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# Optimal trait theory: testing predictions on the Northeast China Transect

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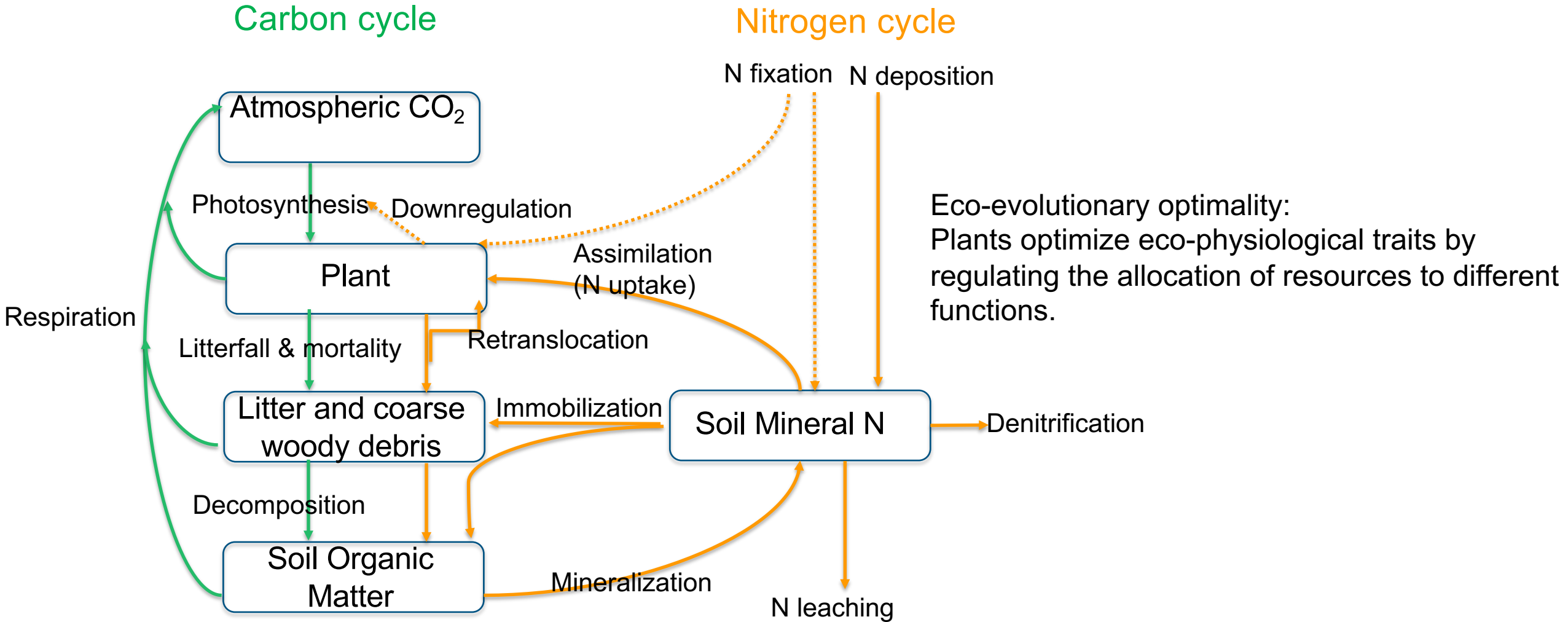
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# Background

## How the terrestrial carbon and nitrogen cycles coupling?





## Theory

### Optimality-based models

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- Least-cost hypothesis

$$\chi_0 = \Gamma^*/c_a + (1 - \Gamma^*/c_a) \xi / (\xi + \sqrt{D})$$

- Coordination hypothesis

$$V_{cmax} = \varphi_0 I_{abs} [(c_i + K)/(c_i + 2 \Gamma^*)]$$

- Light use efficiency (LUE) model

$$GPP = \varphi_0 I_{abs,GPP} m \sqrt{[1 - (c^*/m)^{2/3}]}$$

- Eco-evolutionary optimality approach

Leaf dry mass per unit area (LMA) and leaf longevity (LL)

Maximizes the leaf average net carbon gain.

