

INFERRING VEGETATION MEMORY FROM REMOTE SENSING DATA USING NOVEL CLIMATE RECONSTRUCTION PRODUCTS

M.Sc. Thesis Defense



UNIVERSITETET I BERGEN



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Ecological and Environmental Change Research Group
University of Bergen

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- 1** Background
 - Motivation
 - Dryland Vegetation Memory
- 2** Allocating and Preparing Data
 - Vegetation Data
 - Climate Data
 - Plant Functional Data
- 3** Delineating Vegetation Memory
- 4** Results
 - Coefficients of Vegetation Memory
 - Regional Aspects of Vegetation Memory
 - Functional Aspects to Vegetation Memory
- 5** Conclusion

What is this?

Vegetation Memory is the effect of **antecedent ecosystem/environmental anomalies** on **current vegetation performance**^[1].

Components of Memory:^[2]

- 1 *Intrinsic Memory* (e.g. antecedent vegetation characteristics)^[2,3]
- 2 *Extrinsic Memory* (antecedent climate characteristics)^[2-4]

Explaining Memory:

- 1 *Causal pathways* remain poorly understood^[5]
- 2 Expressions of *Plant Function* as a possible solution

Can we distinguish between **intrinsic** and **extrinsic** memory effects?

What biological traits cause areas to exert **intrinsic** and **extrinsic** memory?

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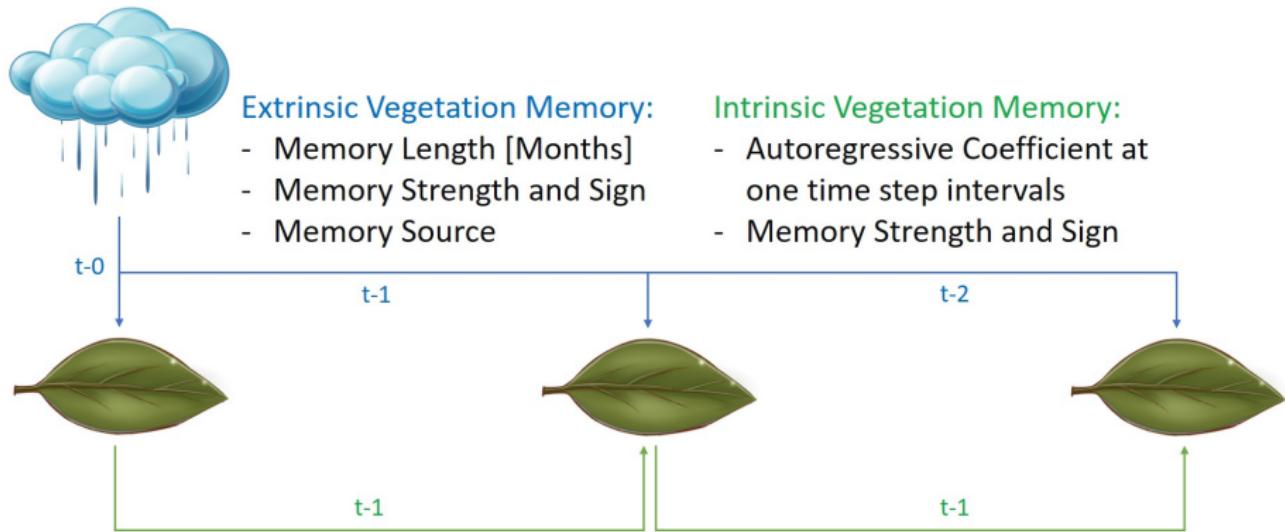
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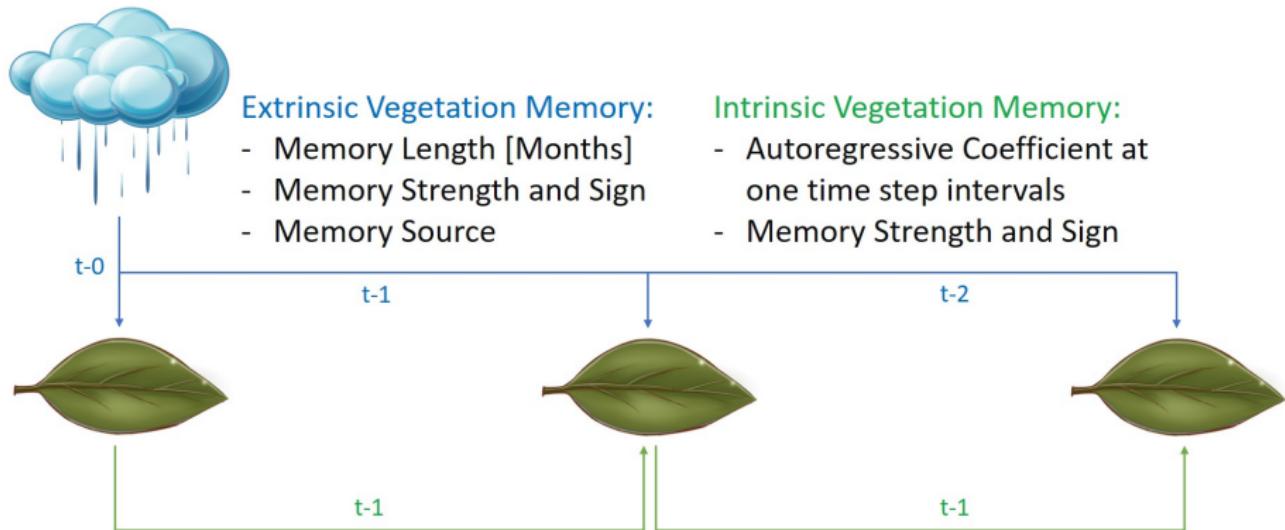
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Intrinsic vs. Extrinsic Memory Components



→ Big emphasis on **dryland regions** due to demonstrated vegetation memory effects^[1,3,4,6], and the strong dependence of dryland vegetation on local water regimes^[5]

