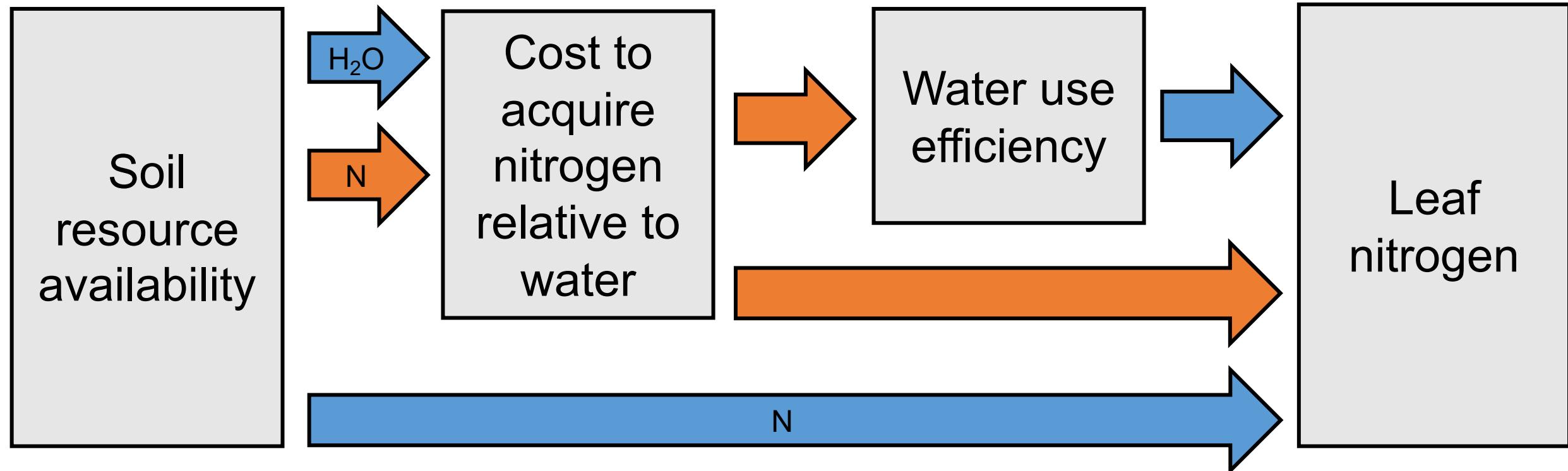


The cost to acquire nitrogen relative to water has a negative nonlinear effect on leaf nitrogen