$$\text{Evergreen: } LMA = \ln \Sigma I_{abs} + 0.5 \ln f - 0.026 T_g + \ln LL + C$$

$$\text{Deciduous: } LMA = \ln \Sigma I_{abs} + \ln f - 0.052 T_g + C$$

- Water-limited leaf area index (LAI)

$$fAPAR = (0.7 MAP/A_0) [c_a(1 - \chi)] / (1.6 D)$$

$$LAI = \ln [1 - \min(0.99, fAPAR)] / (-k)$$



# Theory

## Environmental control of leaf nitrogen and nitrogen isotope model

- Leaf nitrogen

$$N_{area} = n_s LMA + n_r V_{cmax,25}$$

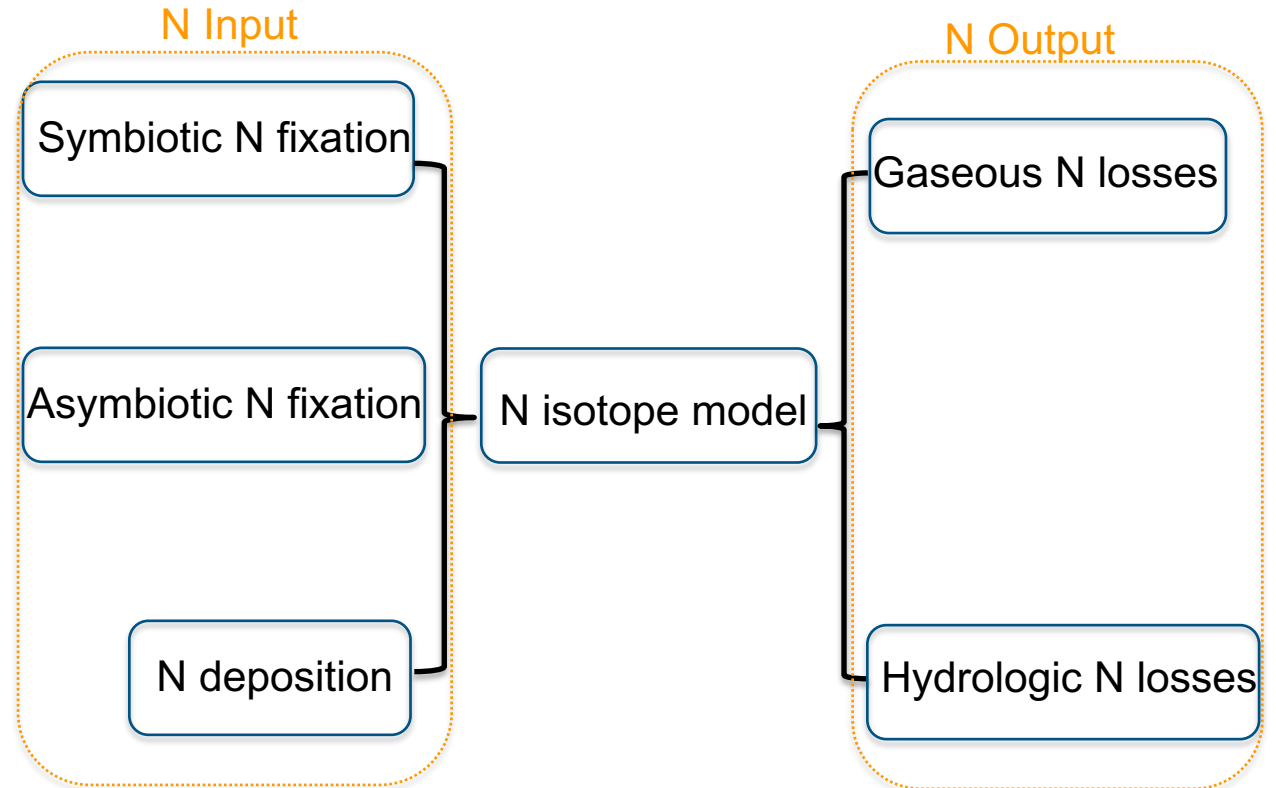
- Nitrogen isotope model

N inputs

$$(\delta^{15}\text{N}) \delta = \delta_0 + \frac{\epsilon_{LL}}{L+G} + \frac{\epsilon_{gas}G}{L+G}$$