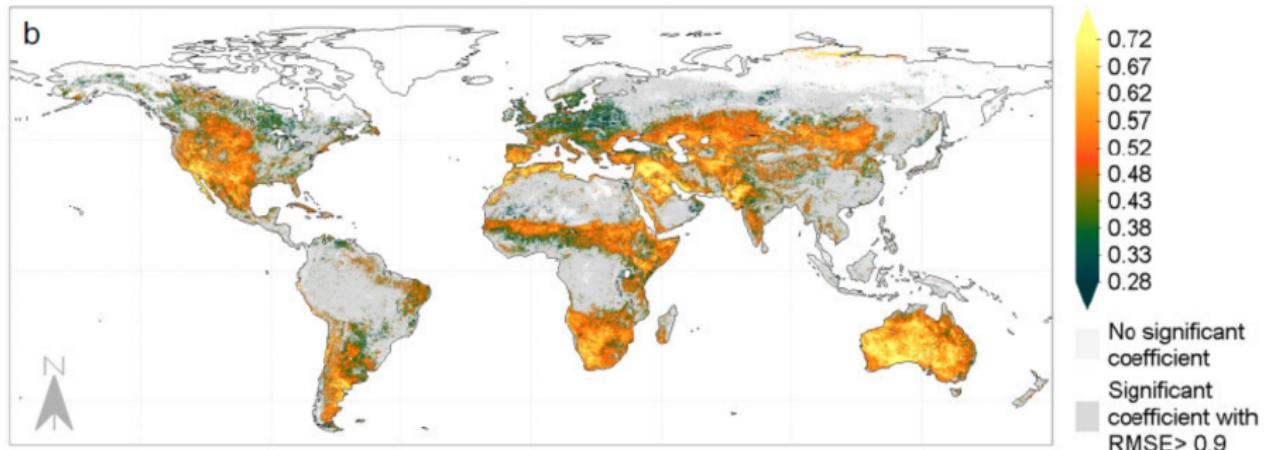
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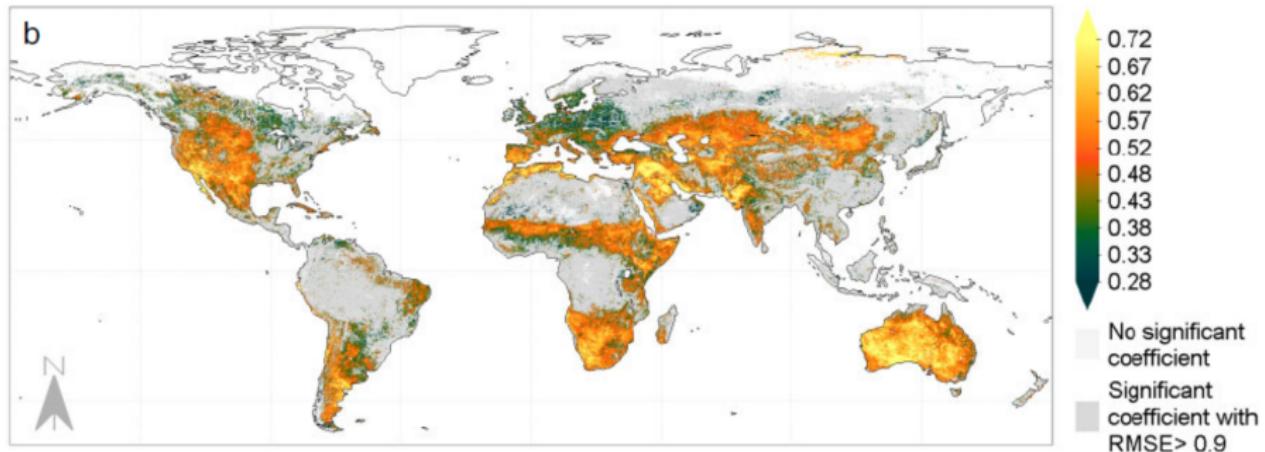
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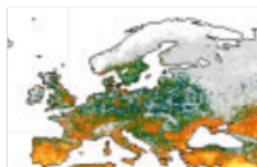


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Study Regions

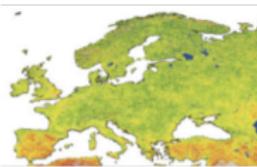
The Iberian Region

Intrinsic Memory

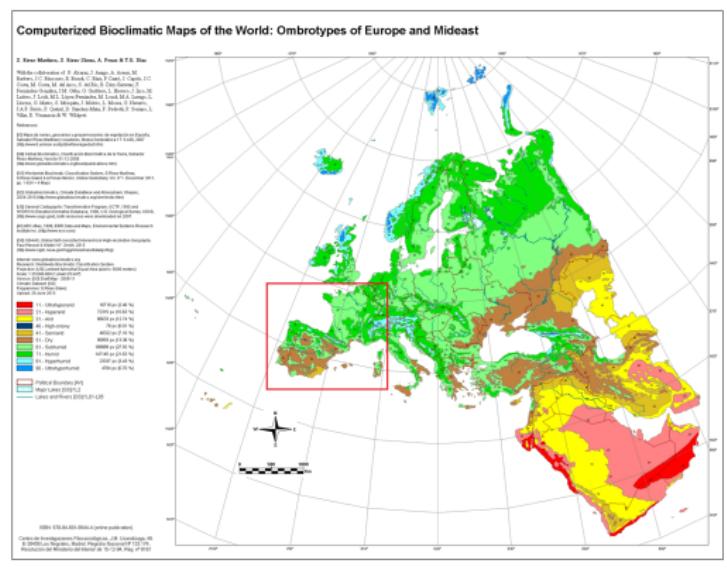


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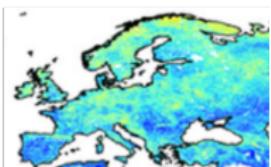
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Additional Study Regions:

■ Caatinga, Brazil

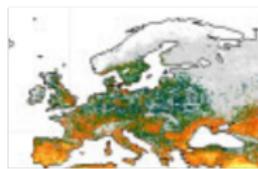
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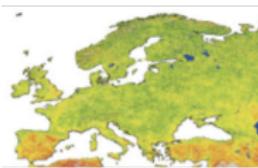
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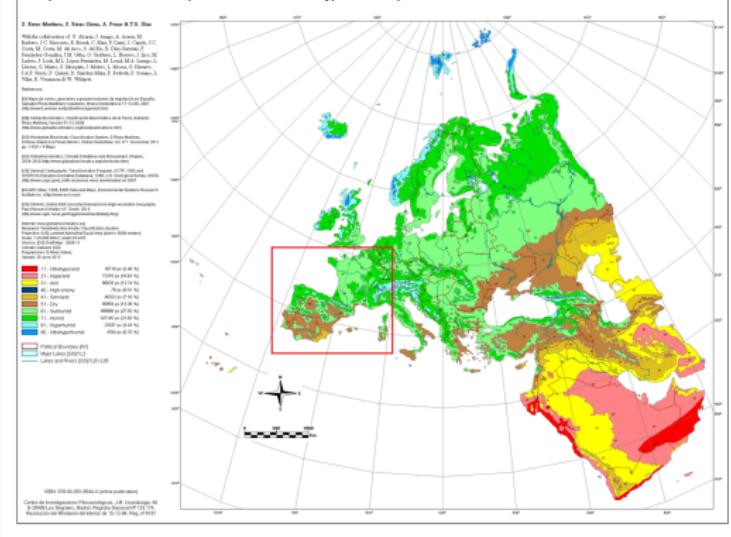
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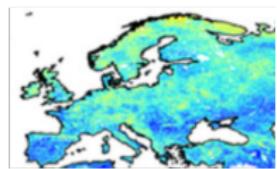


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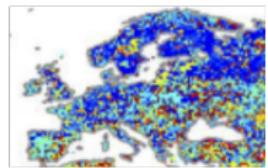