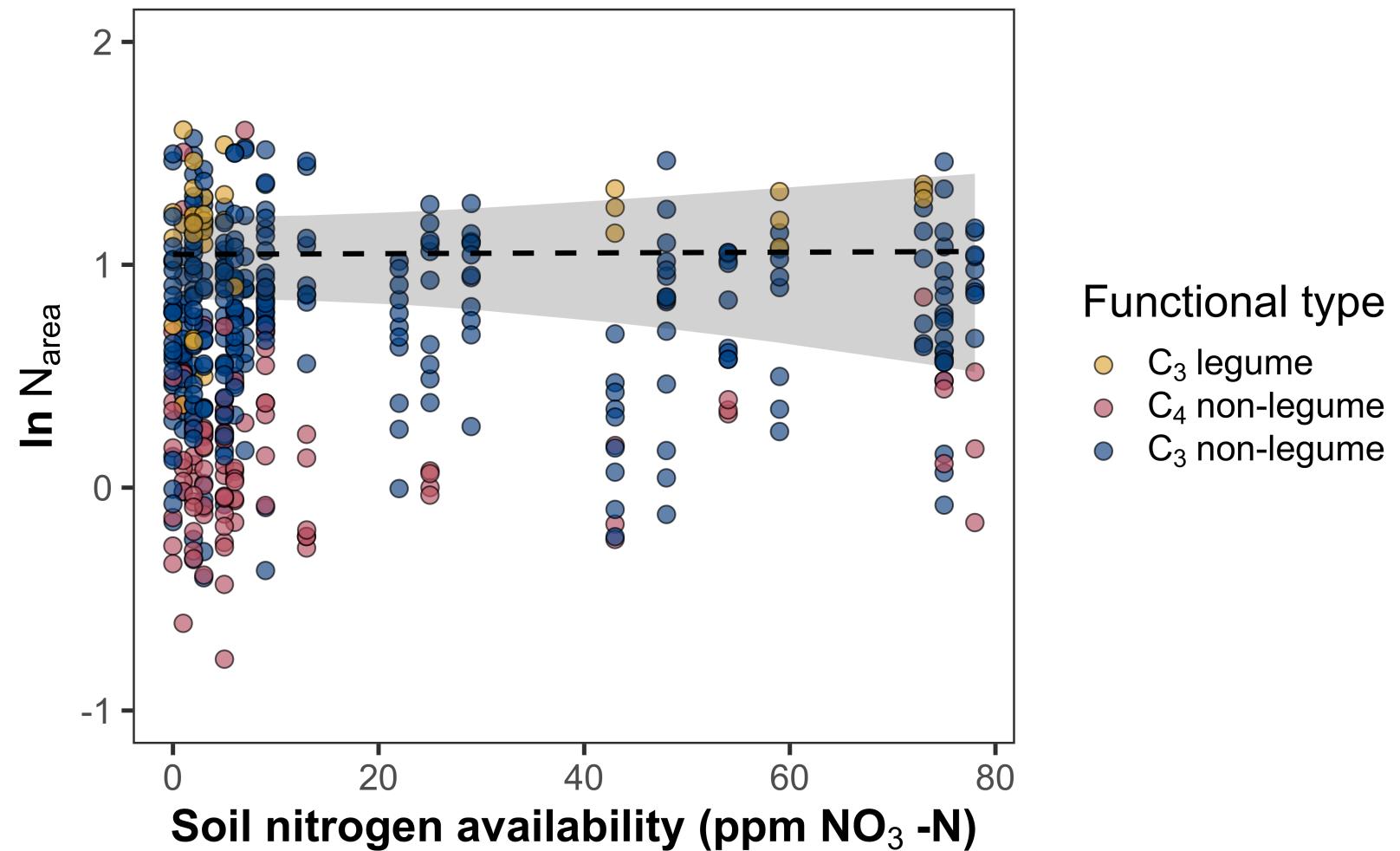


Positive effect

Negative effect



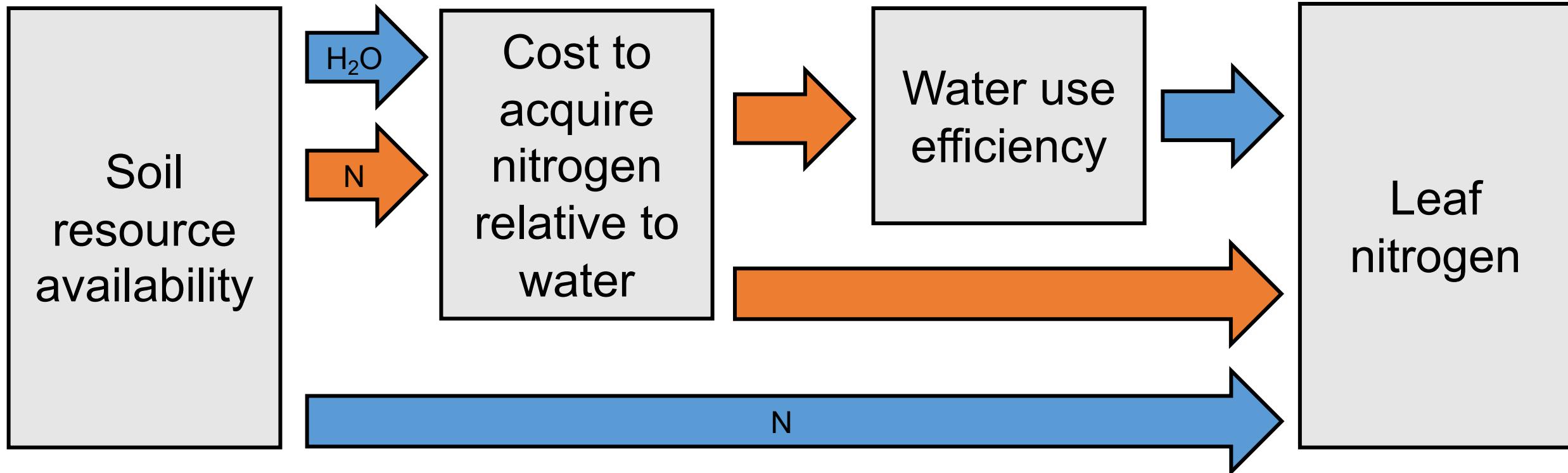
# Soil nitrogen availability does not change leaf nitrogen