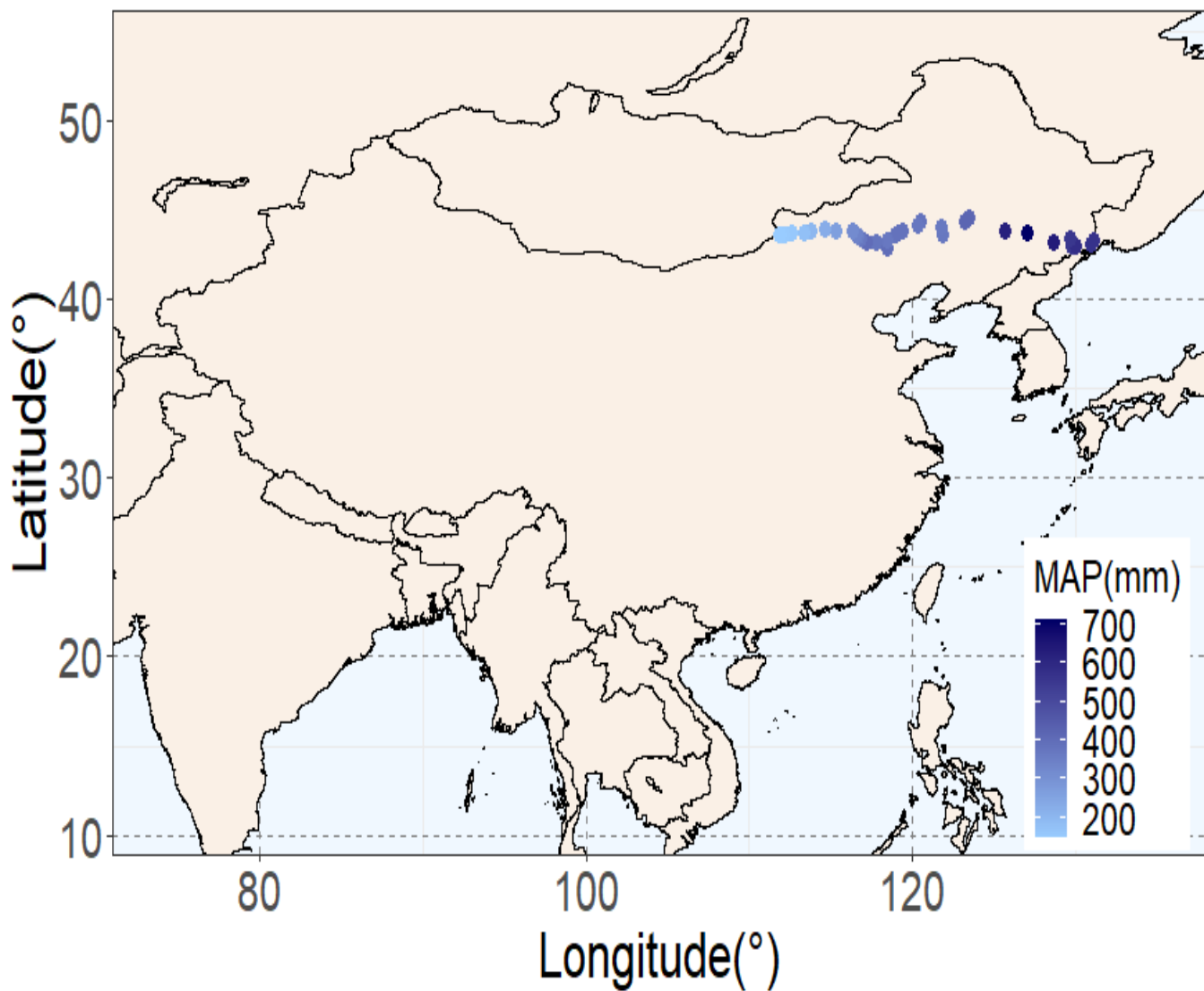
$$\delta = \delta_0 + \frac{\epsilon_{gas}}{1 + k \left( \frac{f_{runoff}}{f_{temp}} \right)} \quad \left\{ \begin{array}{l} f_{temp} = \exp \left[ \left( \frac{E_a}{R} \right) \left( \frac{1}{T_{298}} - \frac{1}{T} \right) \right] \\ f_{runoff} = \frac{R}{(R+W_{max})} \end{array} \right.$$

$$f_{gas} = \frac{G}{(L+G)} = \frac{(\delta - \delta_0)}{\epsilon_{gas}}$$





# Result Sites



Northeast China Transect (NECT)  
(42.88° to 44.59°N, 111.89 to 131.15°E)