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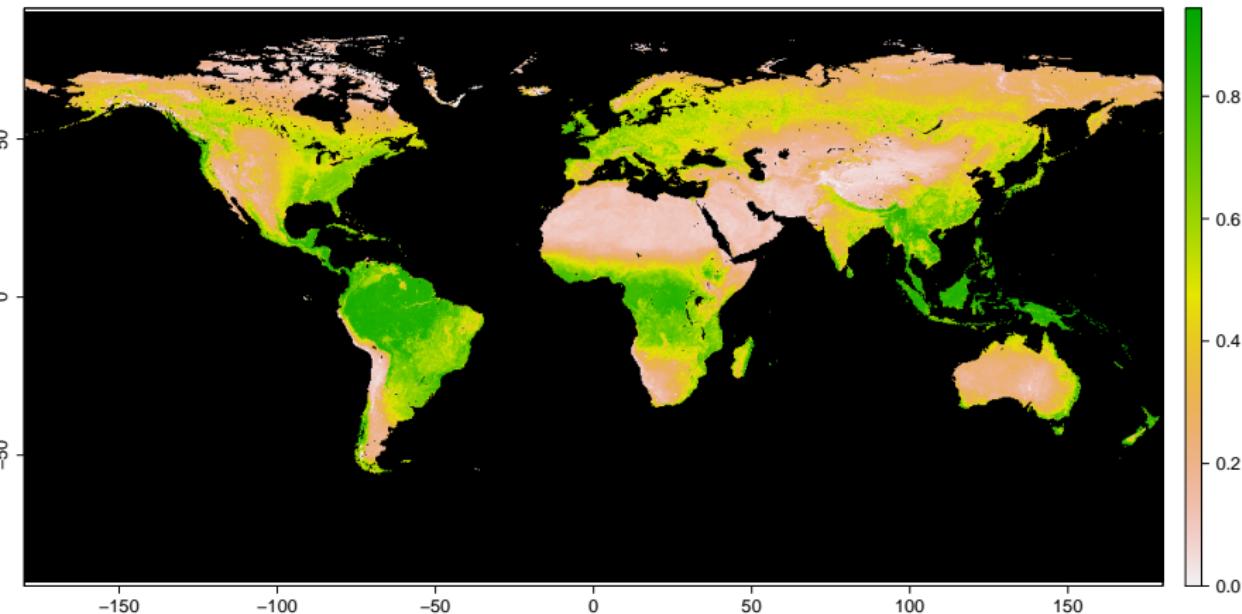
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Normalised Difference Vegetation Index (NDVI)

- *Biological Relevance:* Proxy of biomass and vegetation cover
- *Comparability:* Has been used in other studies of vegetation memory

Mean NDVI 1982 – 2015



ERA5 & Climate Variables

■ Why:

- Applicable globally
- Gap-less time series
- More sophisticated approach than previously utilised:
 - Worldclim - Superior Temporal Resolution (superior resolving of climate extremes)
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■ Soil Moisture - Q_{soil}

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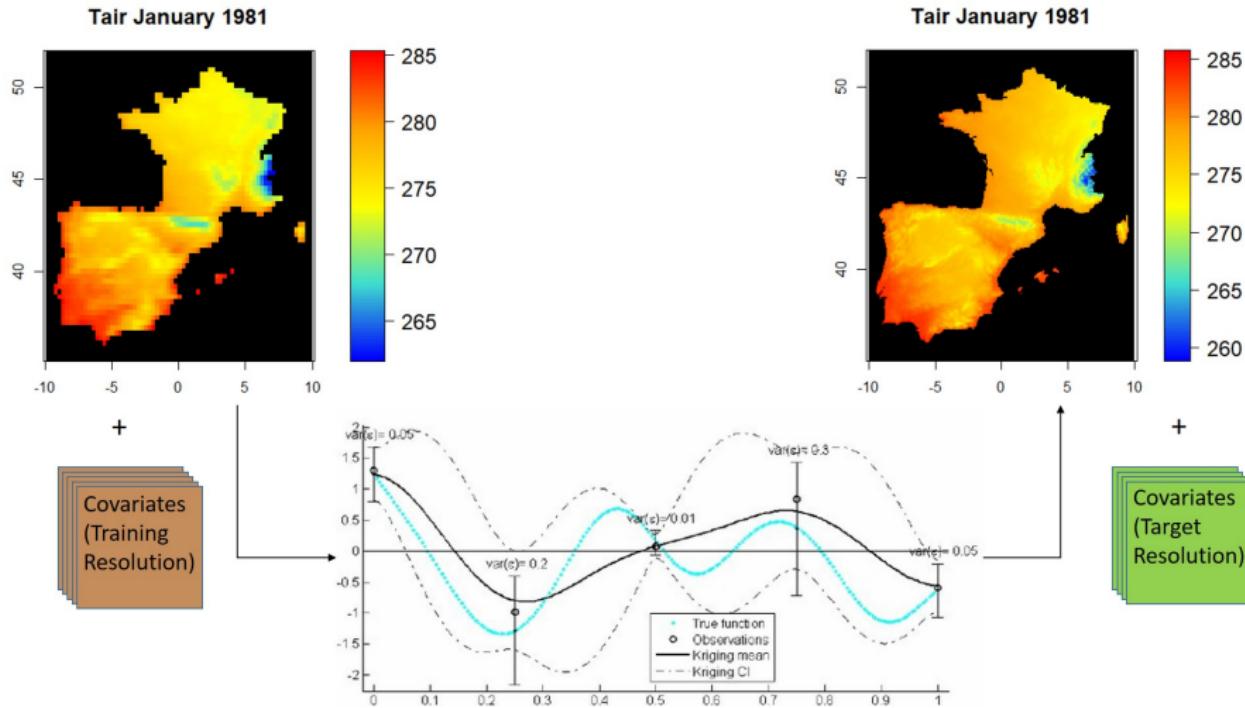
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■ Air Temperature - T_{air}

- *Why*: Temperature drives plant physiology and drives levels of aridity^[3,7].
- *How*: As one single layer (2m above ground)

Kriging



COMPADRE Data

Life History Traits (LHTs)

■ Why:

- *Biological Relevance*: Indices of plant behaviour through time
- *Comparability*: Capture much of natural life strategy variation^[9]

■ Core Measures:

- *Fast-Slow Continuum (FSC)*: Capture over 60% of the variation in plant life history strategies
 - FSC-1: Life History Speed
 - FSC-2: Reproductive Strategy/Output
- *Reactivity*: Instantaneous biological responses

Expressions of **Plant Functional Traits** (PFTs) were tested against vegetation memory but require further research aso of this point in time.

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Pixyel-Wise Model Building

- Linear detrending
- Z-Scores:

$$Anomaly_i = \frac{Detrended_i - \overline{Detrended}_{month}}{SD_{Detrended,month}} \quad (1)$$

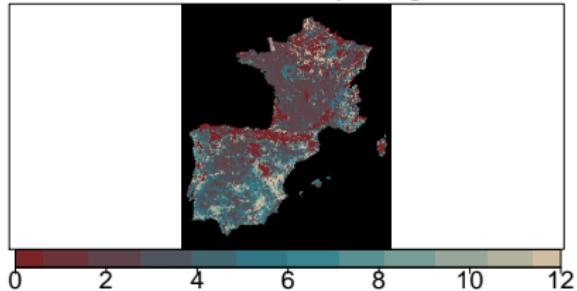
- Calculate:
 - $t - 1$ lag for NDVI
 - Cummulative lags for Q_{soil} data
- Set NDVI anomalies to 'NA' in months for which $Thresholds_i < 0.1$ with

$$Thresholds_i = \overline{Raw_{NDVI,month}}$$
- PCA regression and model selection:

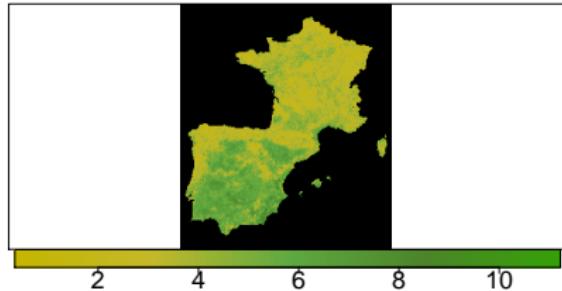
$$NDVI_t = \beta_{t-1} * NDVI_{[t-1]} + \beta_{Q_{soil}} * Q_{soil}_{k;m} + \beta_{Tair} * Tair_t \quad (2)$$