# Revisiting hypotheses

Positive effect

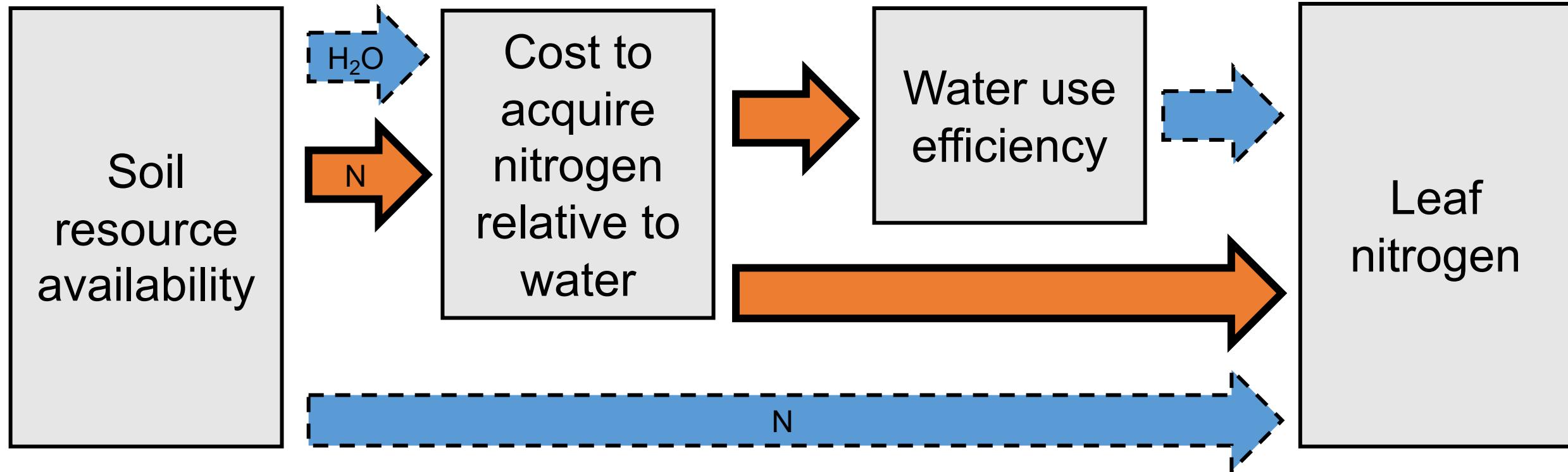
Negative effect



# Revisiting hypotheses

Positive effect

Negative effect





Texas Ecological Laboratory

# Acknowledgements

## Field and lab assistance

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- ESA Biogeosciences Section
- ESA Physiological Ecology Section



**Follow me on Twitter! @EvanPerkowski**

**Shoot me an e-mail! Evan.A.Perkowski@ttu.edu**

**Thank you!**

Slides available at:

<https://github.com/eaperkowski/esa2022>

# Extra slides

# Resource unit cost ratio ( $\beta$ )

cost of acquiring and using N

$$\beta = \frac{b}{a}$$

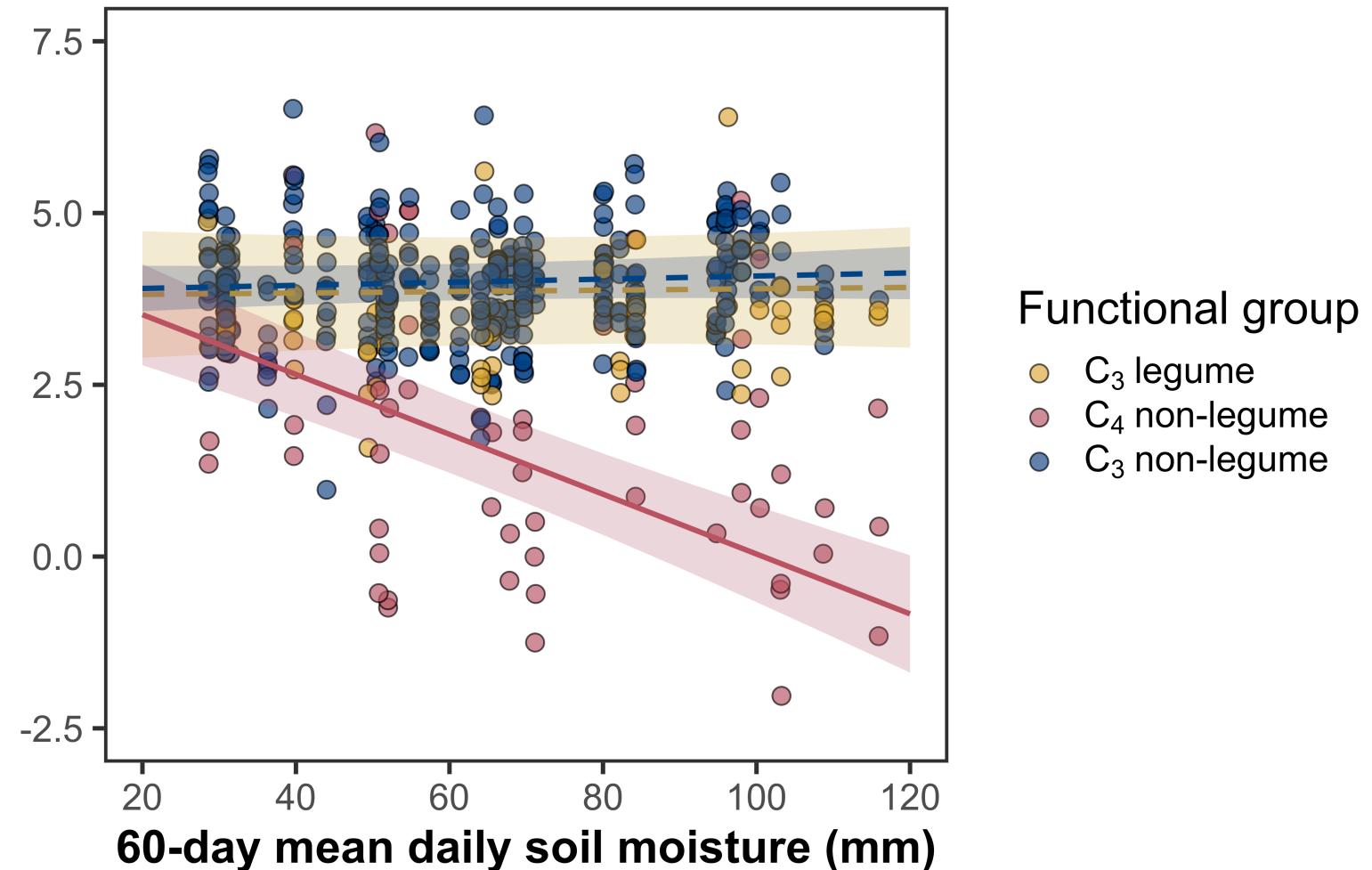
cost of acquiring and using H<sub>2</sub>O

# Resource unit cost ratio ( $\beta$ )

$$\beta = \frac{b}{a} = 1.6\eta^* D \frac{\left( \chi_{leaf} - \frac{\Gamma^*}{C_a} \right)}{\left( 1 - \chi_{leaf} \right)^2 * (K + \Gamma^*)}$$