Optimality theory

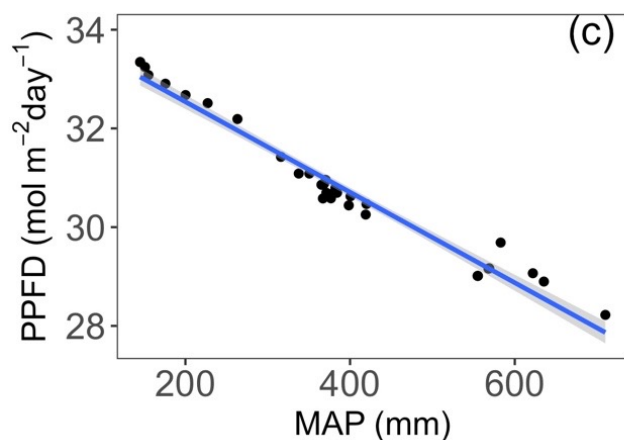
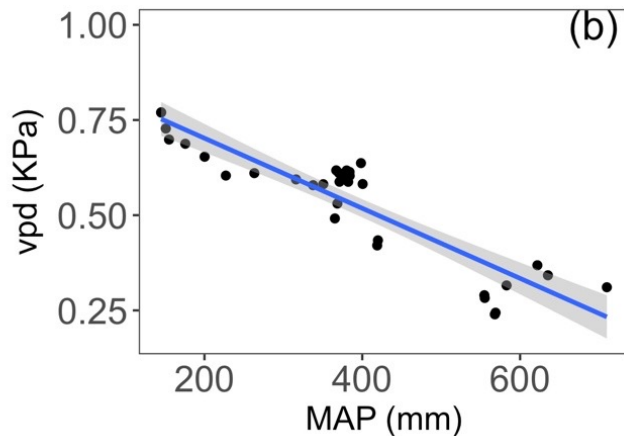
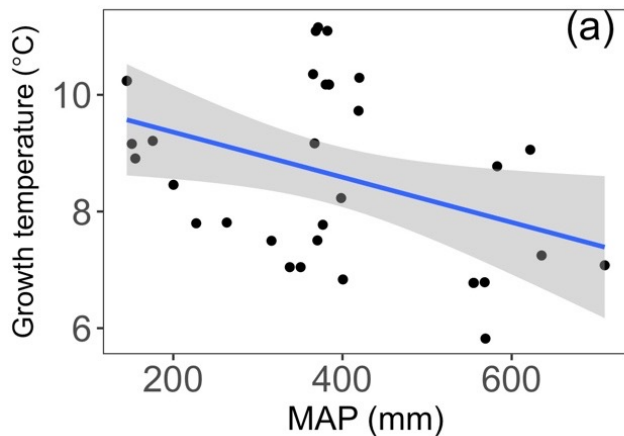
Plants traits  
Productivity  
N content  
N losses