Vegetation Memory Coefficients

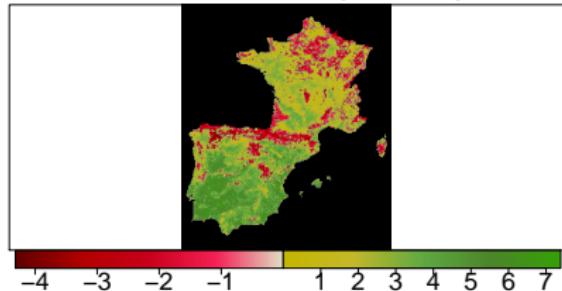
Soil Memory Lag



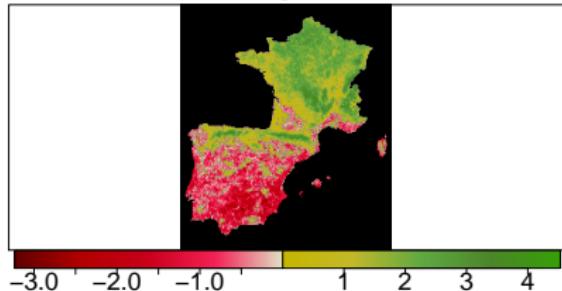
NDVI [t-1]



Soil Moisture (0–7cm)



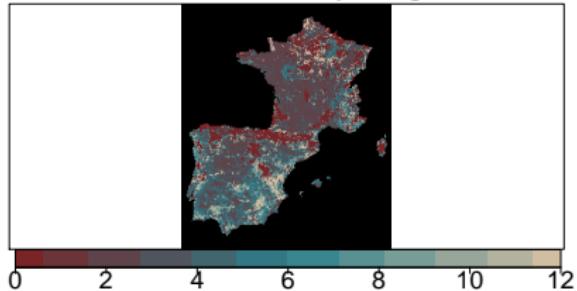
Air Temperature



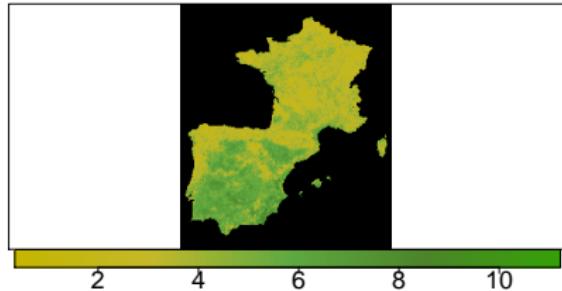
→ Is *intrinsic* memory really *intrinsic*?

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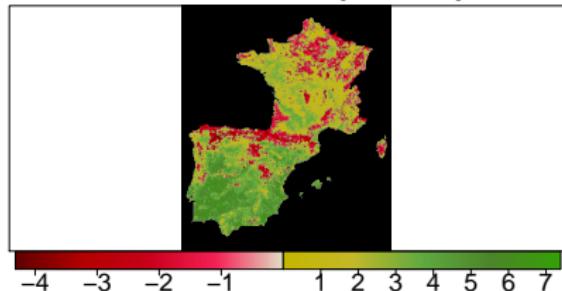
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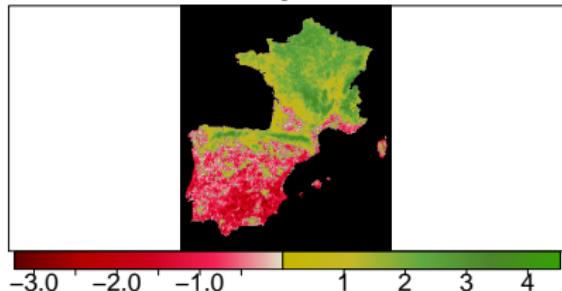
NDVI [t-1]



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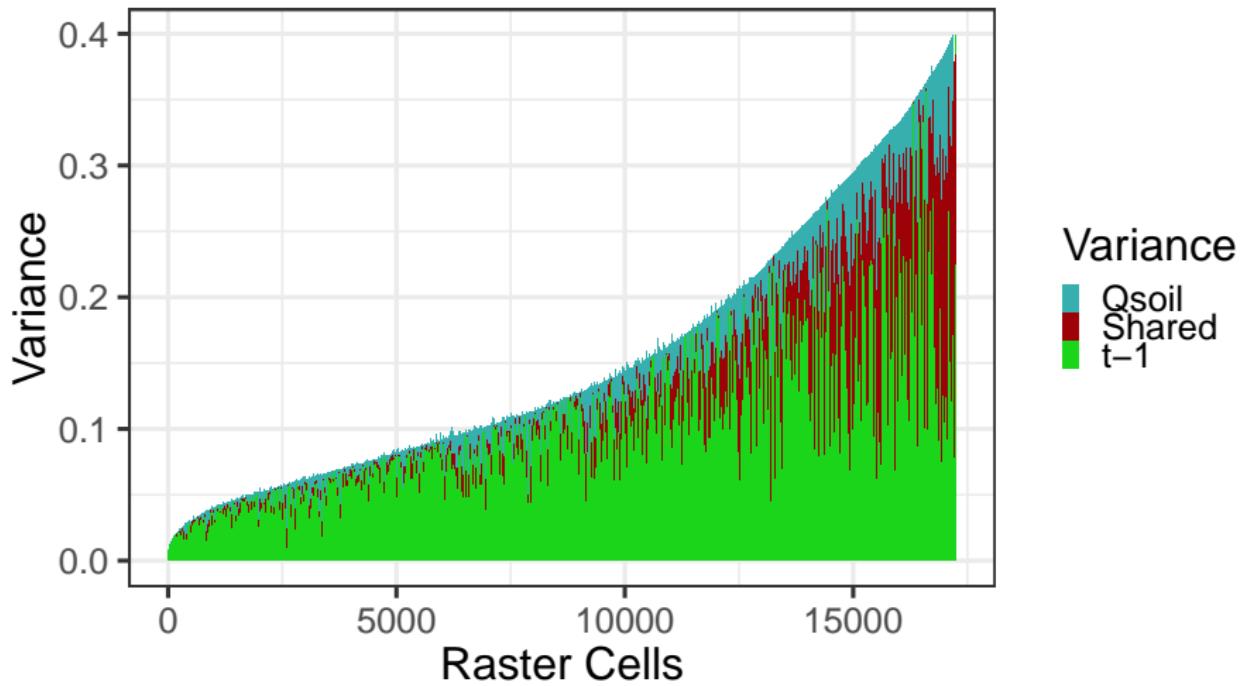
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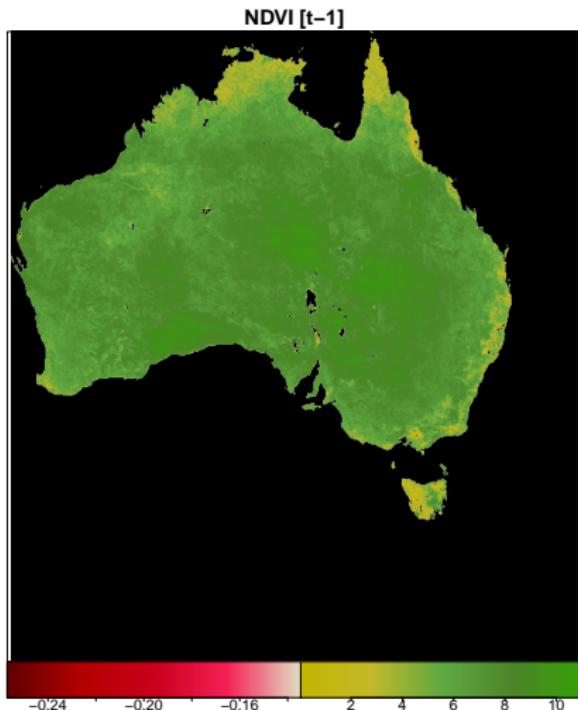
Distinguishing Intrinsic and Extrinsic Memory

Qsoil1 is the most informative of the soil moisture layers!