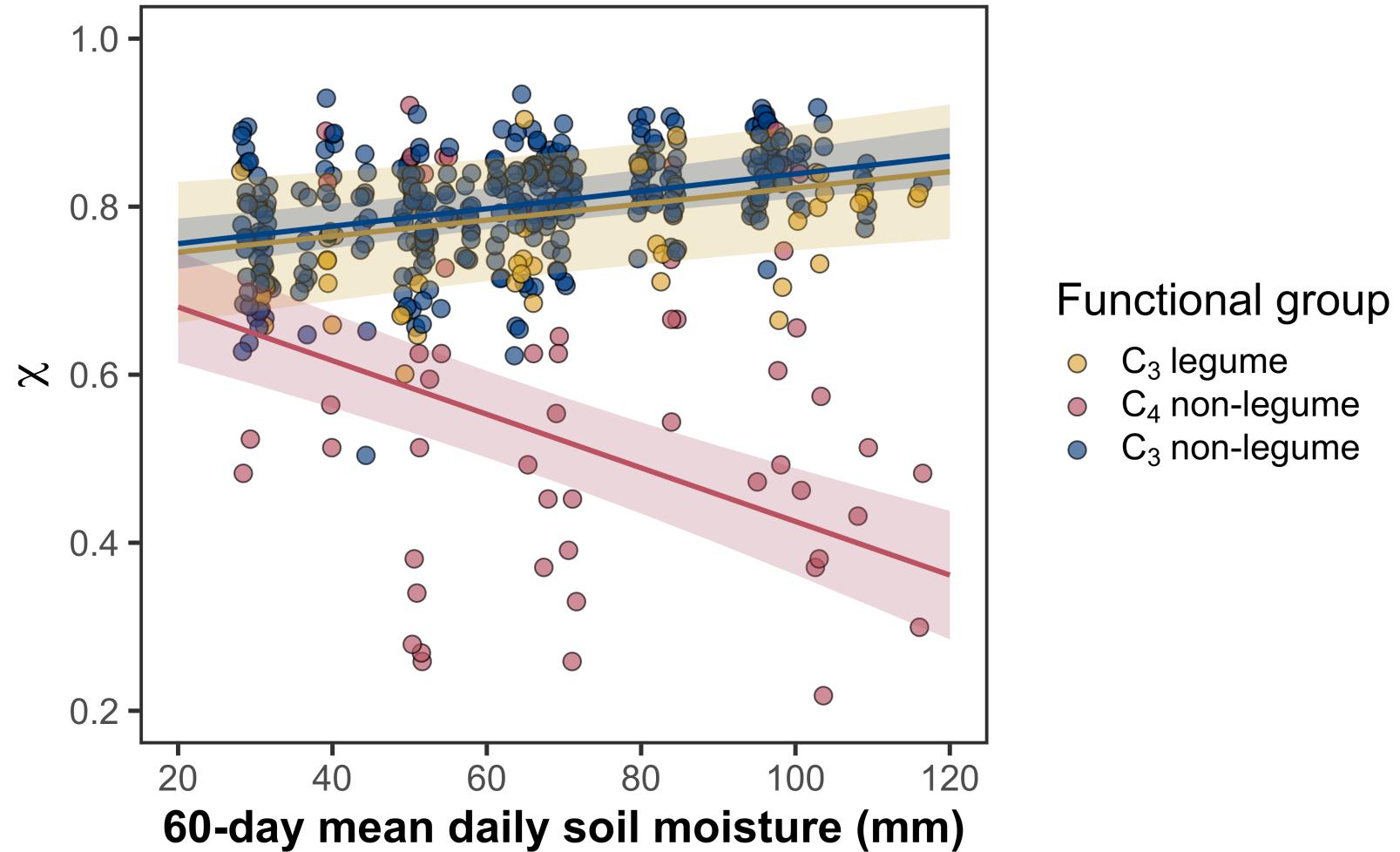
$C_4$  non-legumes experience a reduction in these relative costs with increasing soil moisture

Cost of acquiring nitrogen relative to water →  $\ln \beta$



Soil moisture **decreases** water use efficiency,  
a pattern observed only in C<sub>3</sub> species

Increasing  
WUE



Soil nitrogen availability **increases** water use efficiency, but only in non-legumes

Increasing WUE