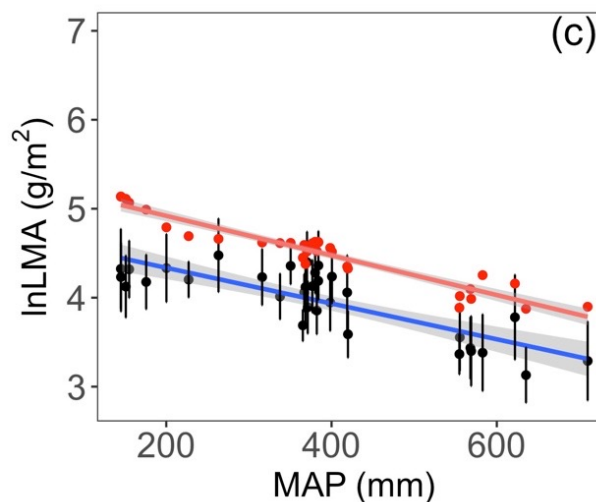
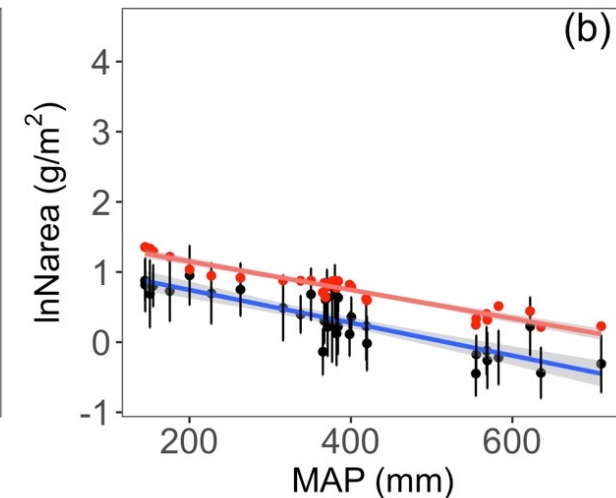
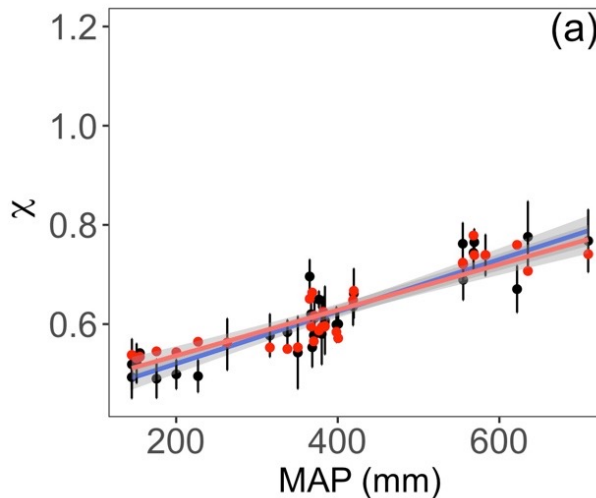
## Result and Discussion