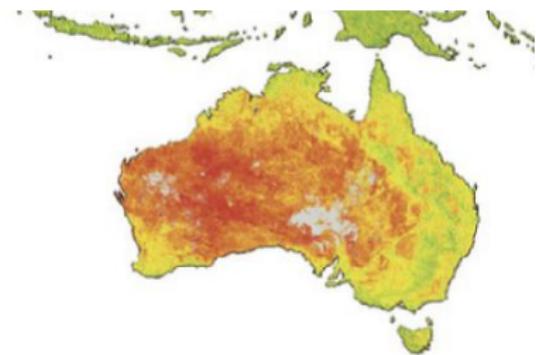


Identifying Underlying Extrinsic Patterns I

Uniform $NDVI[t - 1]$ effect across Australia **contrasts** with **other studies**.

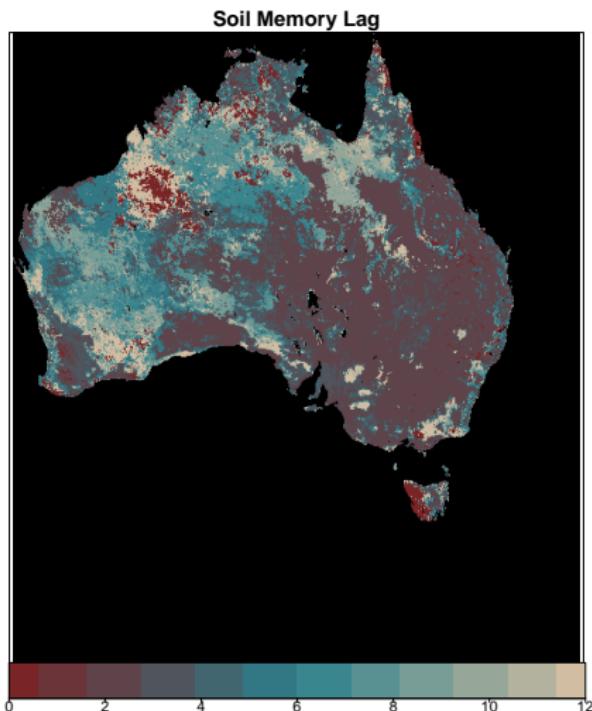


Intrinsic Memory by Seddon et al.^[6]:

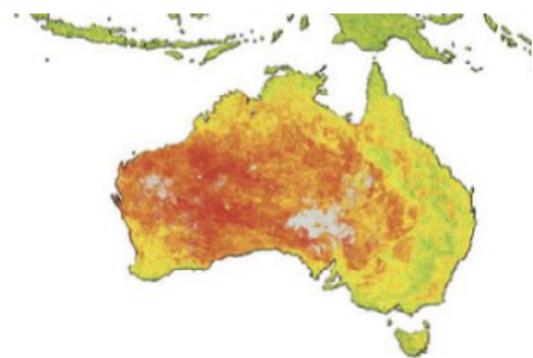


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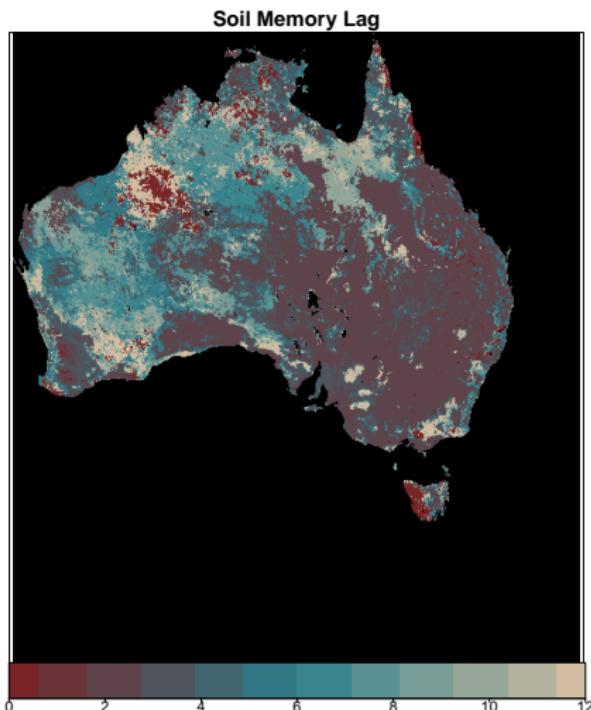


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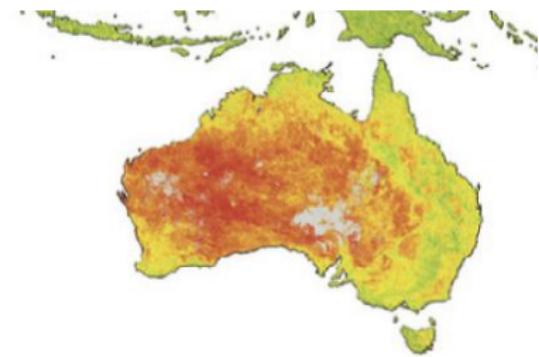


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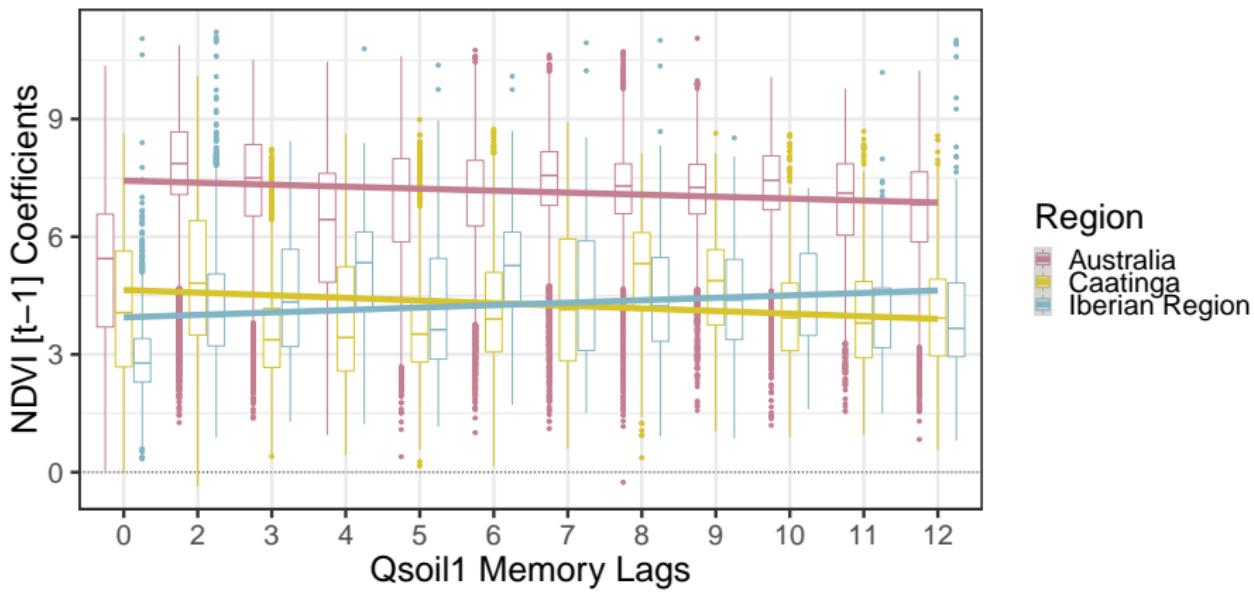


