

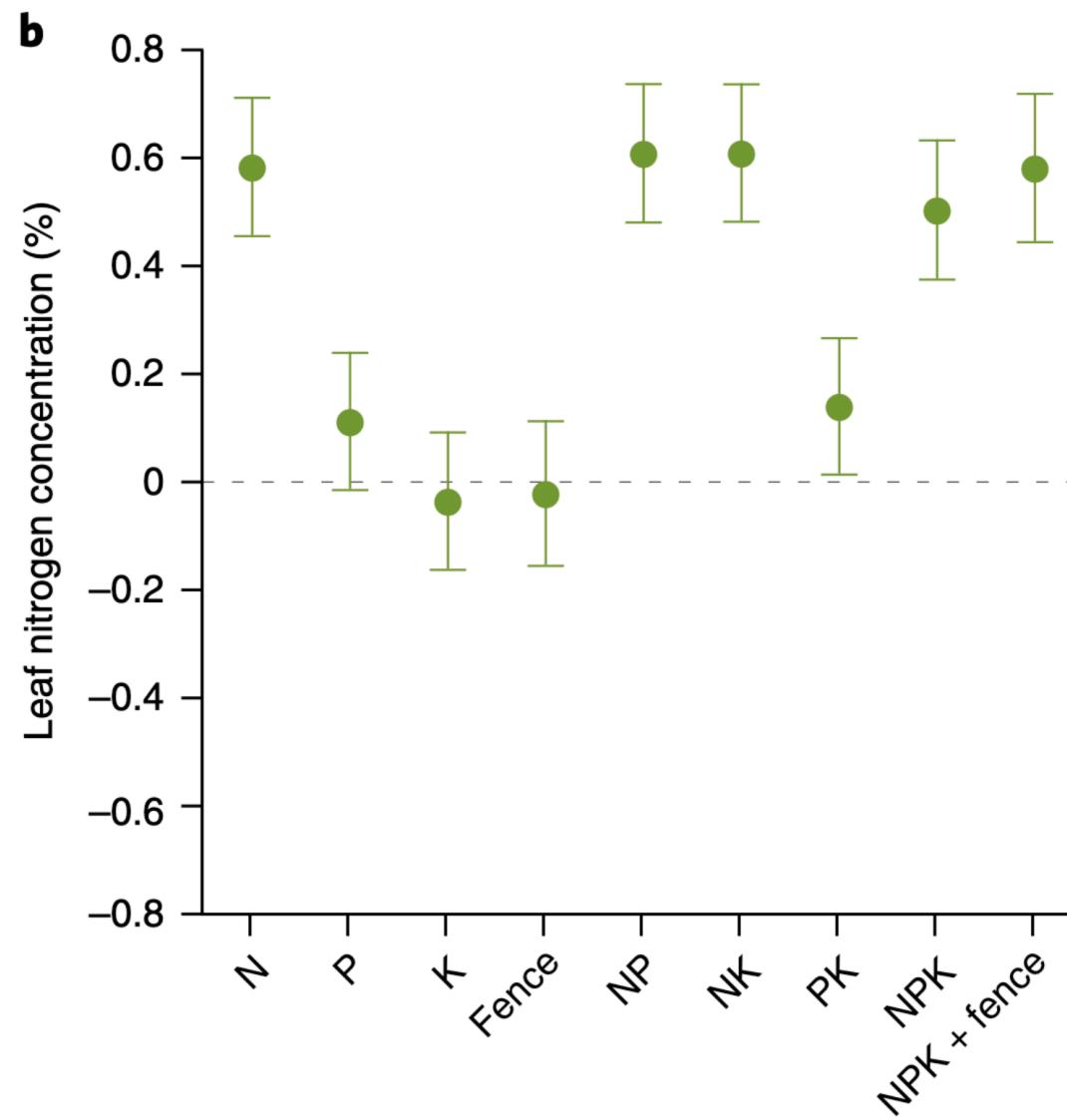


# **Leaf nitrogen is driven by the unit cost of nitrogen and water use in Texan grasslands**

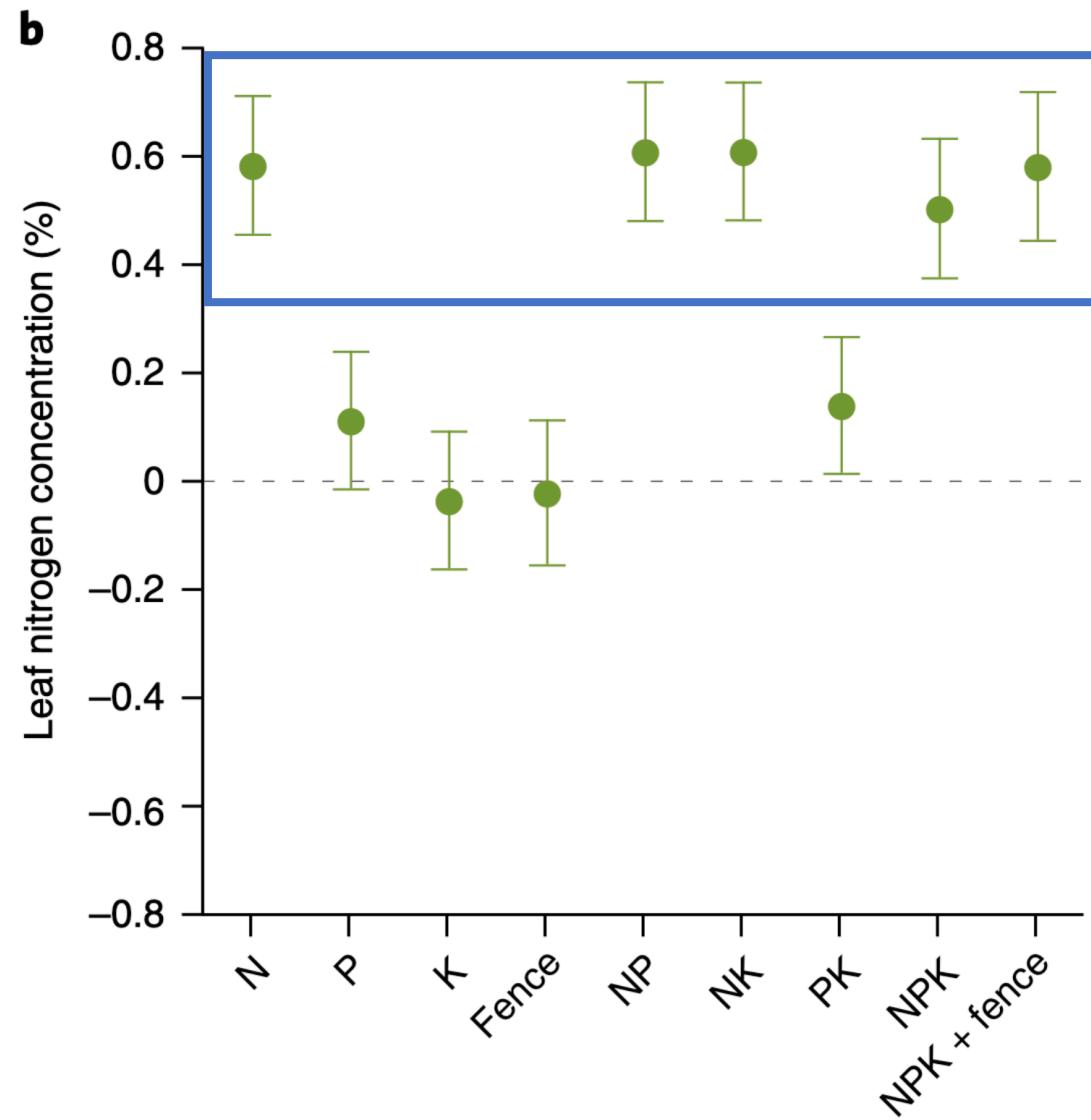
Evan A. Perkowski; Nicholas G. Smith



# Soil nitrogen generally increases leaf nitrogen

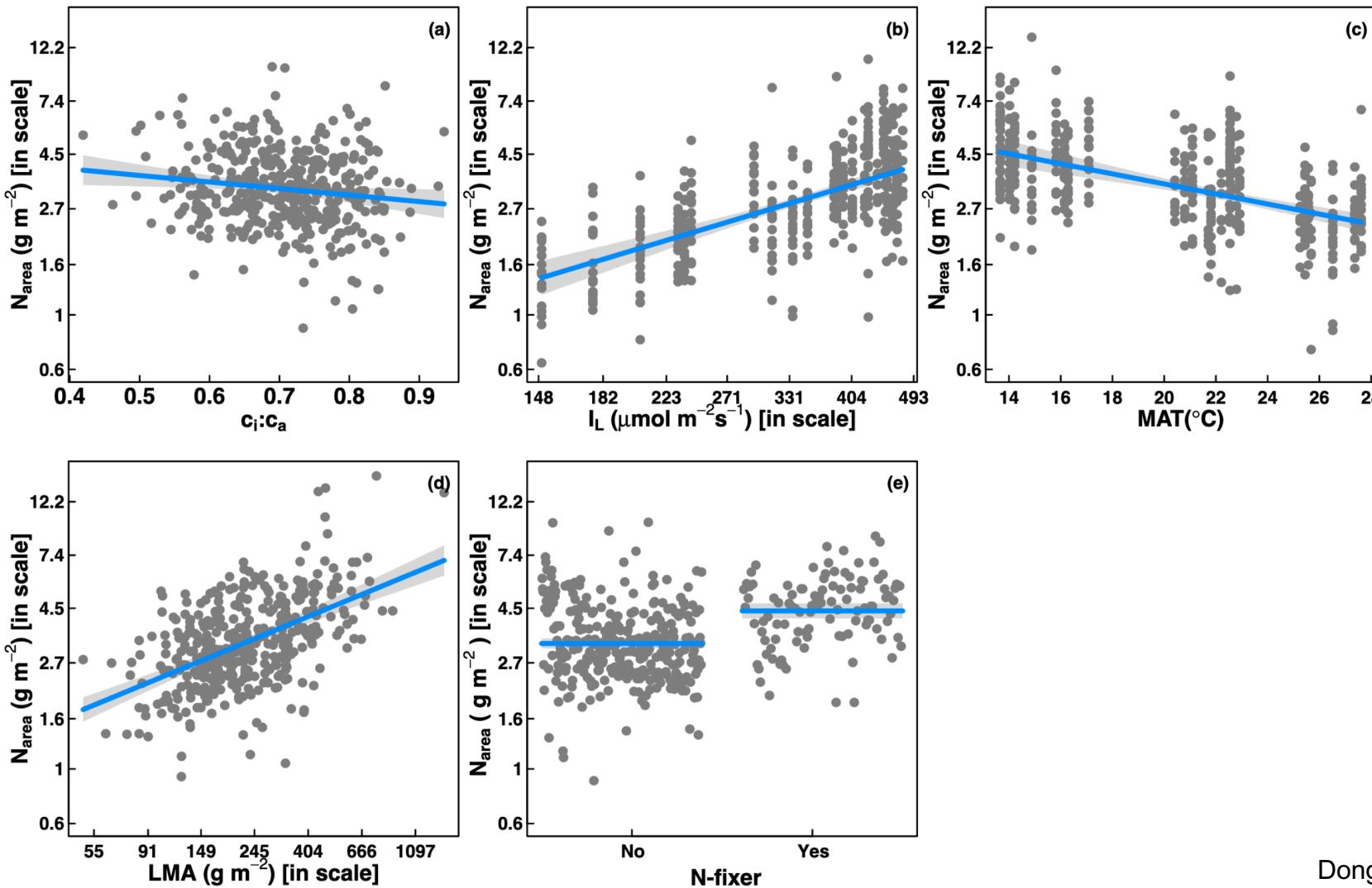


# Soil nitrogen generally increases leaf nitrogen



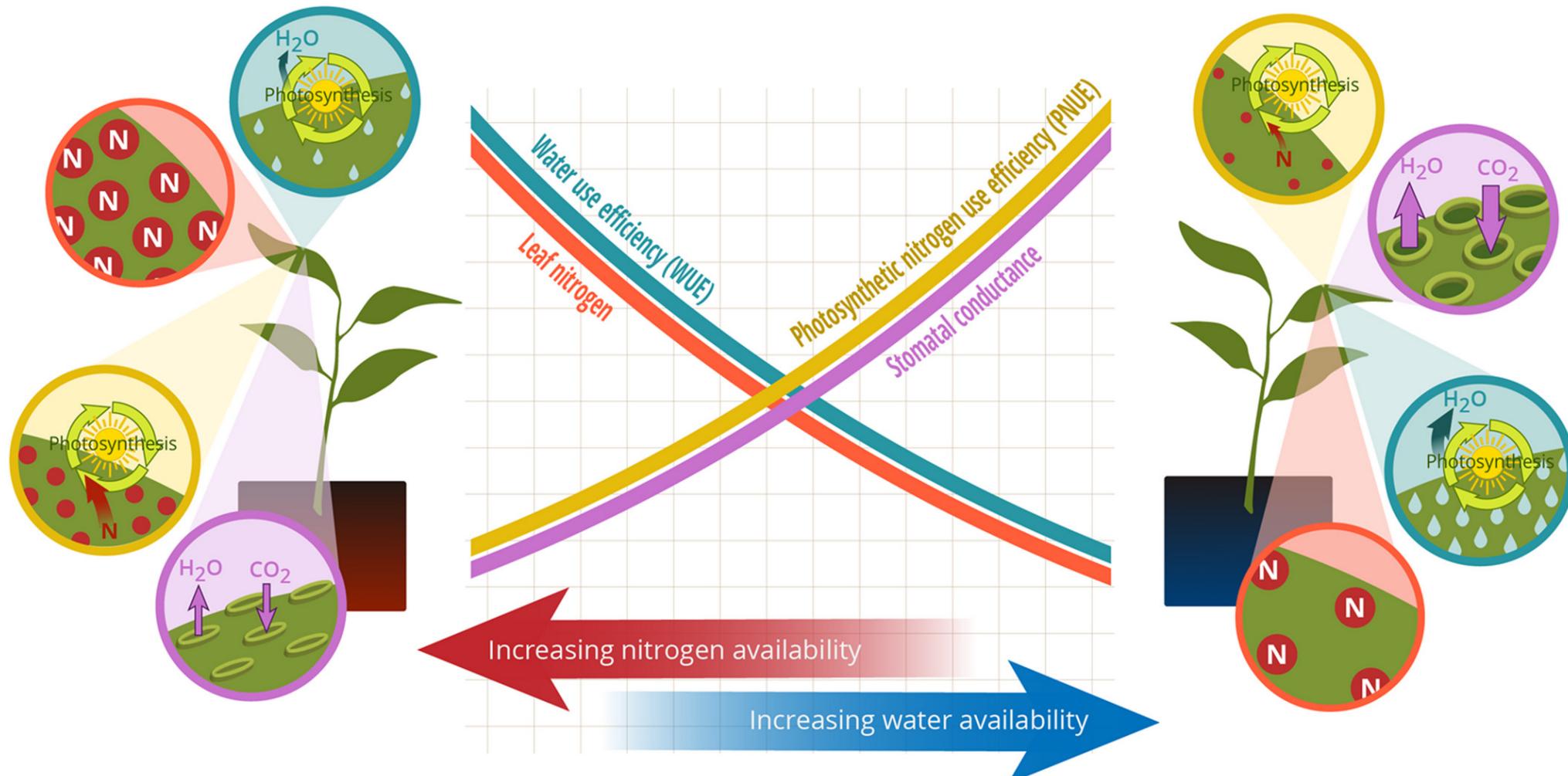
Plots that receive  
nitrogen have higher  
leaf nitrogen content