### Variation in environmental variables and leaf traits along NECT

#### ➤ Environmental variables



#### ➤ Leaf traits



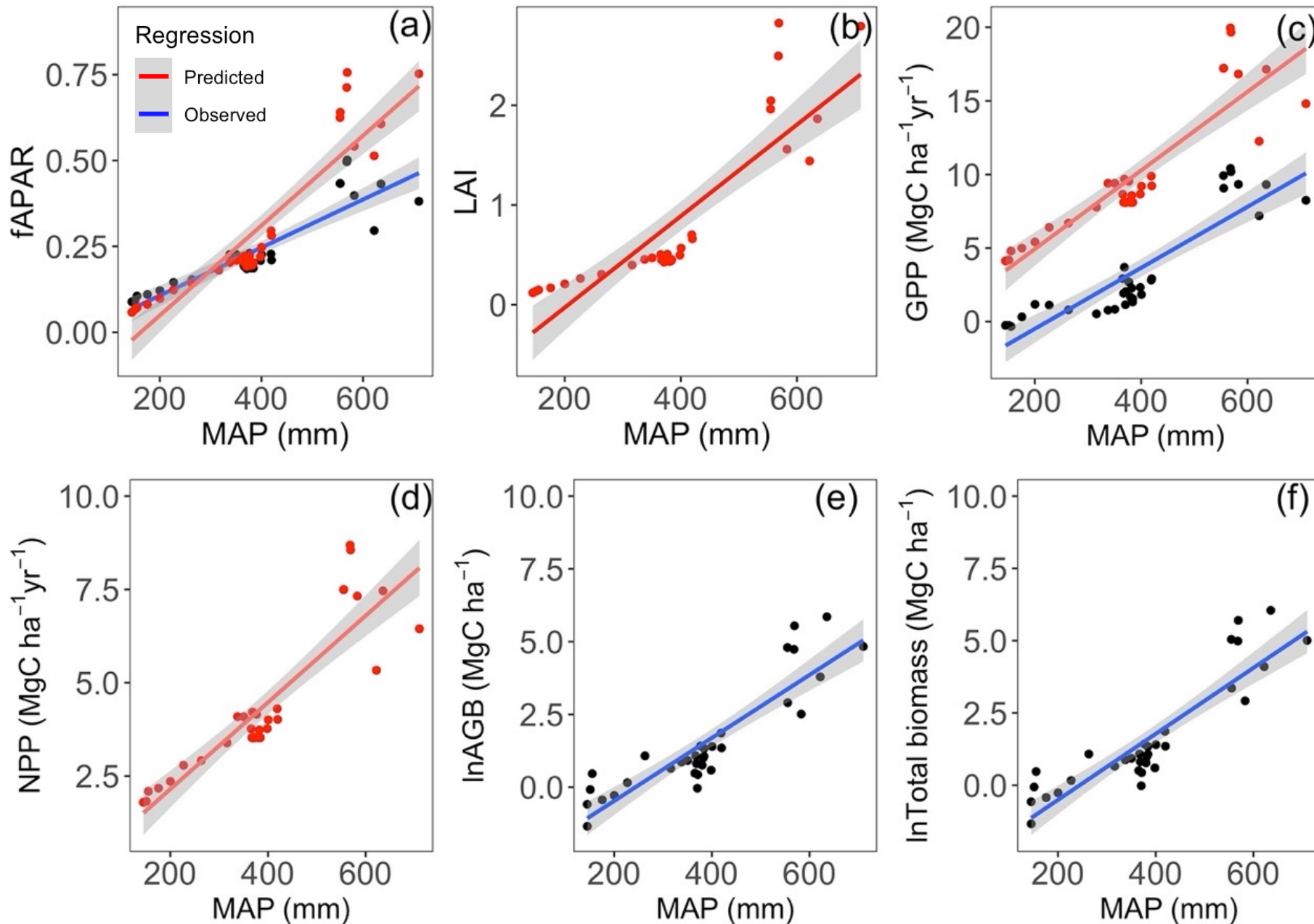
Regression  
— Predicted  
— Observed

Lower  $\chi$  → Greater photosynthetic capacity ( $V_{cmax}$ ) + High LMA → High  $N_{area}$