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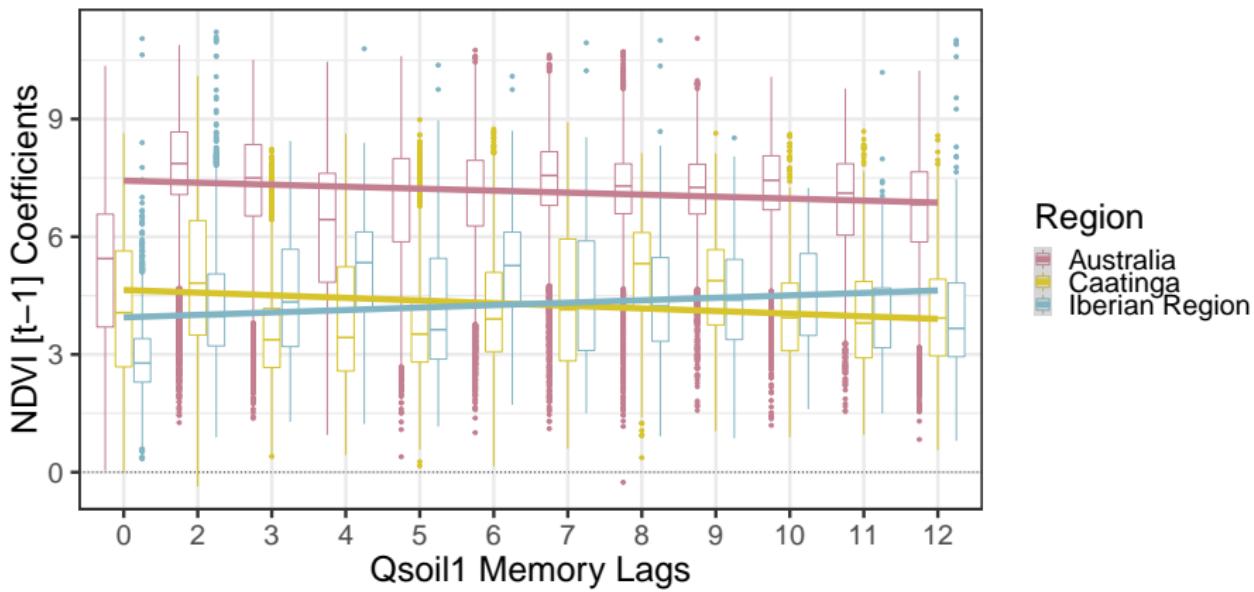
Previous $t - 1$ variation can
be understood through
extrinsic vegetation memory.

Vegetation Memory Adaptation



Relationship of $t - 1$ coefficient and extrinsic vegetation memory length
is not uniform within or between study regions.

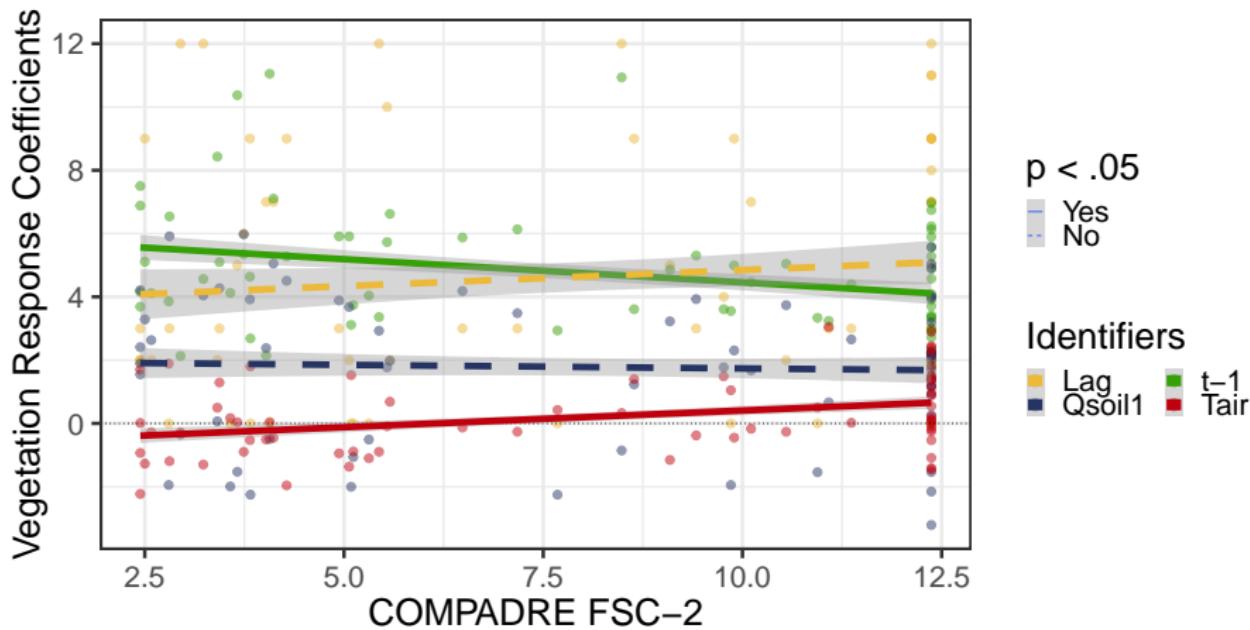
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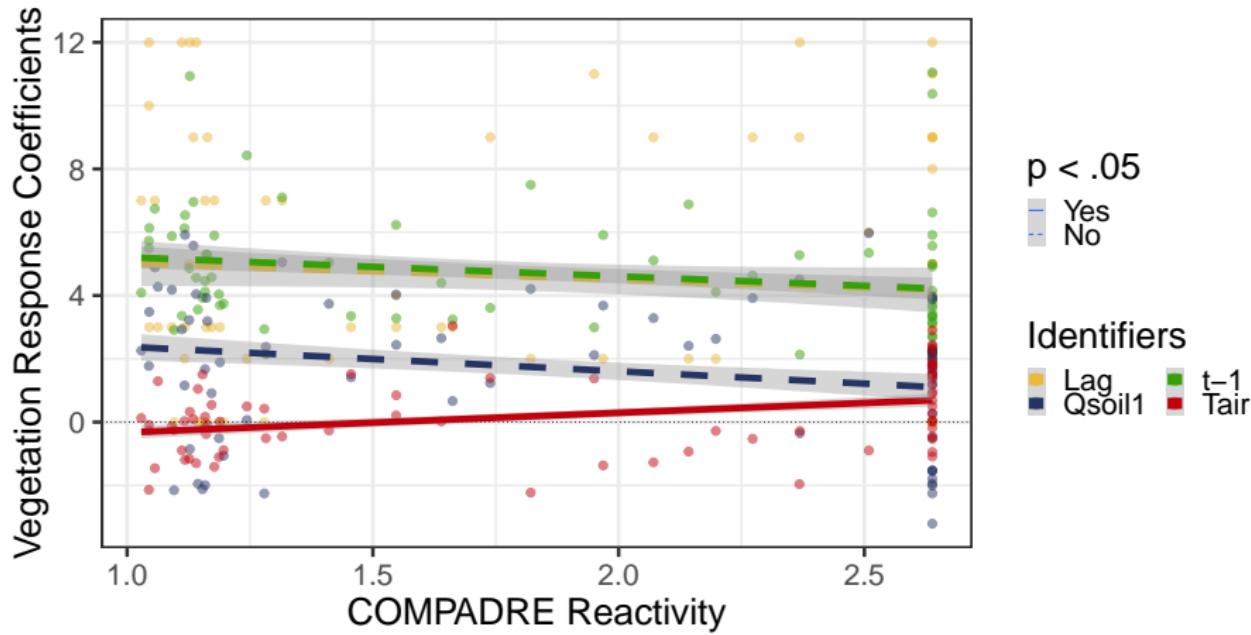
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Plant Function I

Linking **plant functional traits** and vegetation memory proved **non-conclusive** but life history traits showed **interesting patterns**:

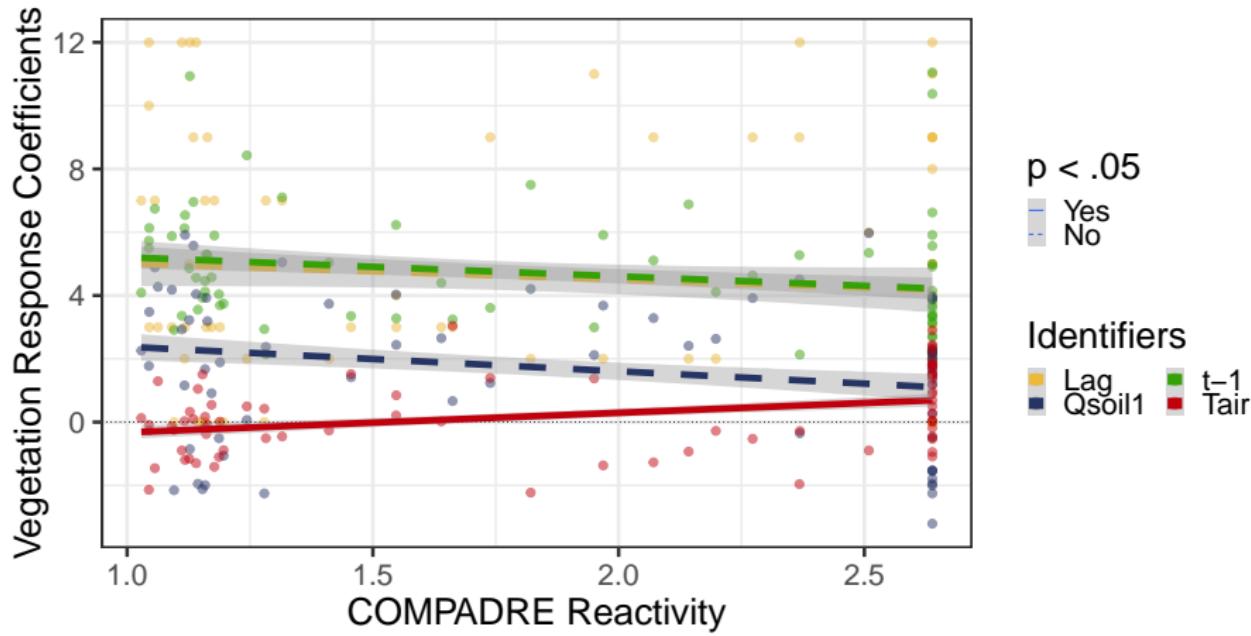


Plant Function II



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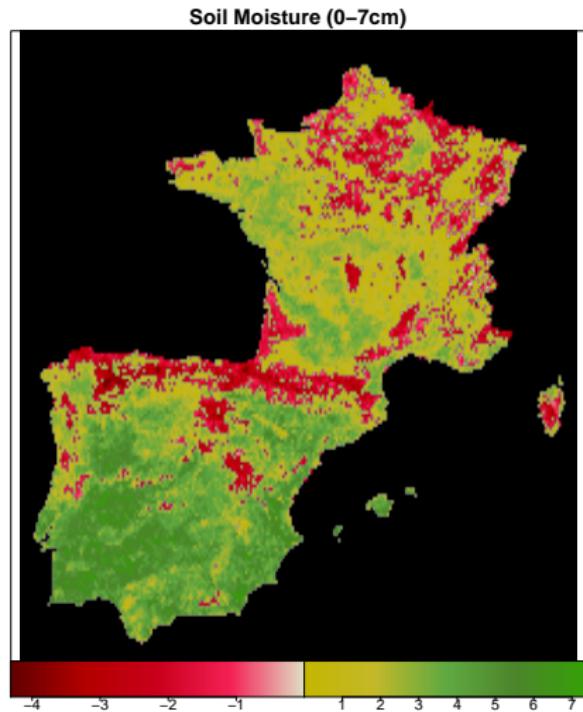


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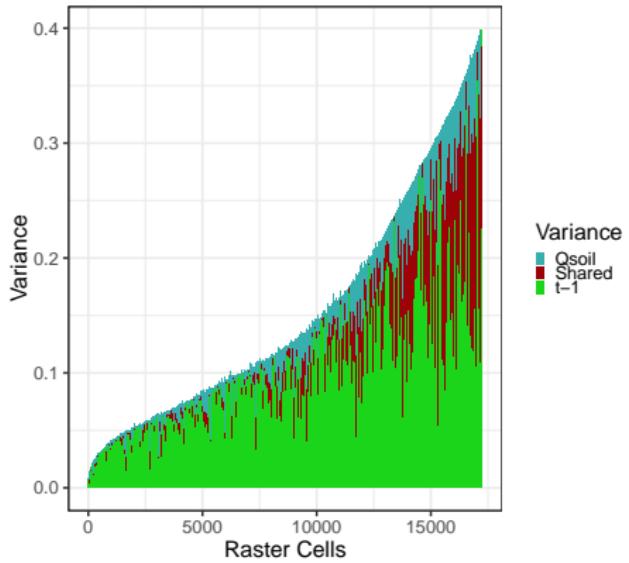


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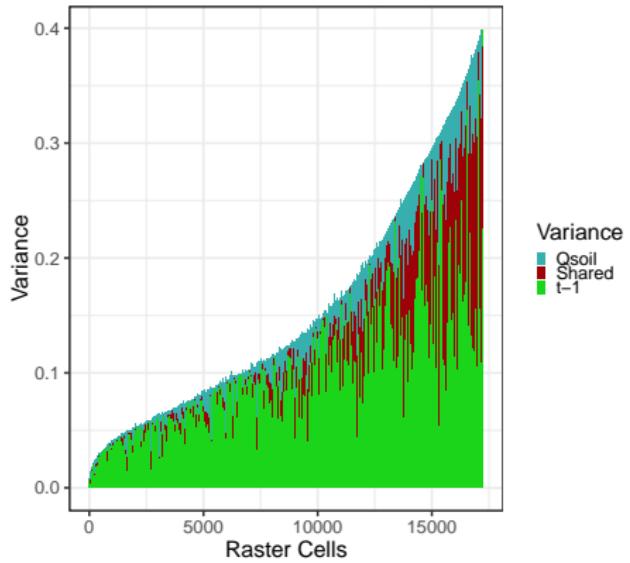


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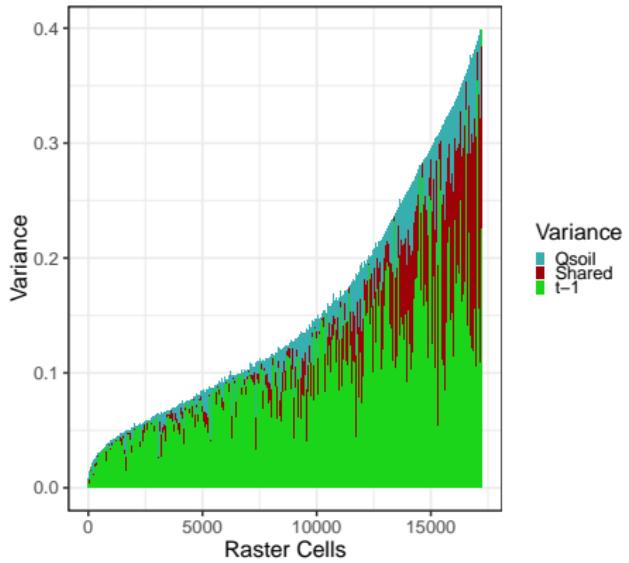


Distinguishing intrinsic and extrinsic memory components remains challenging.

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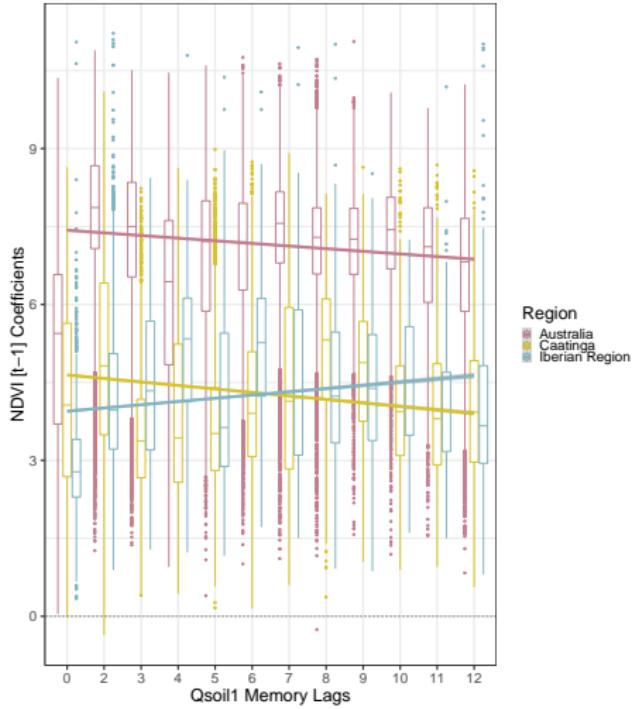
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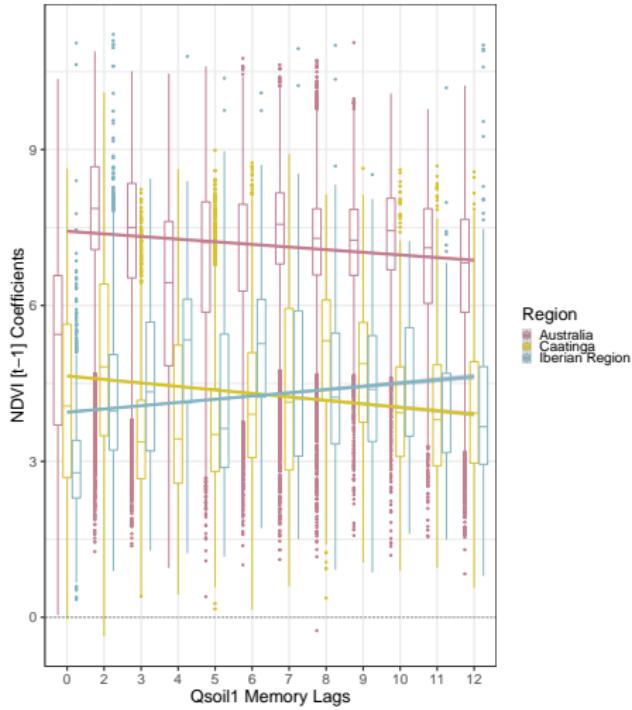
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- 2 Vegetation memory processes differ greatly between regions.

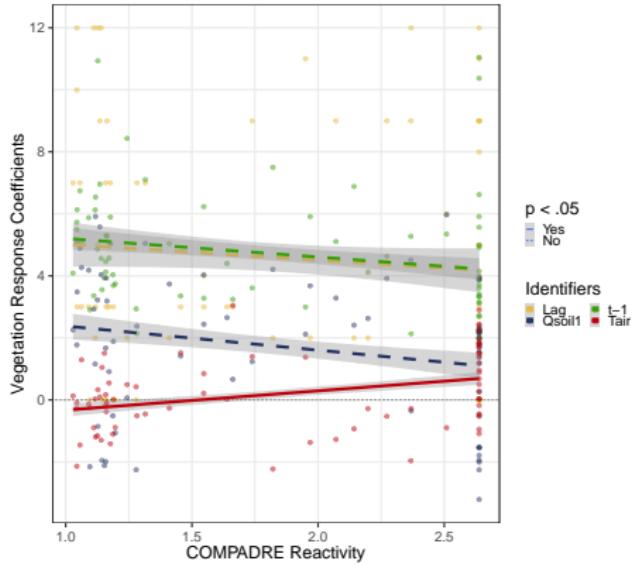


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Some measures of life history strategies are related to vegetation memory characteristics.

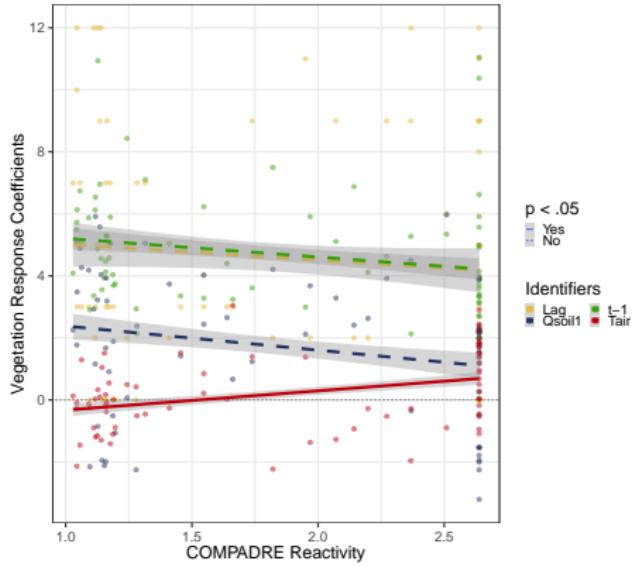


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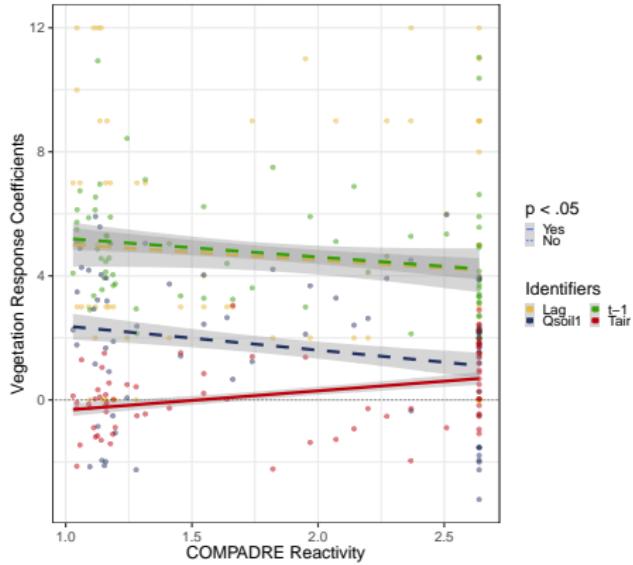


Challenging to establish direct proxies of either intrinsic or extrinsic vegetation memory components.

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