... but leaf nitrogen can be predicted independent of soil nitrogen

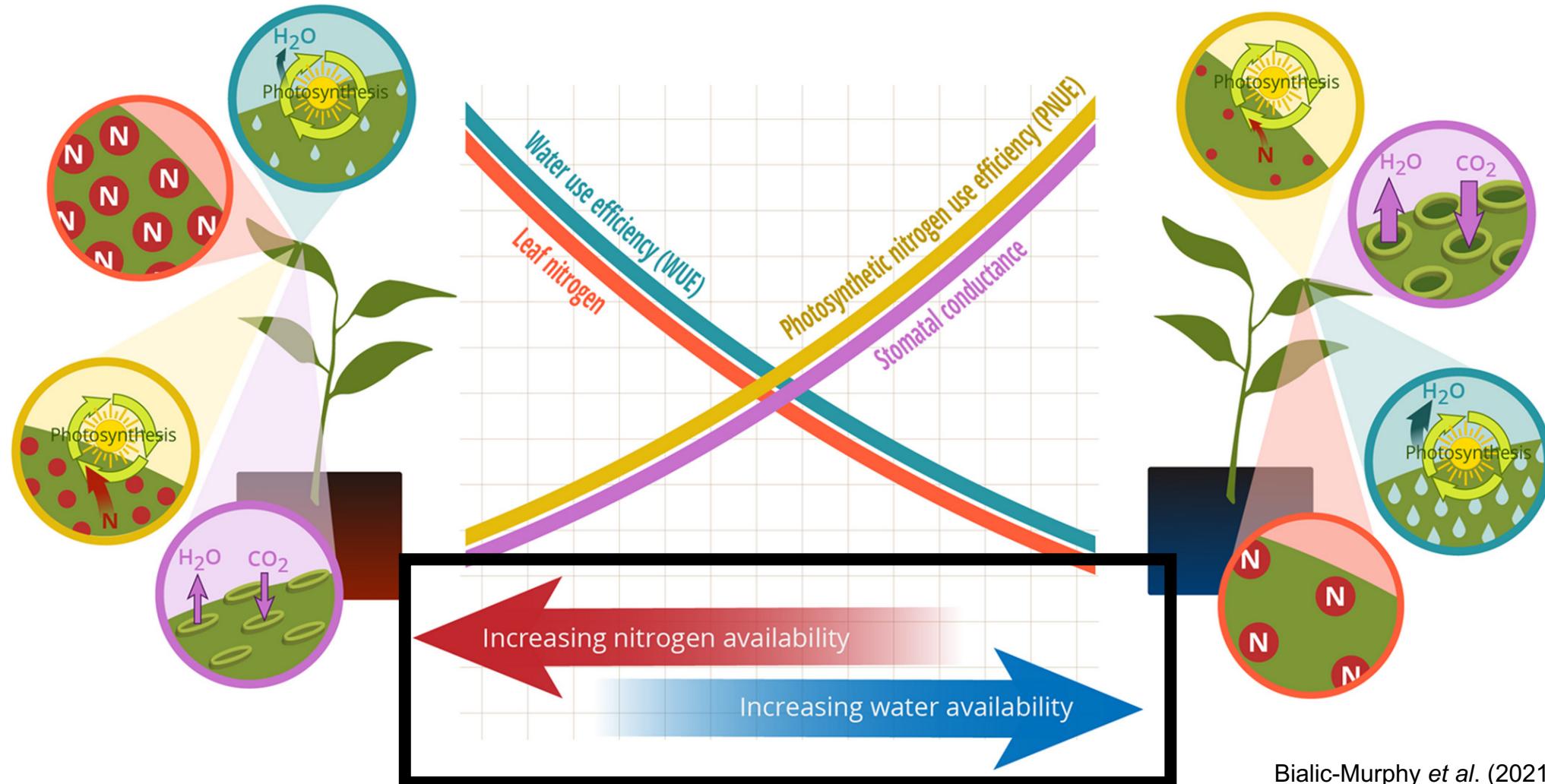


Leaf N is likely a product of interactions between climatic and edaphic factors

# Photosynthetic ‘least-cost’ theory



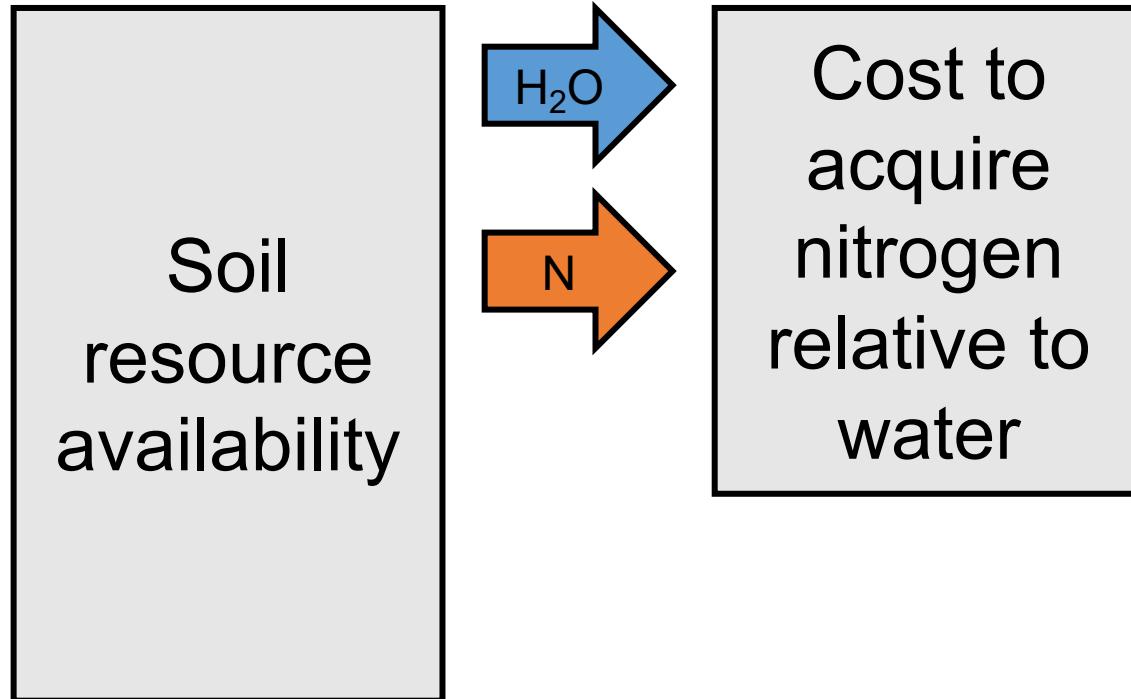
# Photosynthetic ‘least-cost’ theory: leaves acclimate to changing climatic and edaphic environments via summed cost of resource use (nitrogen and water)



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

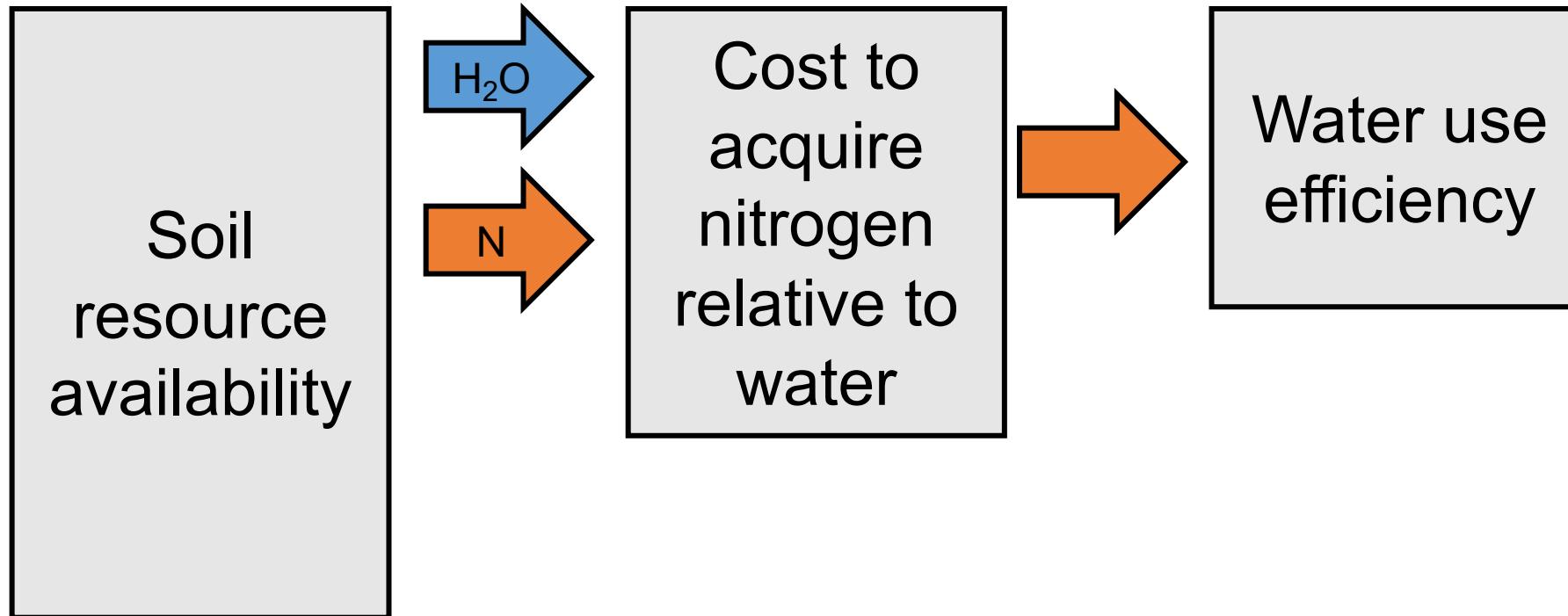
Positive effect

Negative effect



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

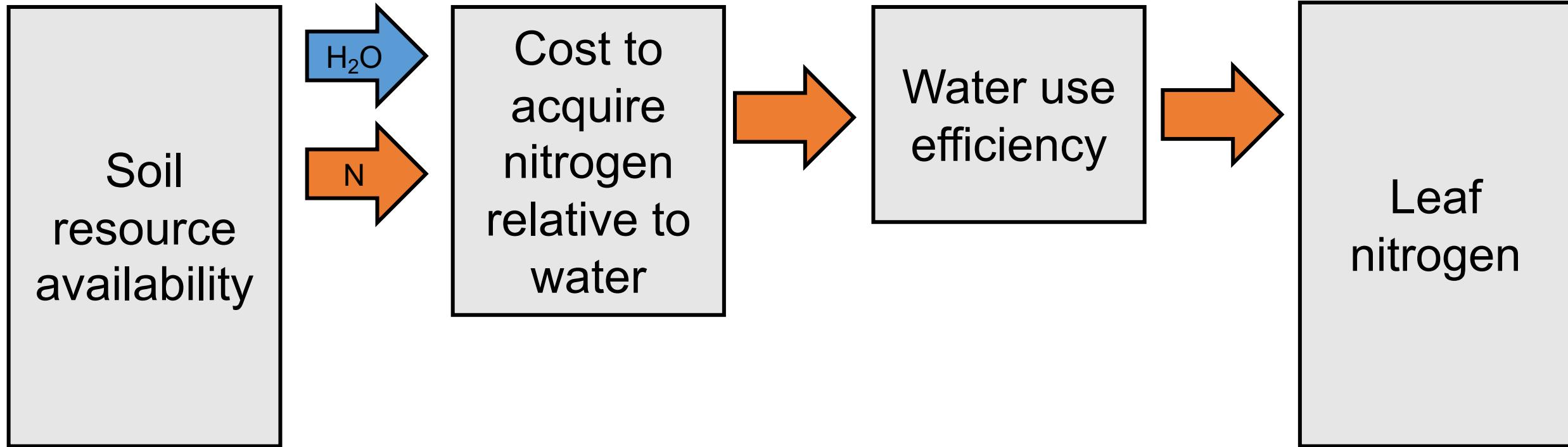
Positive effect  
Negative effect



Increasing water use efficiency should decrease leaf N

Positive effect

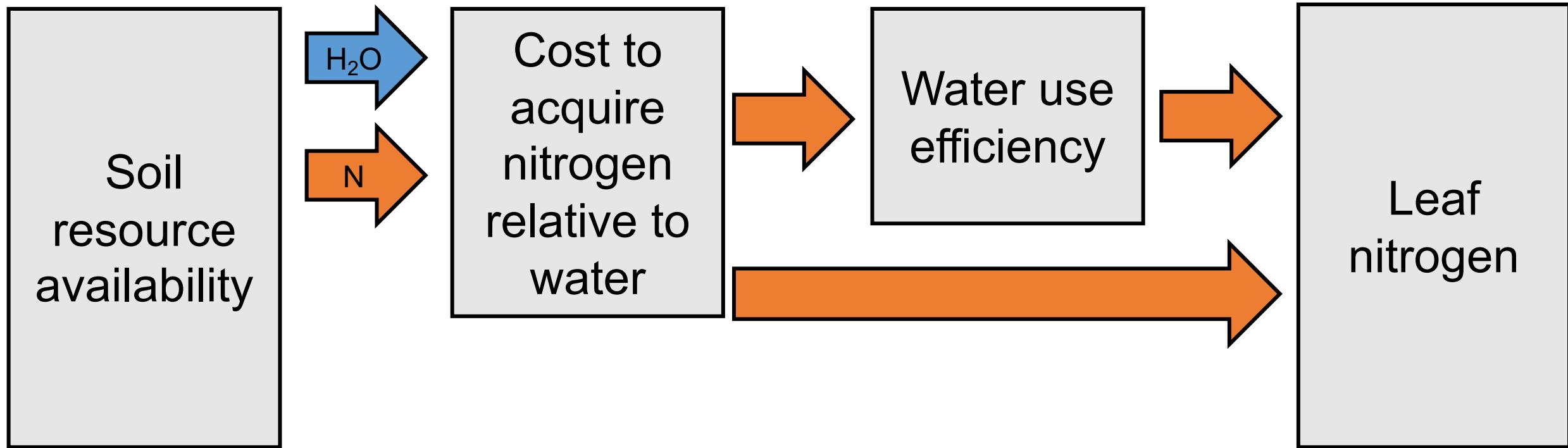
Negative effect



Positive effect

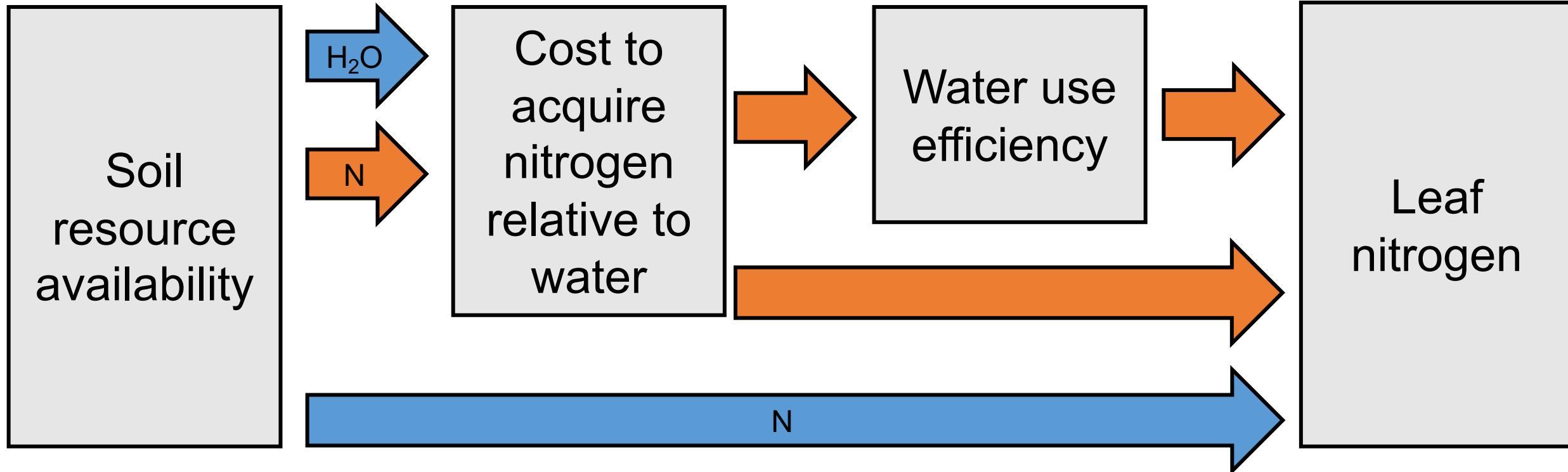
Negative effect

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



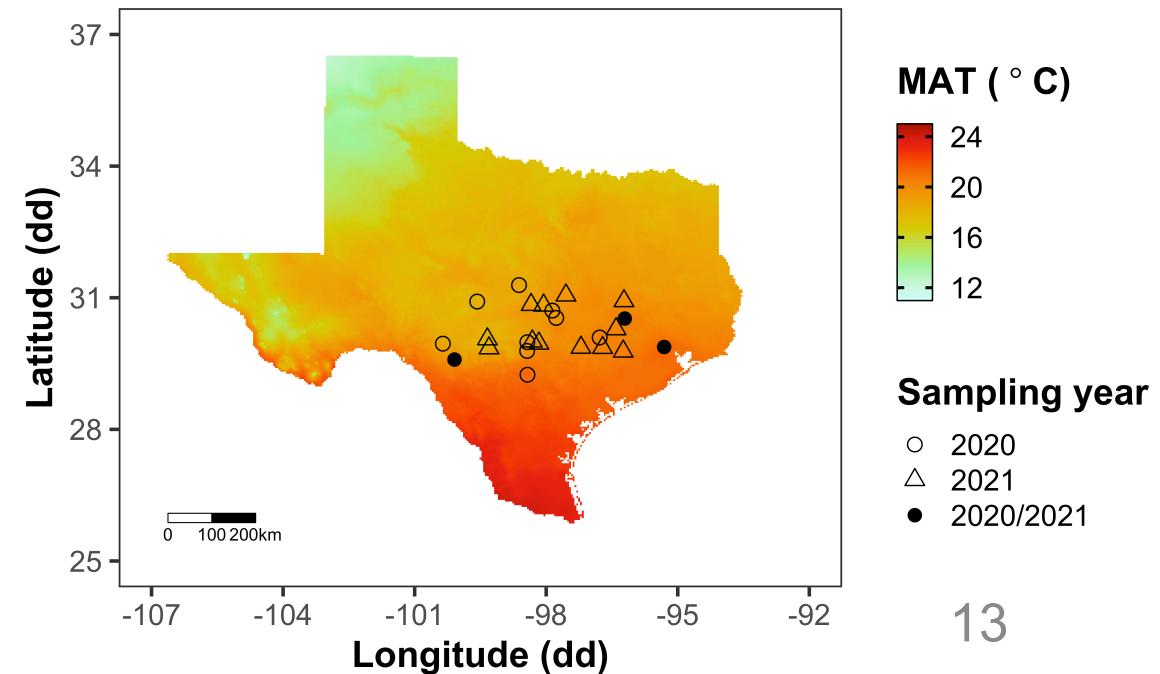
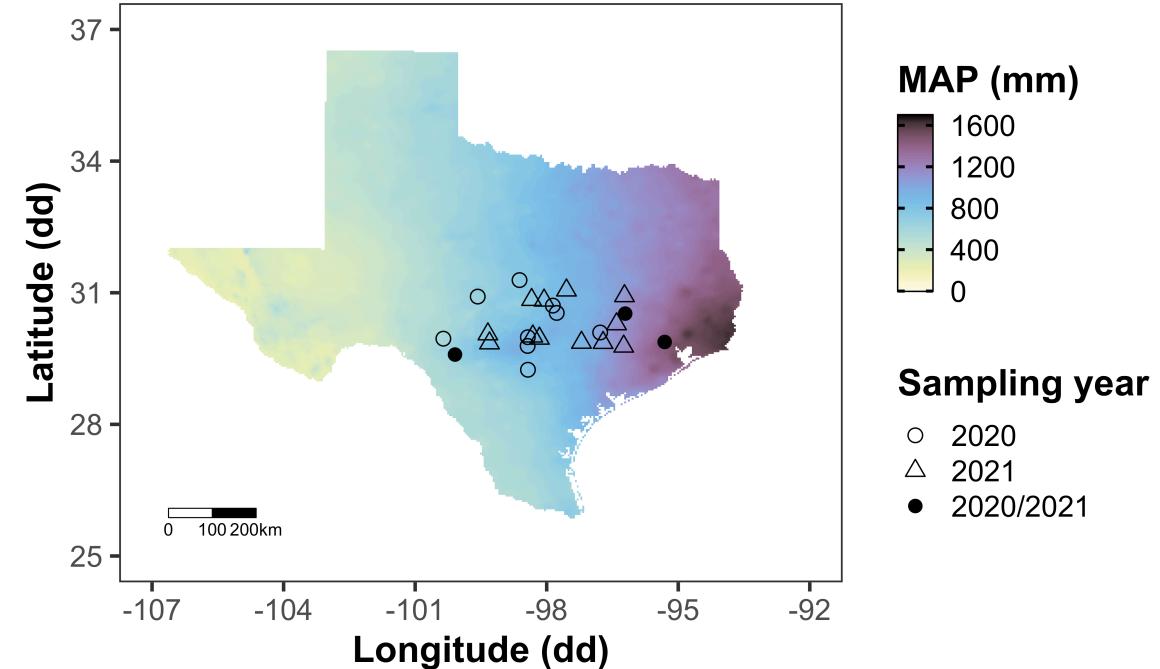
... and may be independent of the cost to acquire nitrogen relative to water

Positive effect  
Negative effect



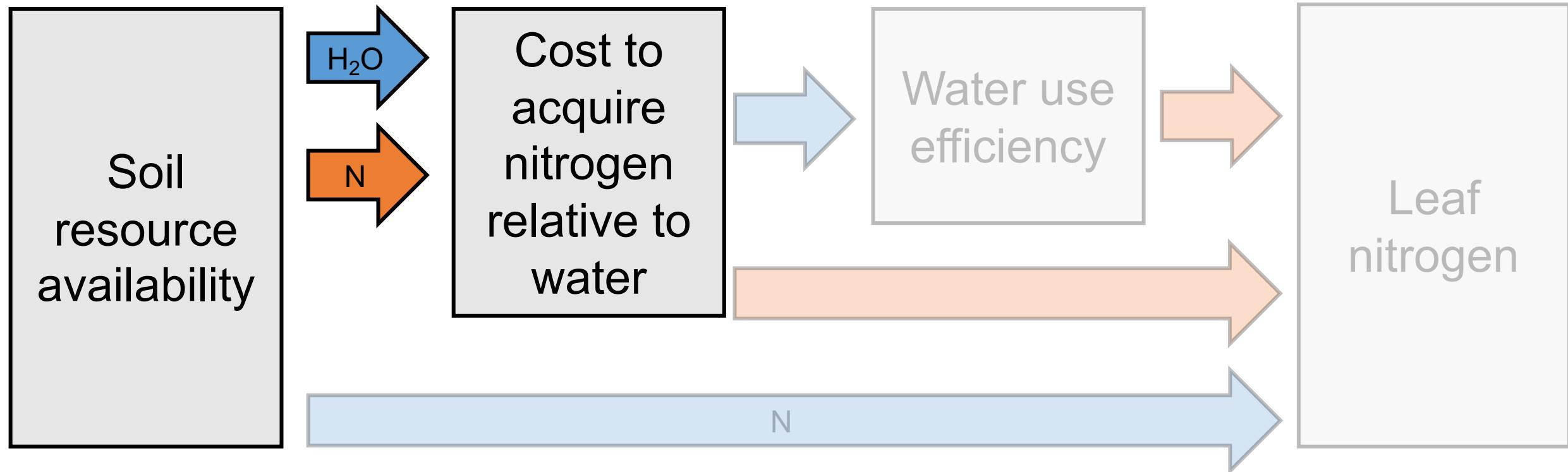
# Study sites, collection methods, traits

- 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
  - $[\text{NO}_3\text{-N}]$



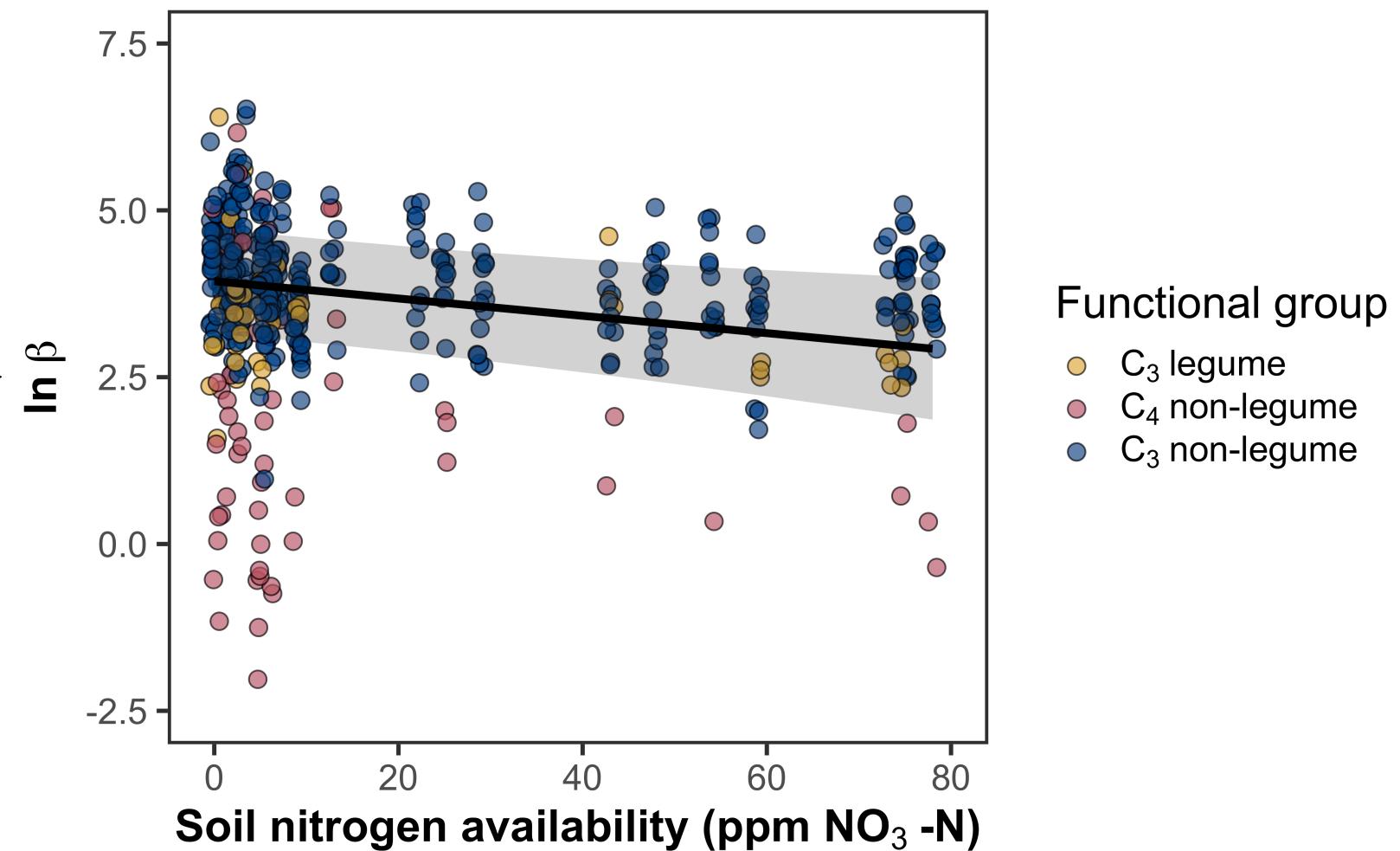
Positive effect

Negative effect



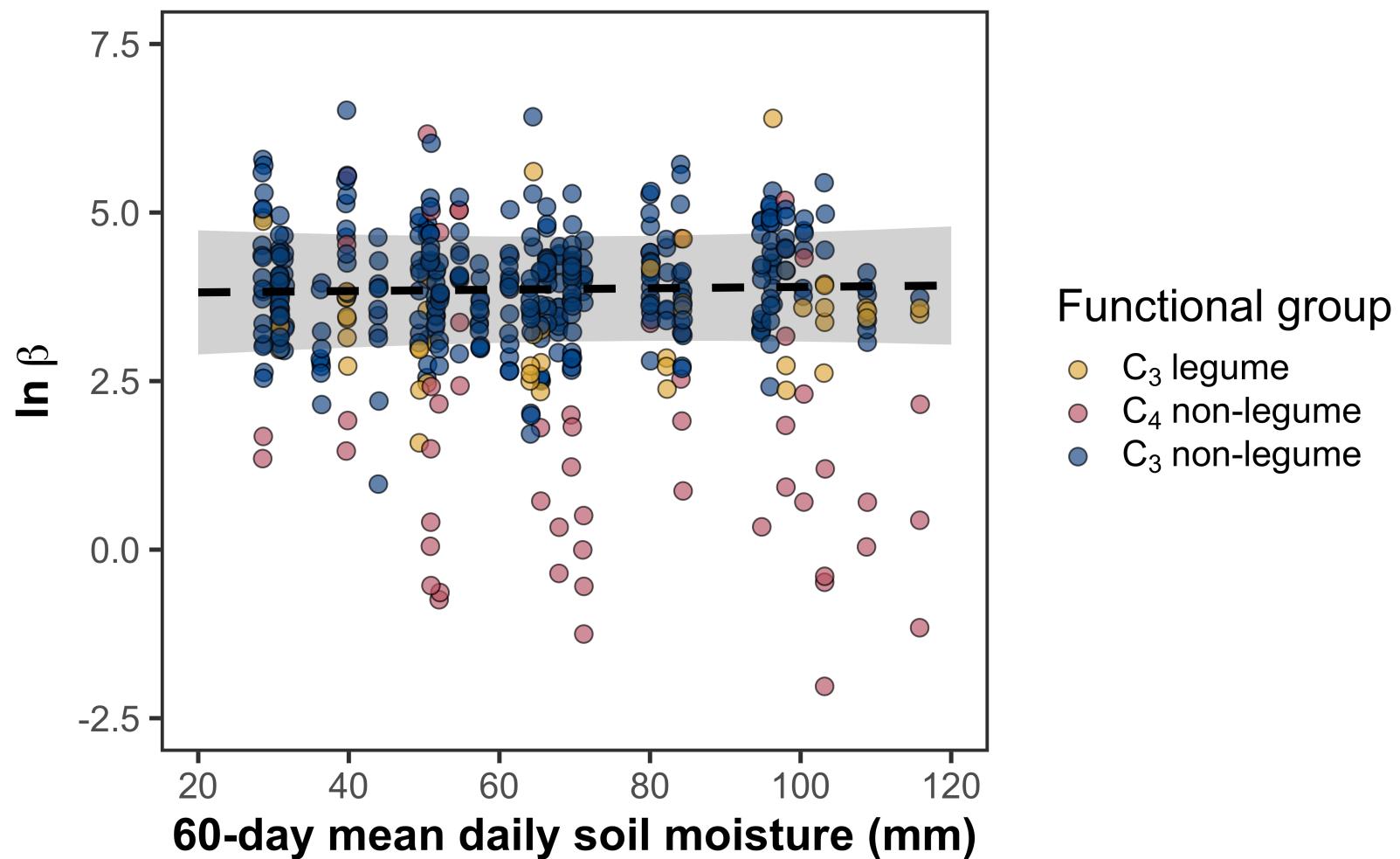
Soil nitrogen availability **decreases** the cost of acquiring nitrogen relative to water

Cost of acquiring  
nitrogen relative  
to water



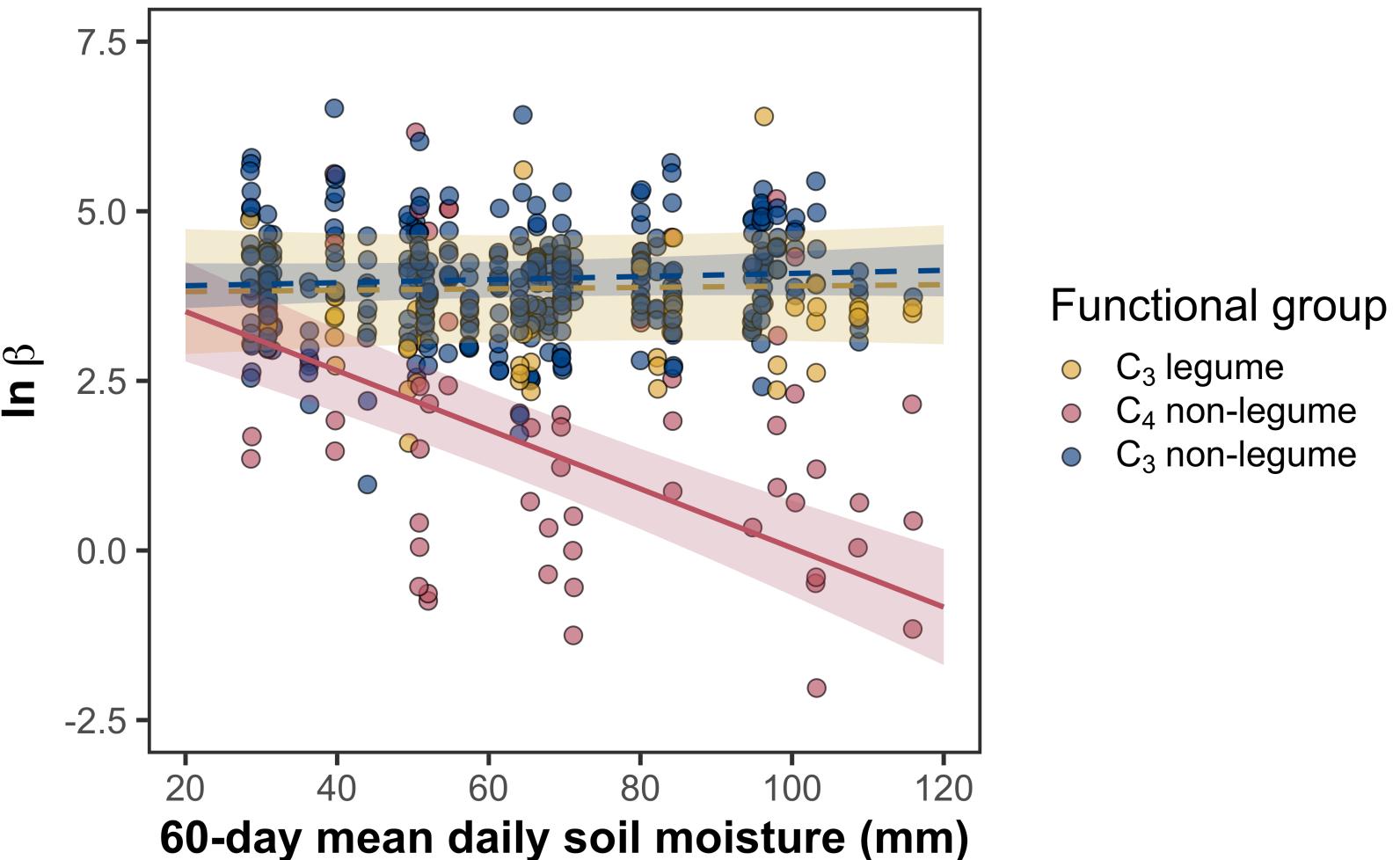
# Soil moisture does not change the cost of acquiring nitrogen relative to water

Cost of acquiring  
nitrogen relative  
to water



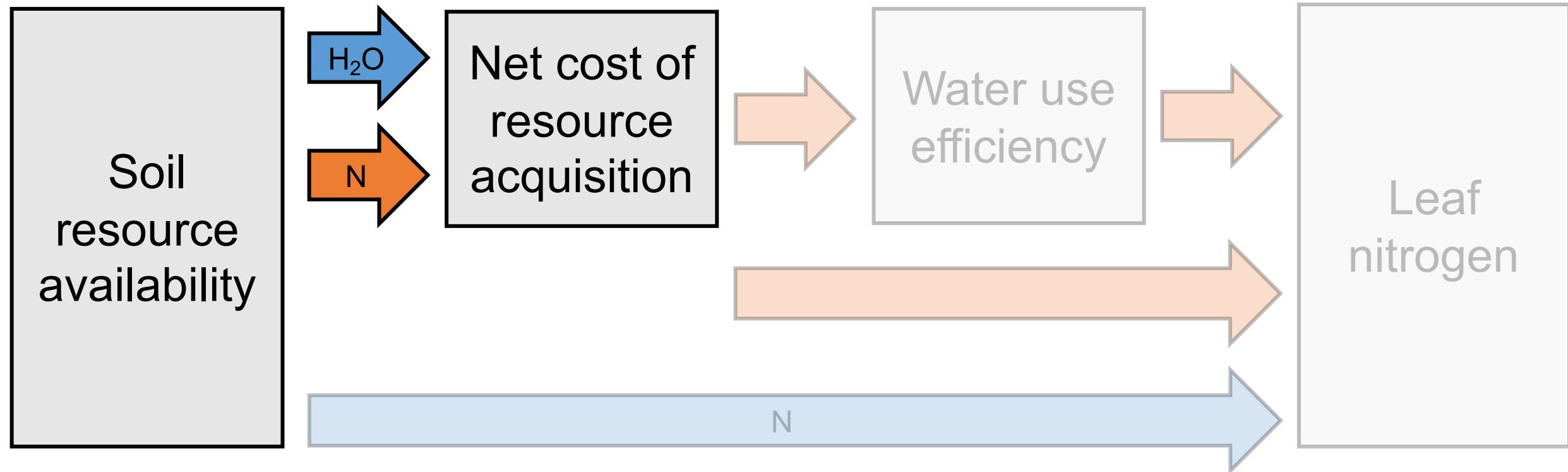
... although C<sub>4</sub> non-legumes experience a reduction in these relative costs with increasing soil moisture

Cost of acquiring  
nitrogen relative  
to water



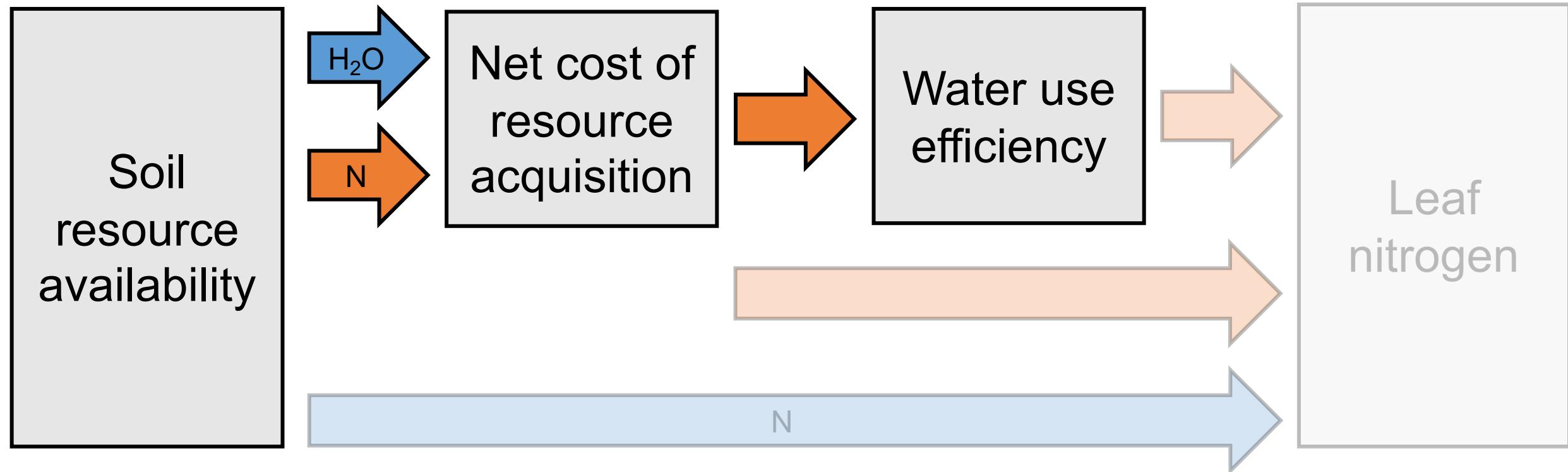
Positive effect

Negative effect

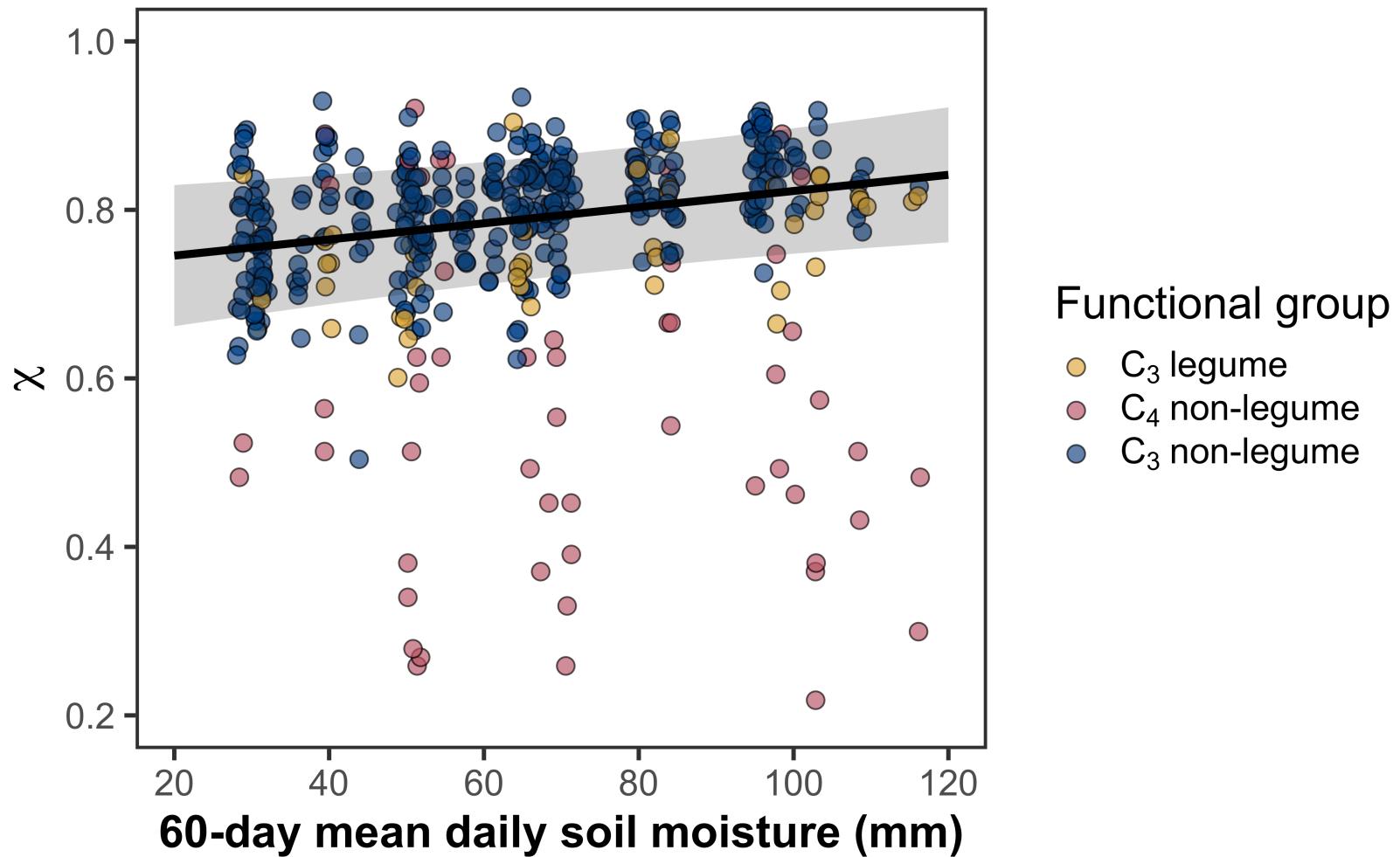


Positive effect

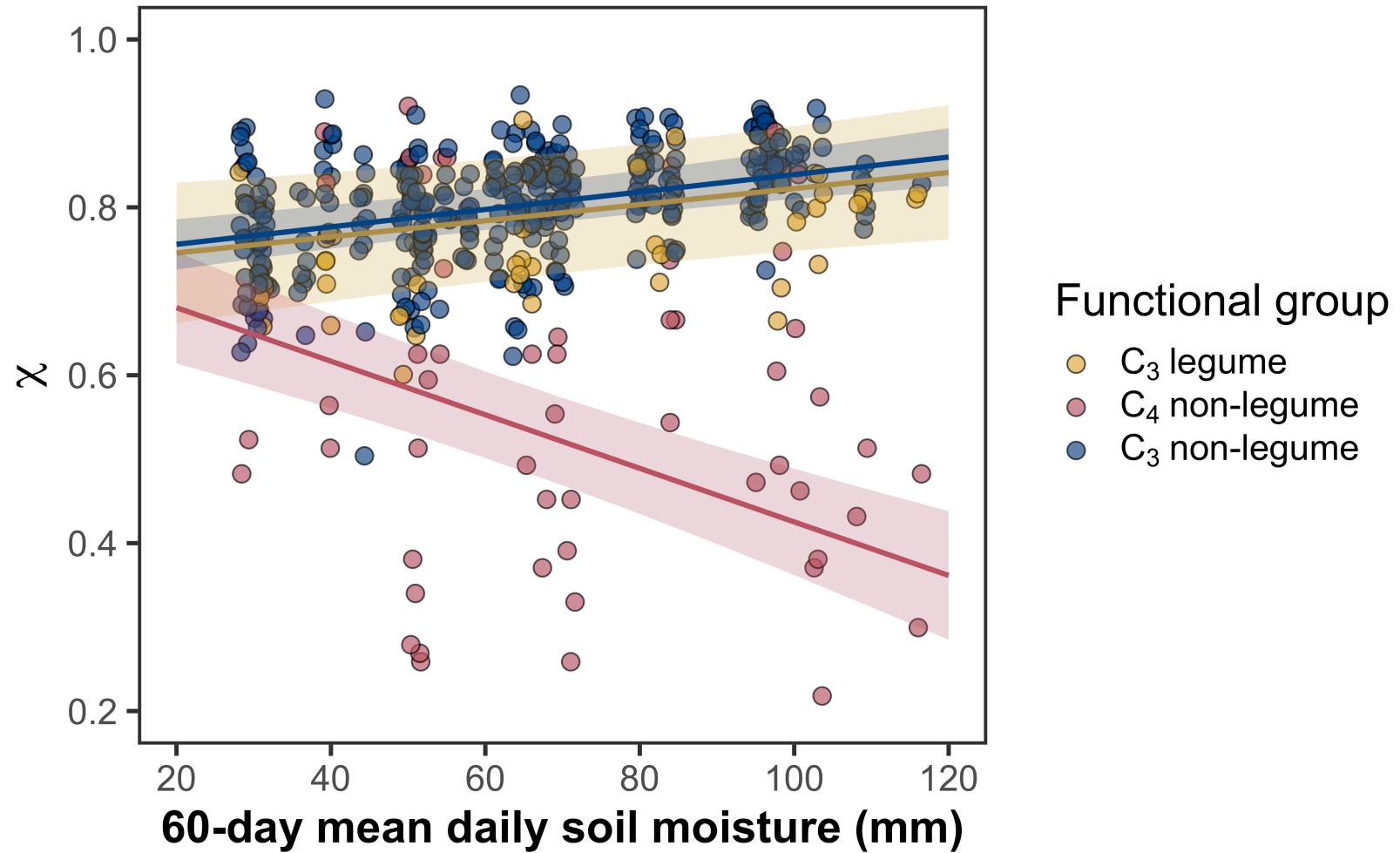
Negative effect



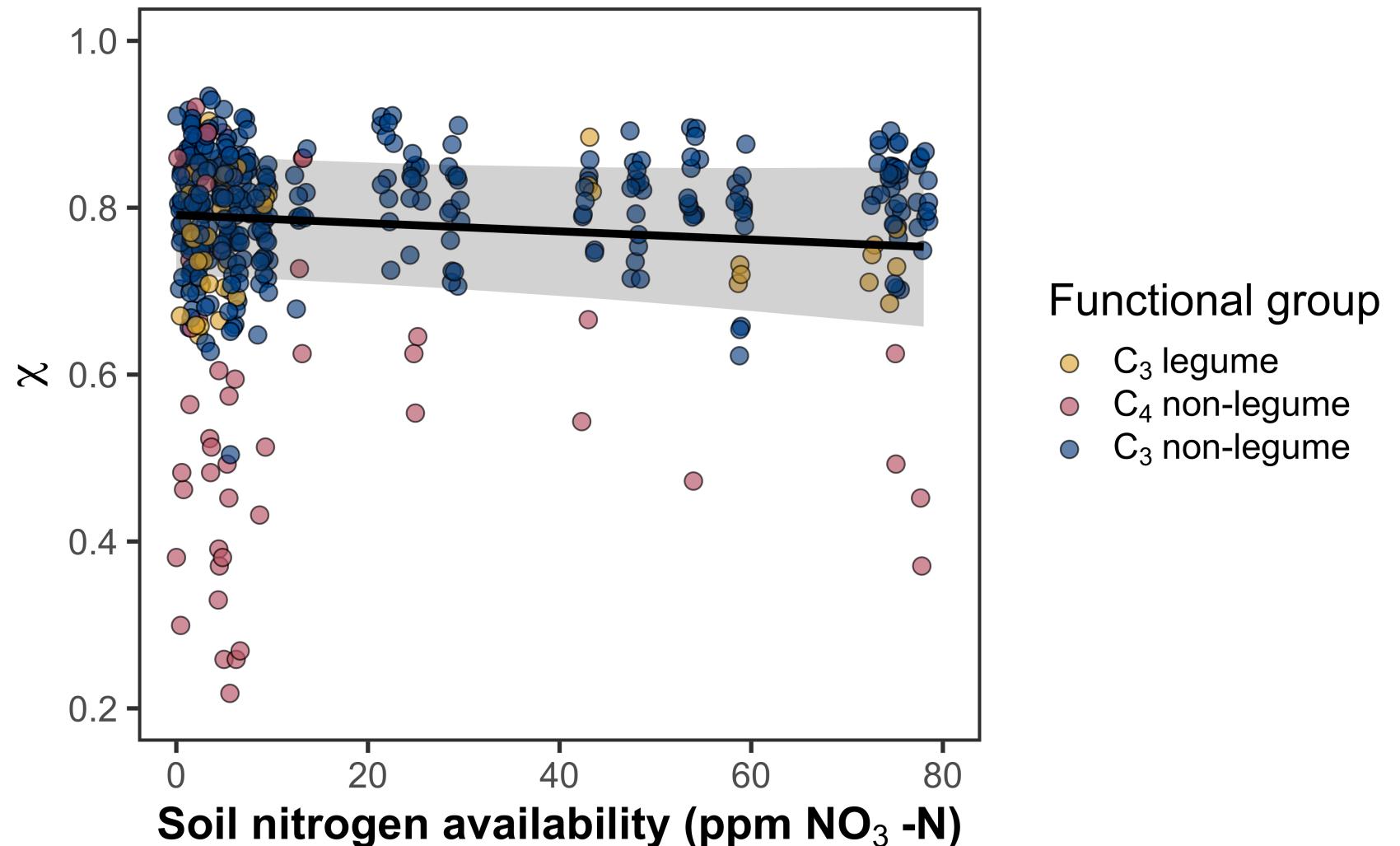
# Soil moisture **decreases** water use efficiency



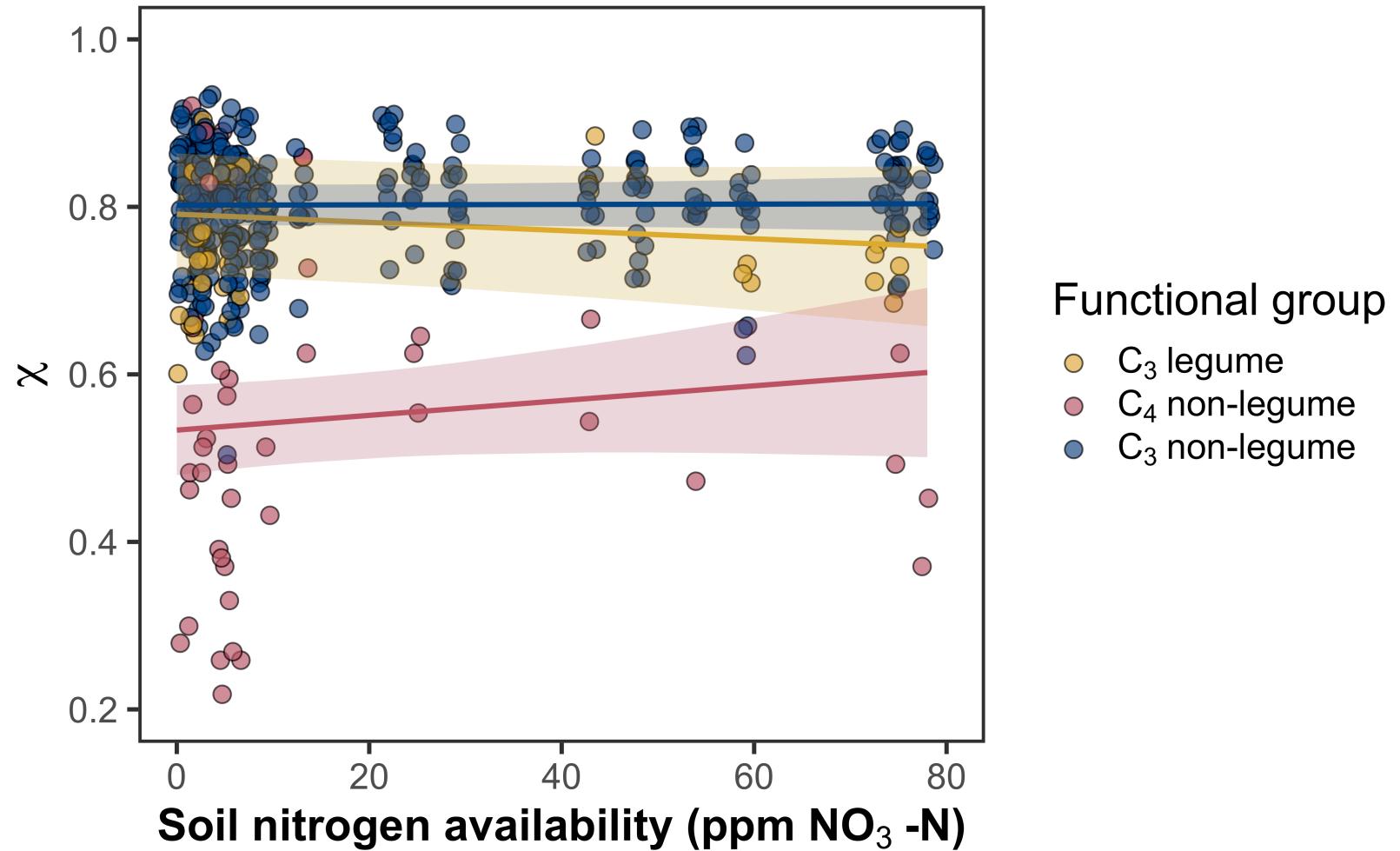
Soil moisture **decreases** water use efficiency,  
a pattern observed only in C<sub>3</sub> species



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

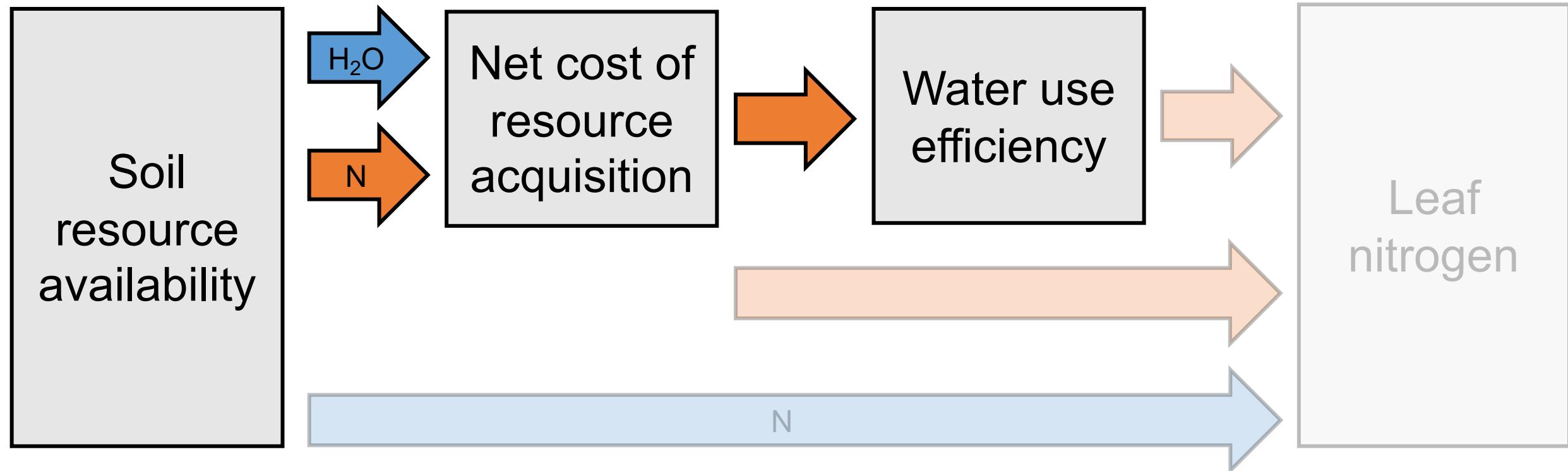


Soil nitrogen availability **increases** water use efficiency, but only in non-legumes



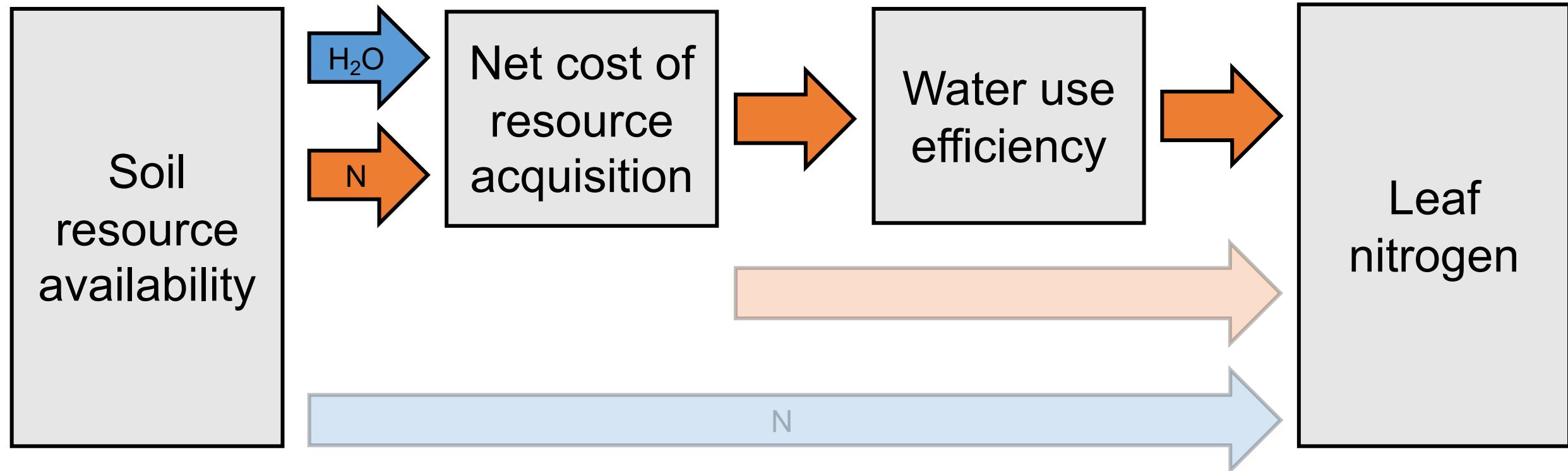
Positive effect

Negative effect

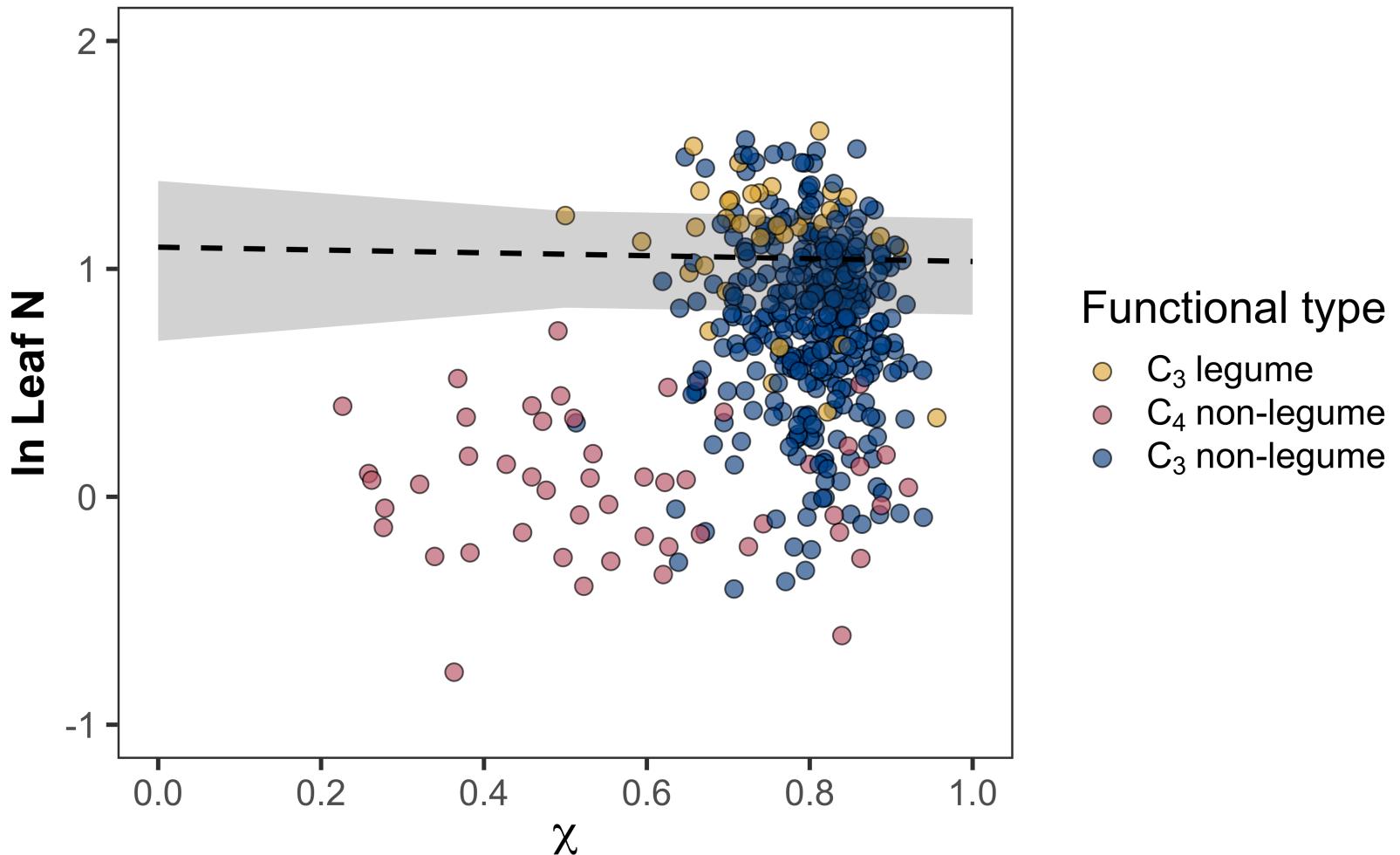


Positive effect

Negative effect

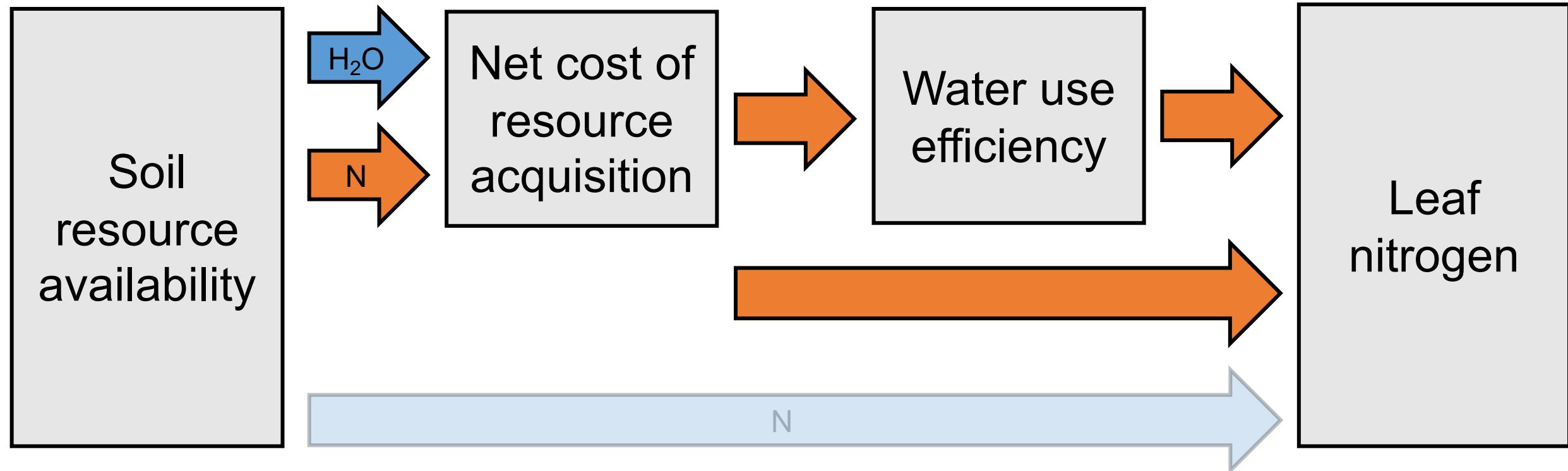


# Water use efficiency does not change leaf nitrogen

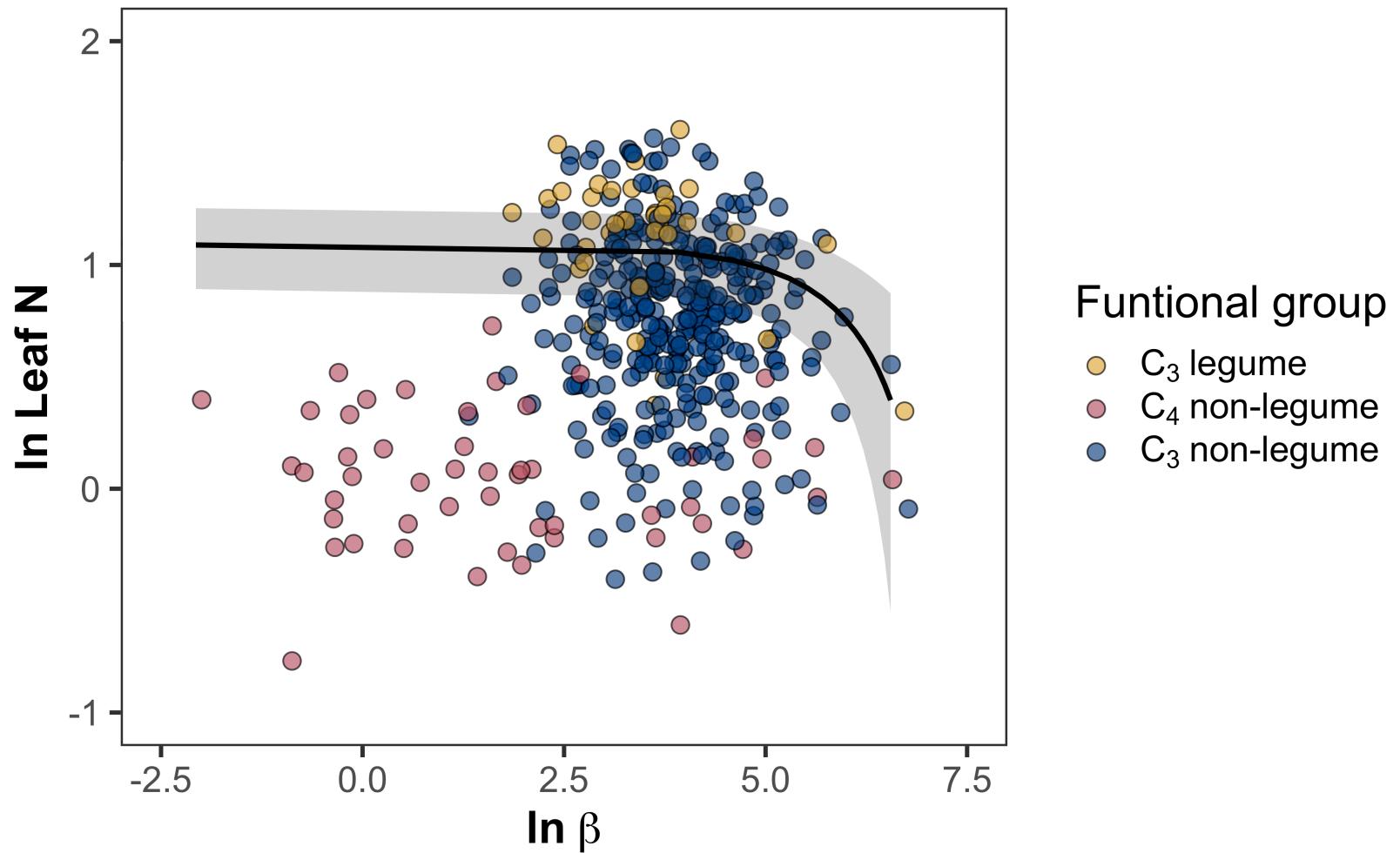


Positive effect

Negative effect

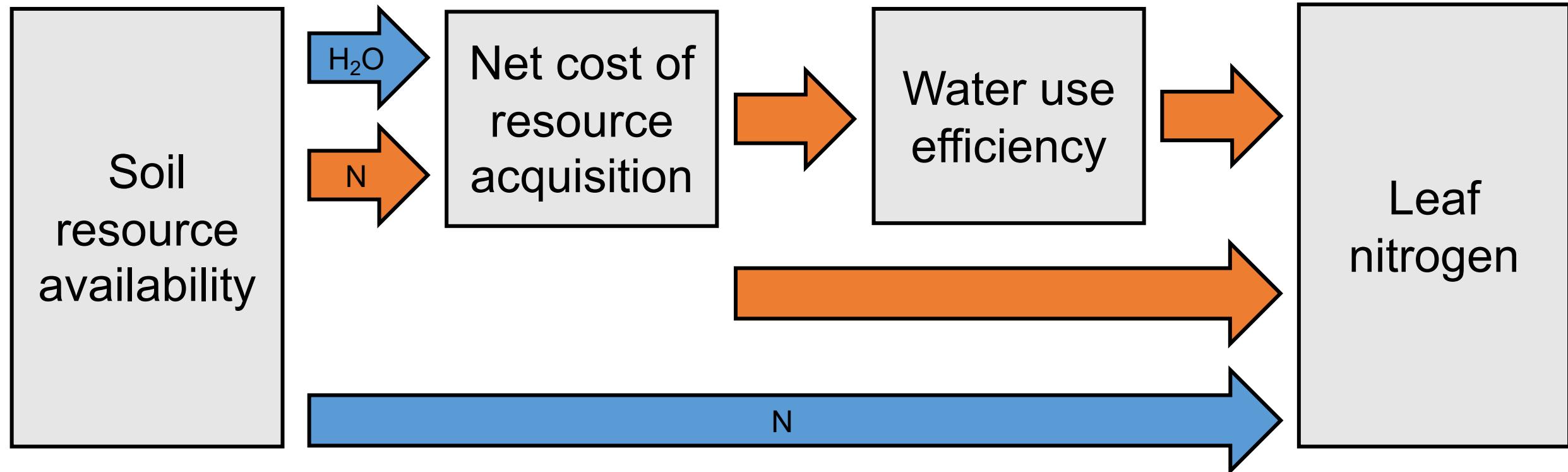


The cost to acquire nitrogen relative to water has a nonlinear, but overall negative effect on leaf nitrogen

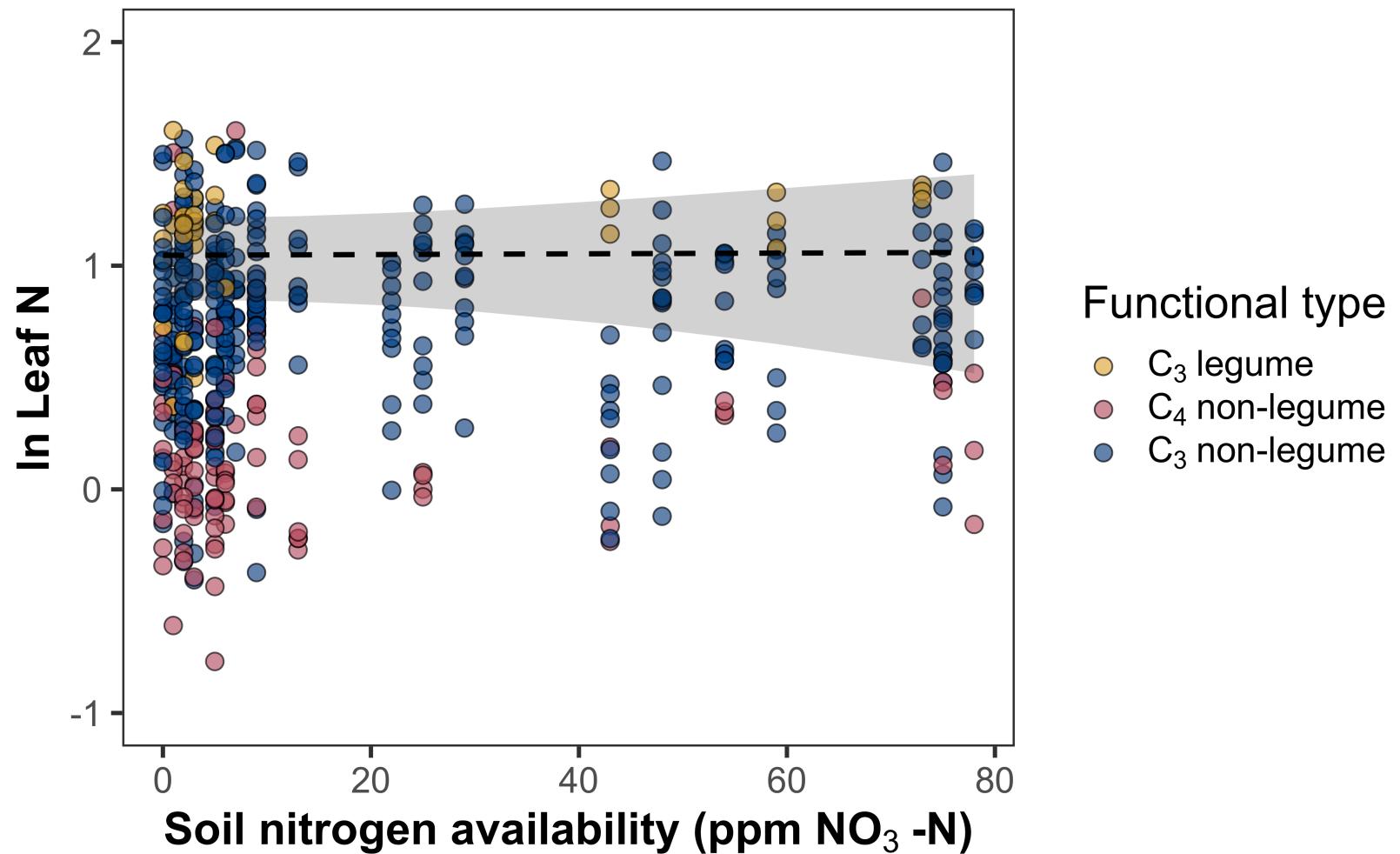


Positive effect

Negative effect



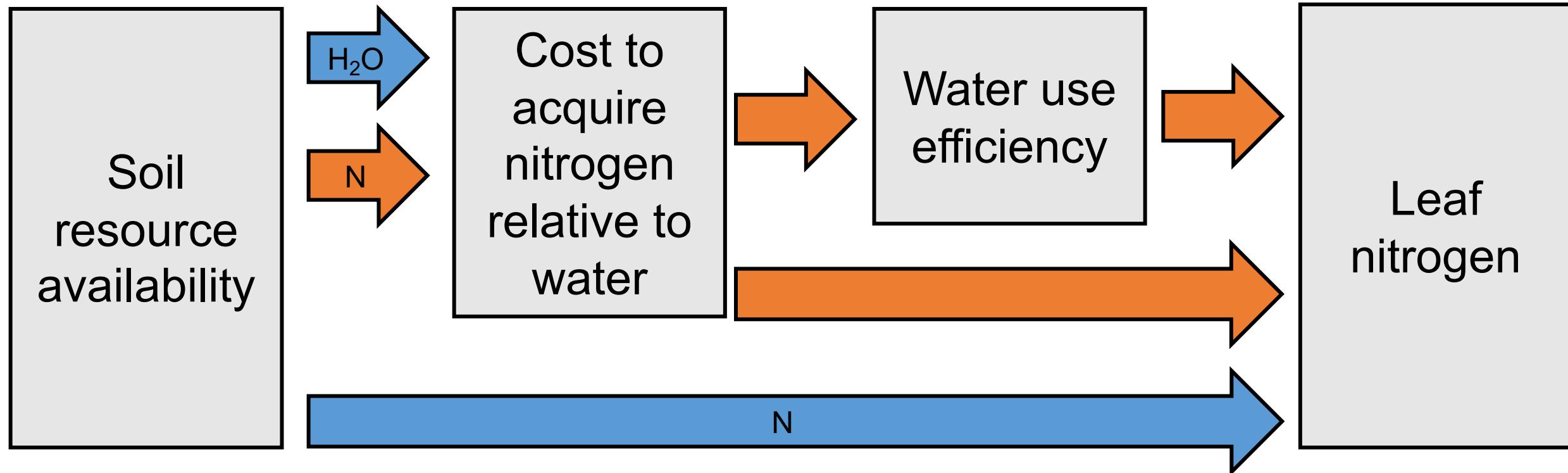
# Soil nitrogen availability does not change leaf nitrogen



# Revisiting hypotheses

Positive effect

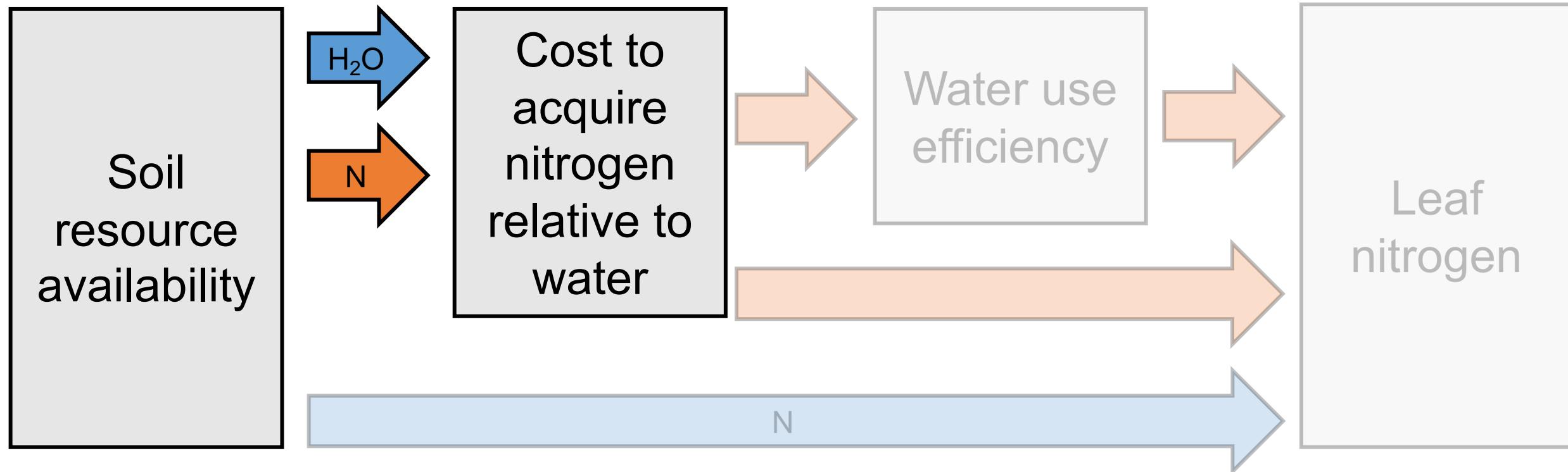
Negative effect



# Revisiting hypotheses

Positive effect

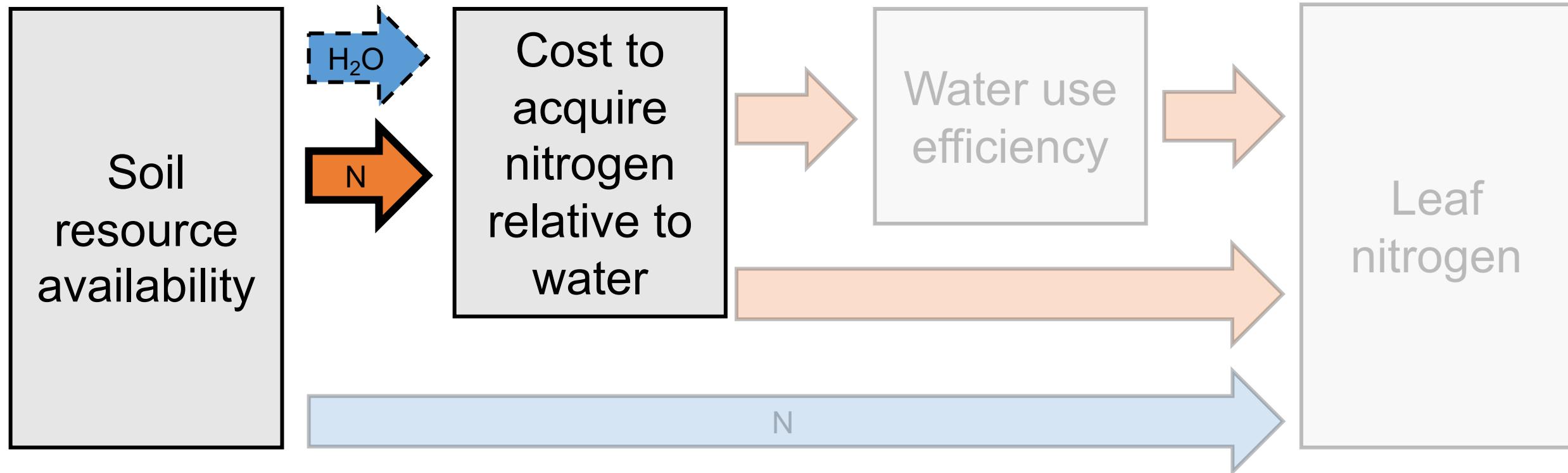
Negative effect



# Revisiting hypotheses

Positive effect

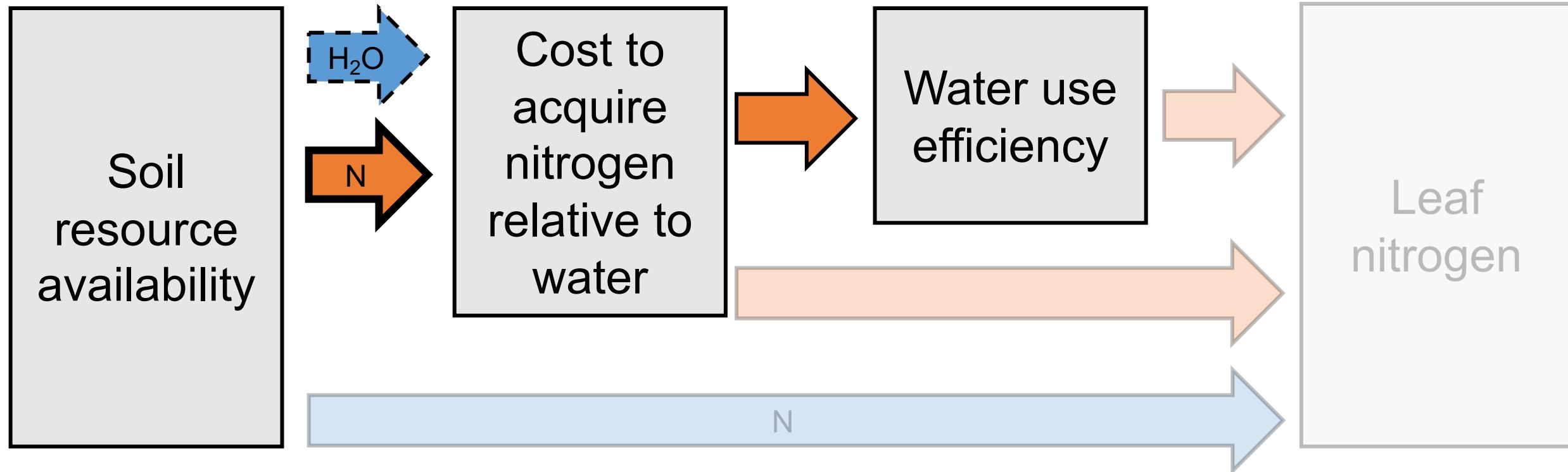
Negative effect



# Revisiting hypotheses

Positive effect

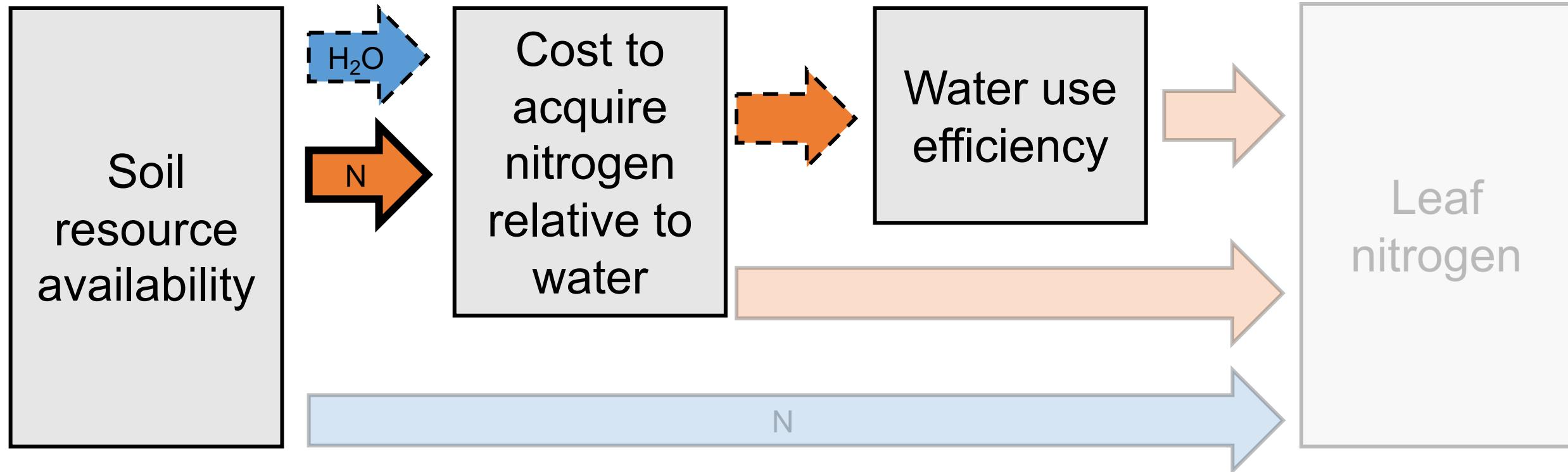
Negative effect



# Revisiting hypotheses

Positive effect

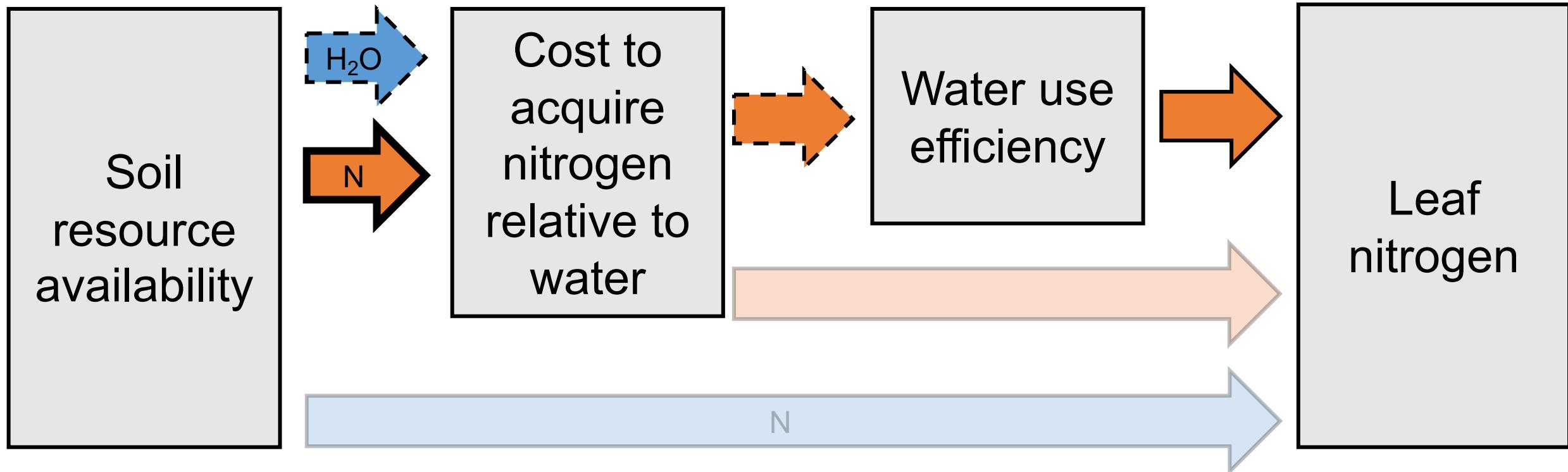
Negative effect



Positive effect

Negative effect

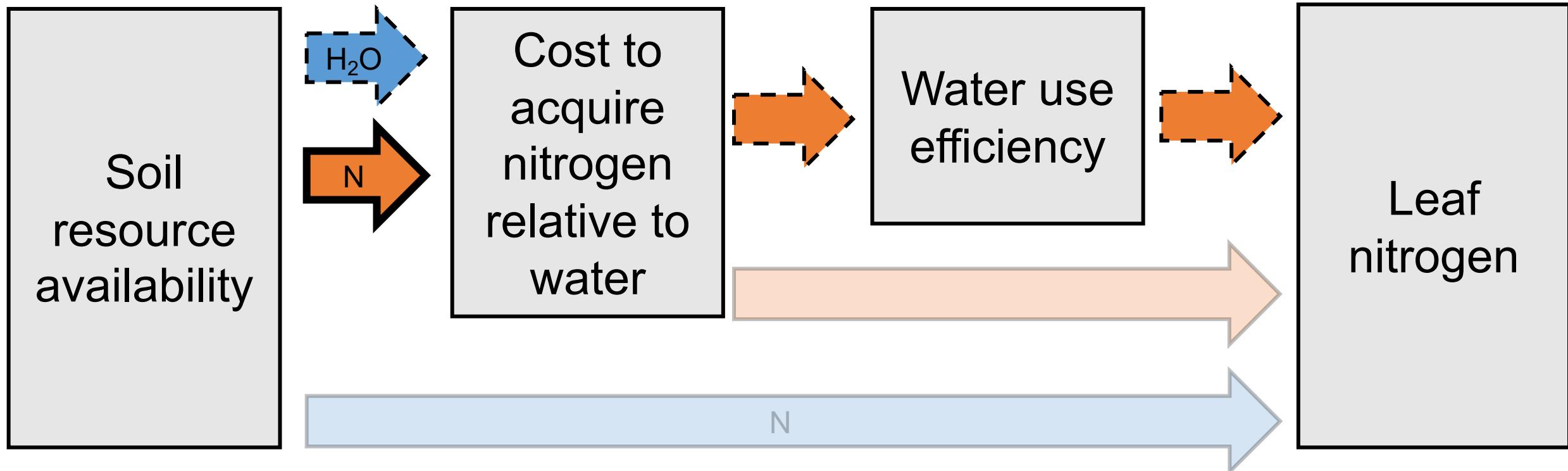
# Revisiting hypotheses



Positive effect

Negative effect

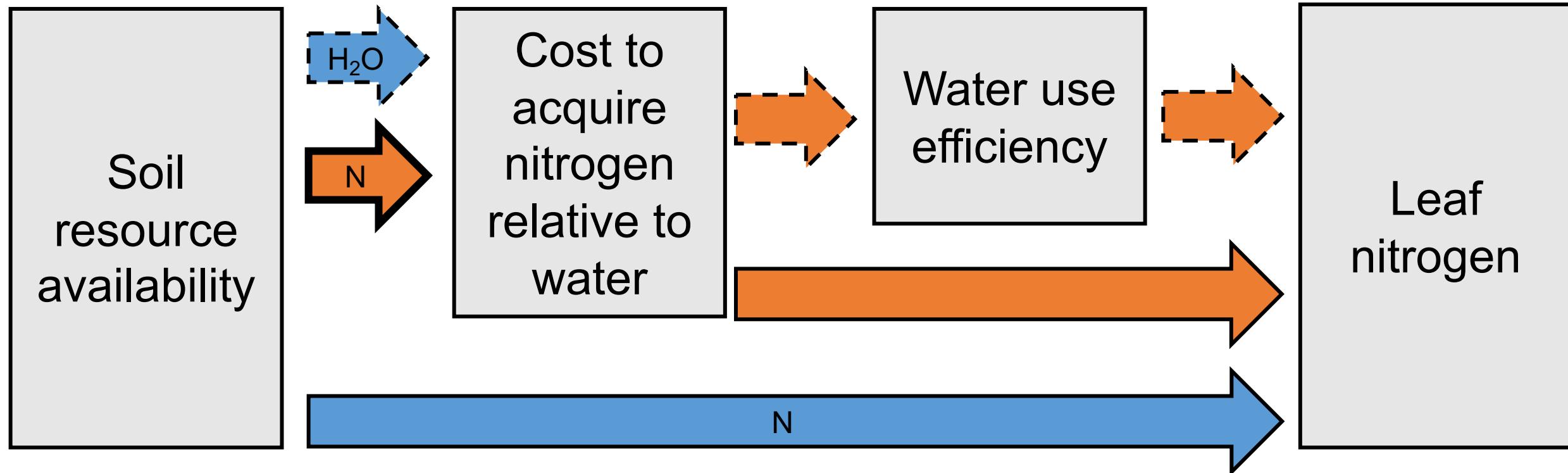
# Revisiting hypotheses



# Revisiting hypotheses

Positive effect

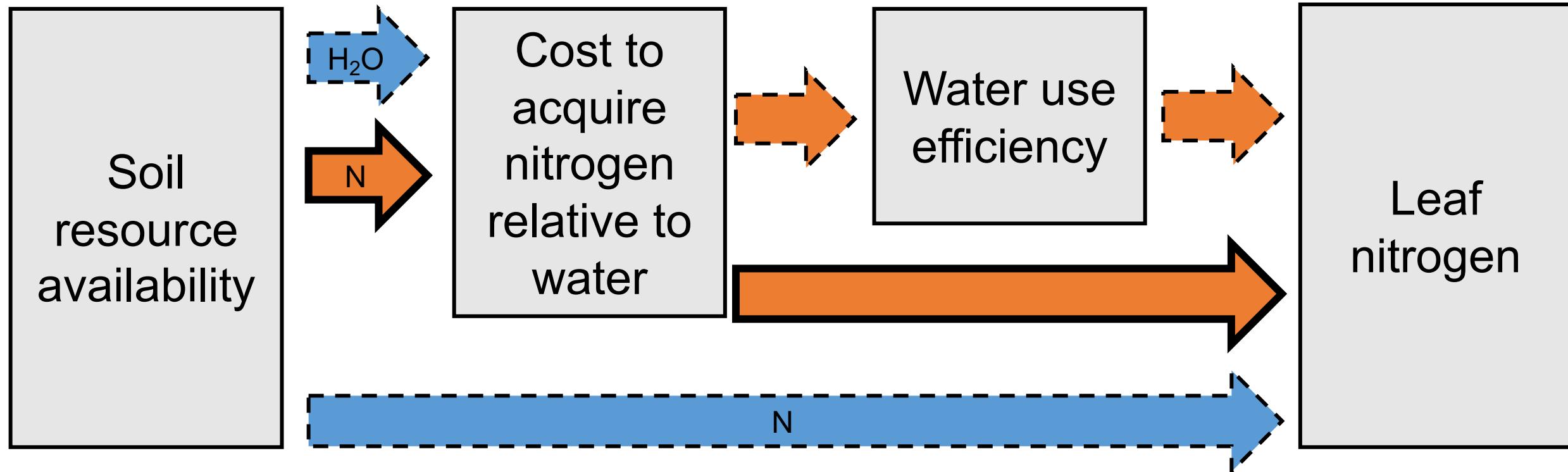
Negative effect



# Revisiting hypotheses

Positive effect

Negative effect





Texas Ecological Laboratory

# Acknowledgements

## Field and lab assistance (\*UG mentees)

- Risa McNellis
- Jorge Ochoa\*
- Peter Eludini
- Christine Vanginault\*
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- Jose Villeda\*
- Hannah German\*
- Avery Schoenherr\*

## Travel funds

- 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:

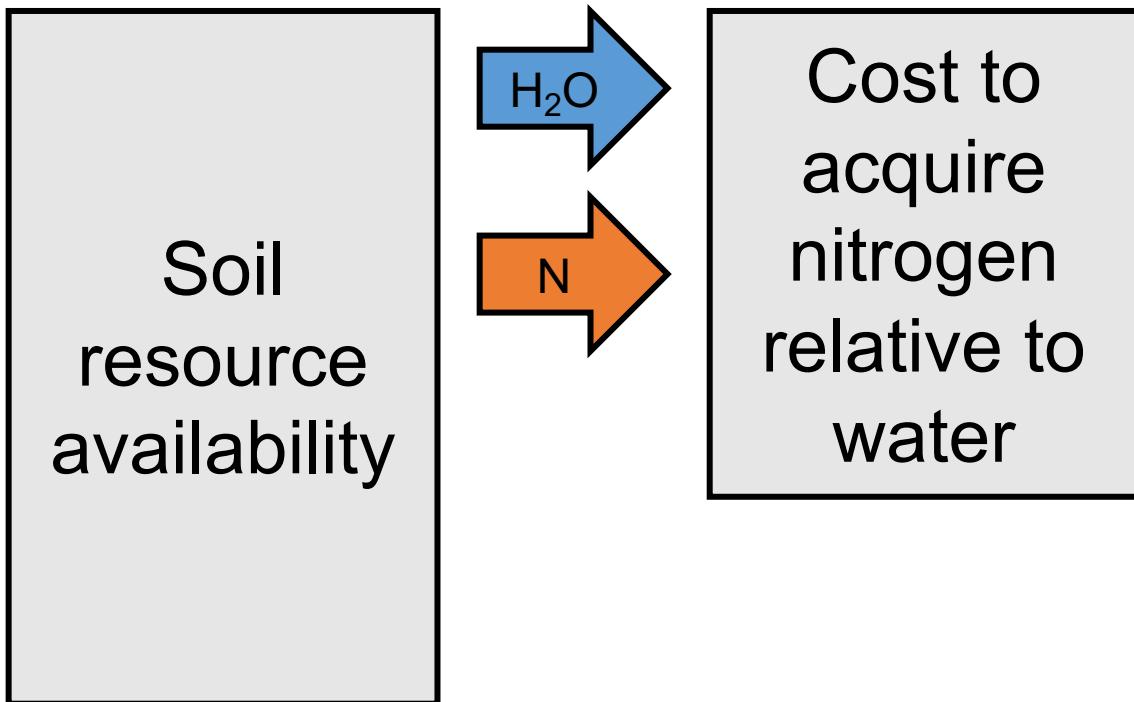
**<https://github.com/eaperkowski/esa2022>**

# Extra slides

Positive effect

Negative effect

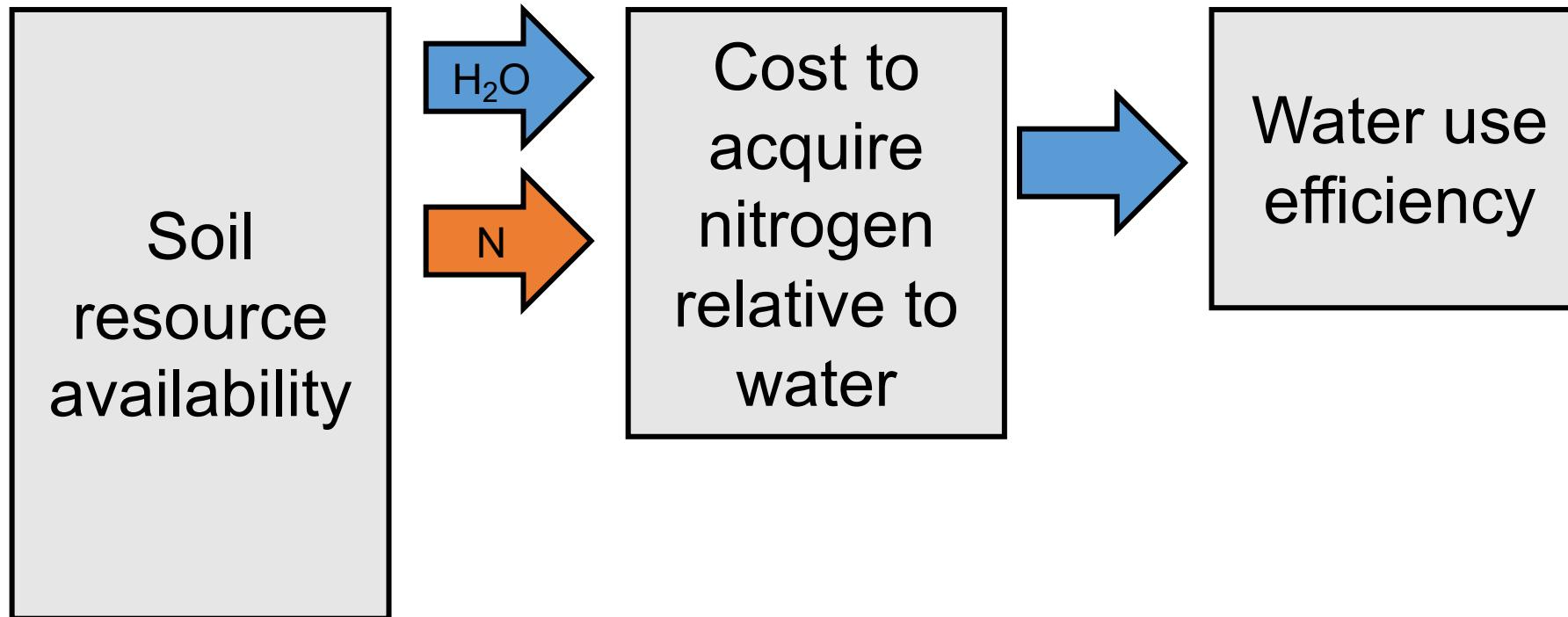
# Hypotheses



Positive effect

Negative effect

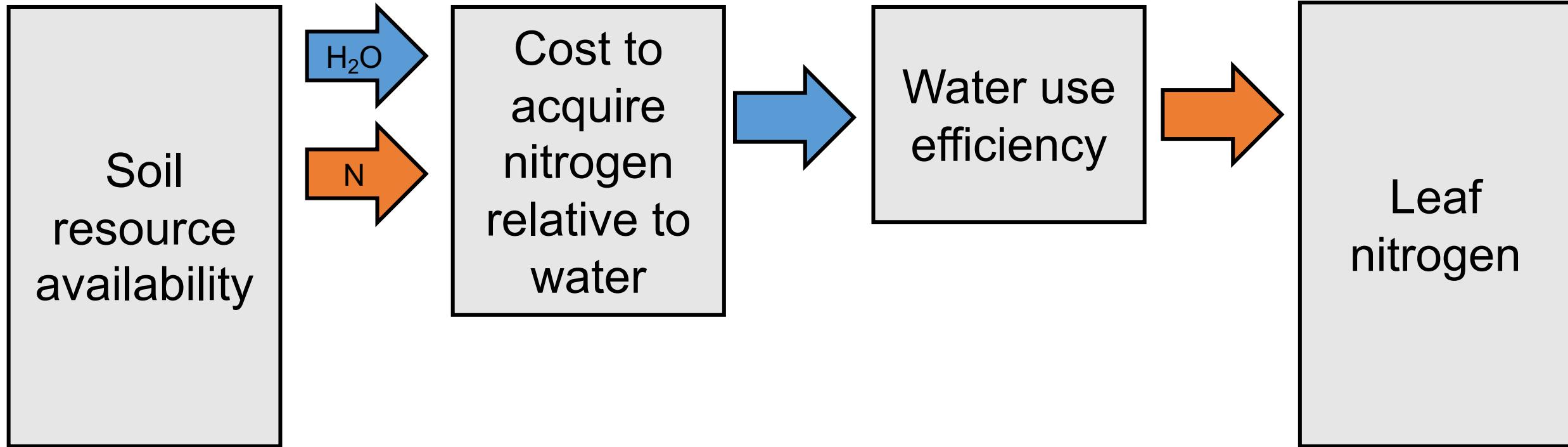
# Hypotheses



# Hypotheses

Positive effect

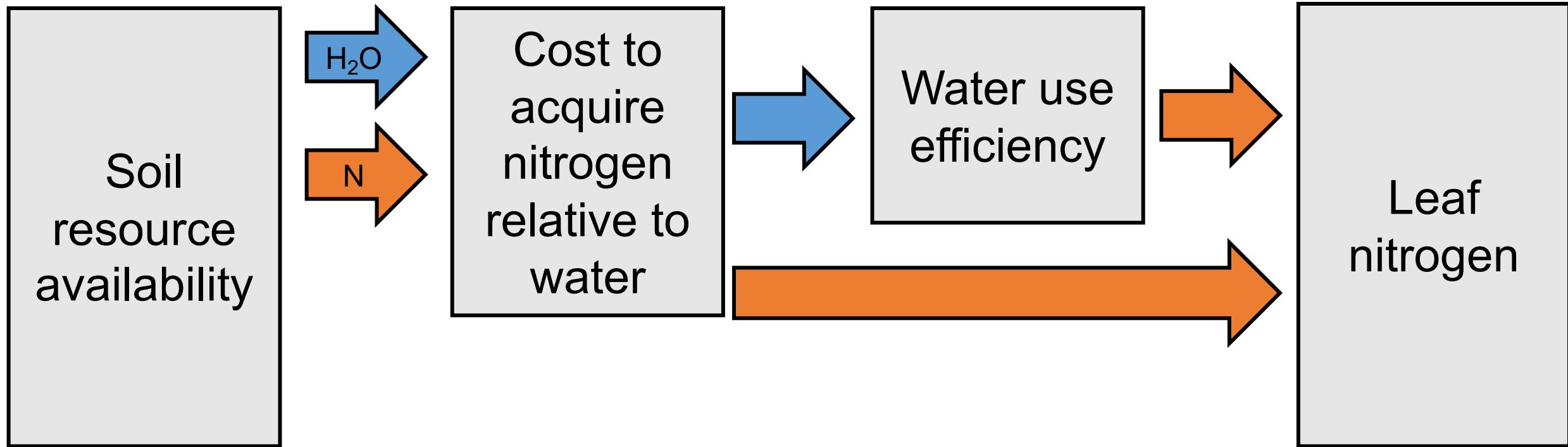
Negative effect



Positive effect

Negative effect

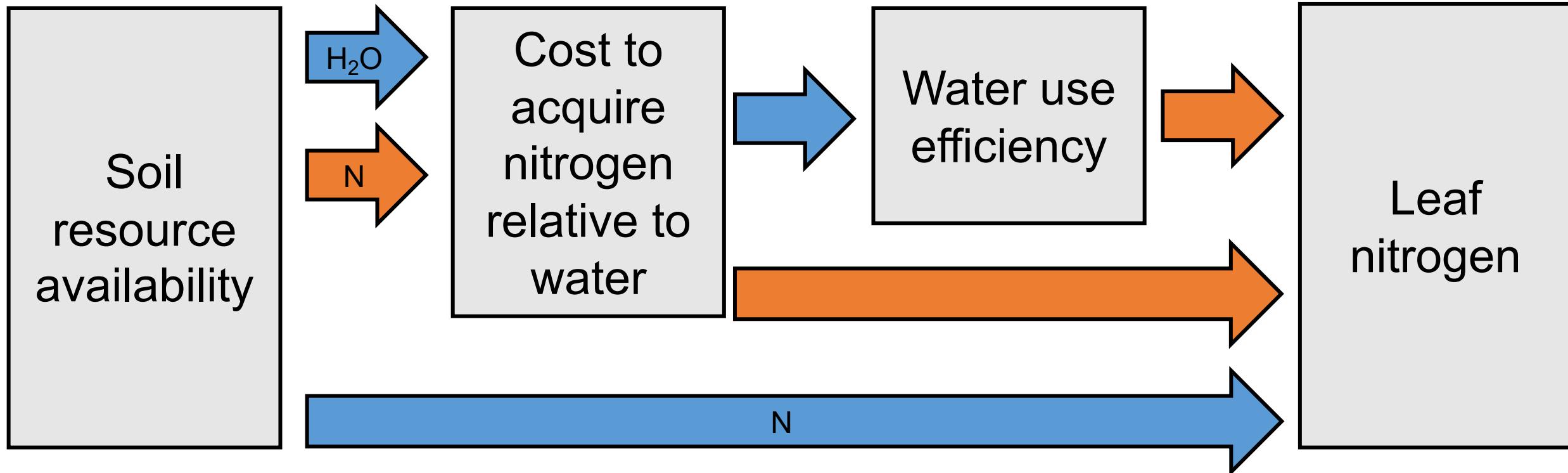
# Hypotheses



# Hypotheses

Positive effect

Negative effect



# 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 ( $\beta$ )

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