## Result and Discussion

### Comparison of variation in ecosystem properties

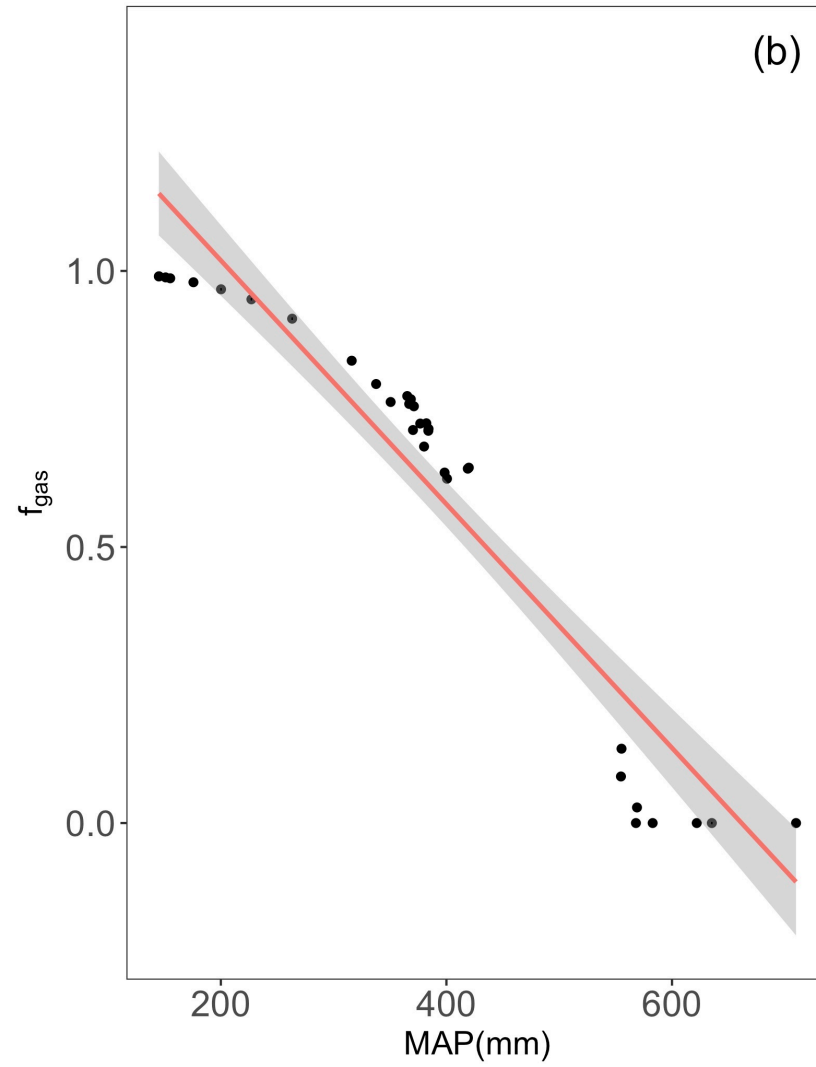
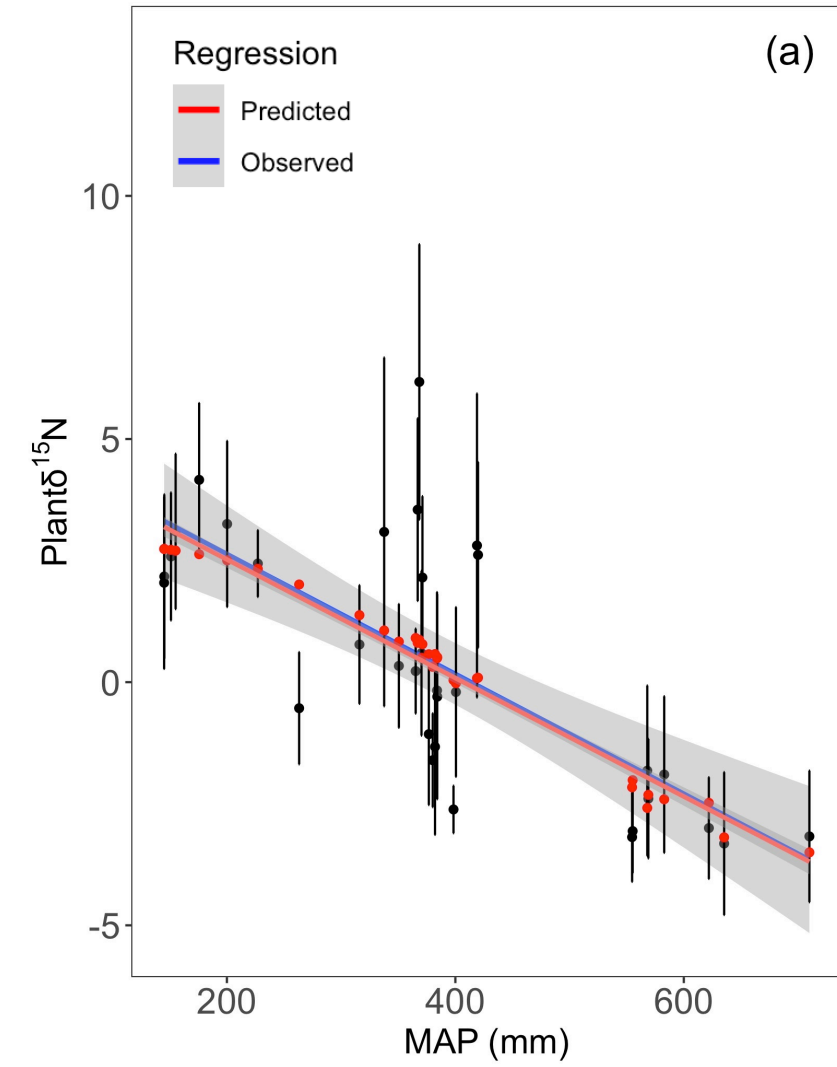


- Soil moisture and root water uptake
- Evapotranspiration reduction



## Result and Discussion

### Comparison of variation in plant $\delta^{15}\text{N}$ along NECT



➤ N cycling is more positive at the drier sites.

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Thank you !

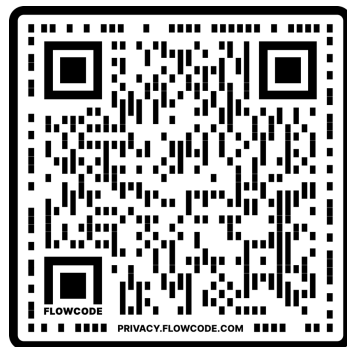
Thanks for LEMONTREE project!

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LEMONTREE Team:



REALM Team:



Abstract:

