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Neural networks to estimate and map world forest foliar elemental composition and stoichiometry

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Introduction: Barrel theory

N, P and K stocks, fluxes and availability improve the projections about the potential impacts of global change, in particular of global warming, on C-cycle (Jiang et al, 2017; Sardans & Peñuelas, 2015)

Only gross N and P concentration maps in vegetal tissues and any K data is available at the moment

Liebig's law of the minimum

Methods: Data gathering & classification

Natural conditions

- 230 published articles
- TRY plant trait database
- ICP forest
- TTT Tundra Trait Team
- IFC Catalan Forestal Institute

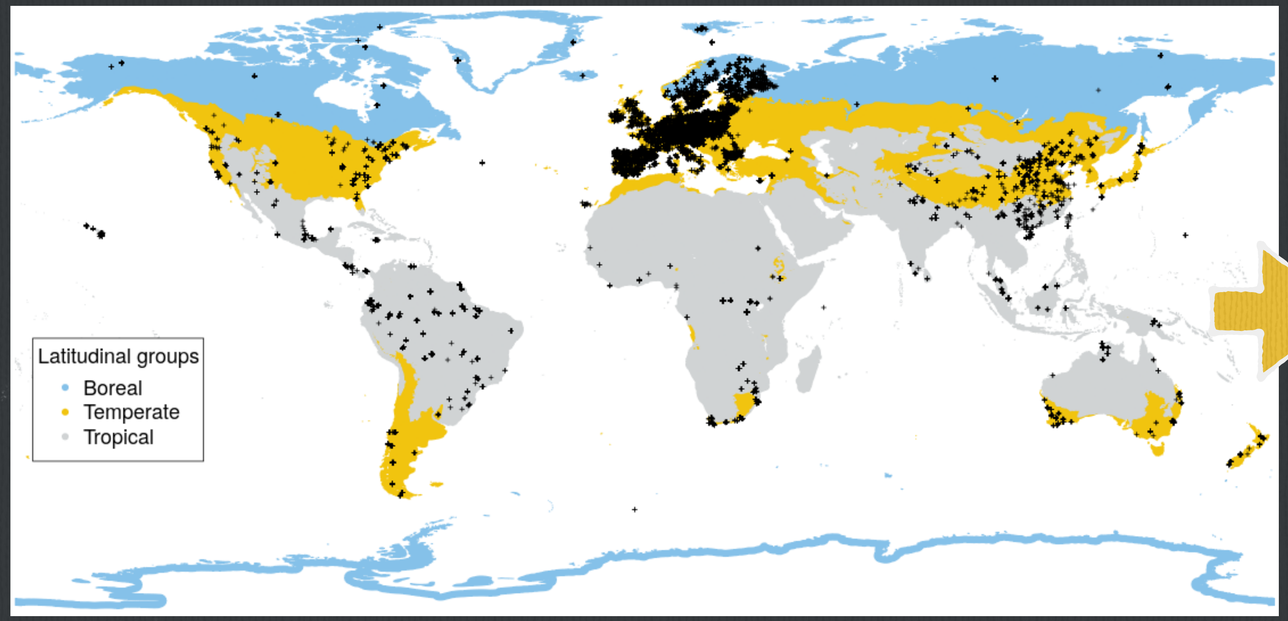
Georeferenced plots

Biomas

- Boreal
- Temp. deciduous broadleaves
- Temp. evergreen broadleaves
- Temperate coniferous
- Tropical deciduous
- Tropical evergreen

WWF biome categories

Methods: predictors



N, P and K sampled points. Color separation by latitudinal groups based on WWF ecoregion map (Olson et al, 2001)

73 predictor maps

- Climatic data: WorldClim (Fick & Hijmans, 2017)
- Aridity & evapotranspiration: CGIAR-CSI (Trabucco & Zomer, 2019)
- Soil gridded data (Sangguan et al. 2014)
- N deposition : (Ackerman et al. 2018)
- P deposition: (Wang et al. 2017)

Methods: Neural Networks = NNTools

NN structure

↓

[Training (80% samples)] * 500

↓

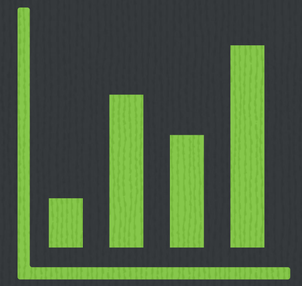
Test (20% samples)

↓

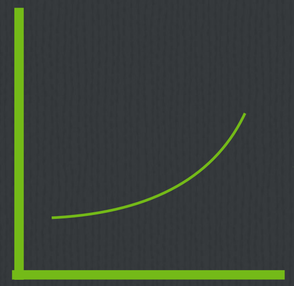
Predictions

R^2

Performance



Variables importance



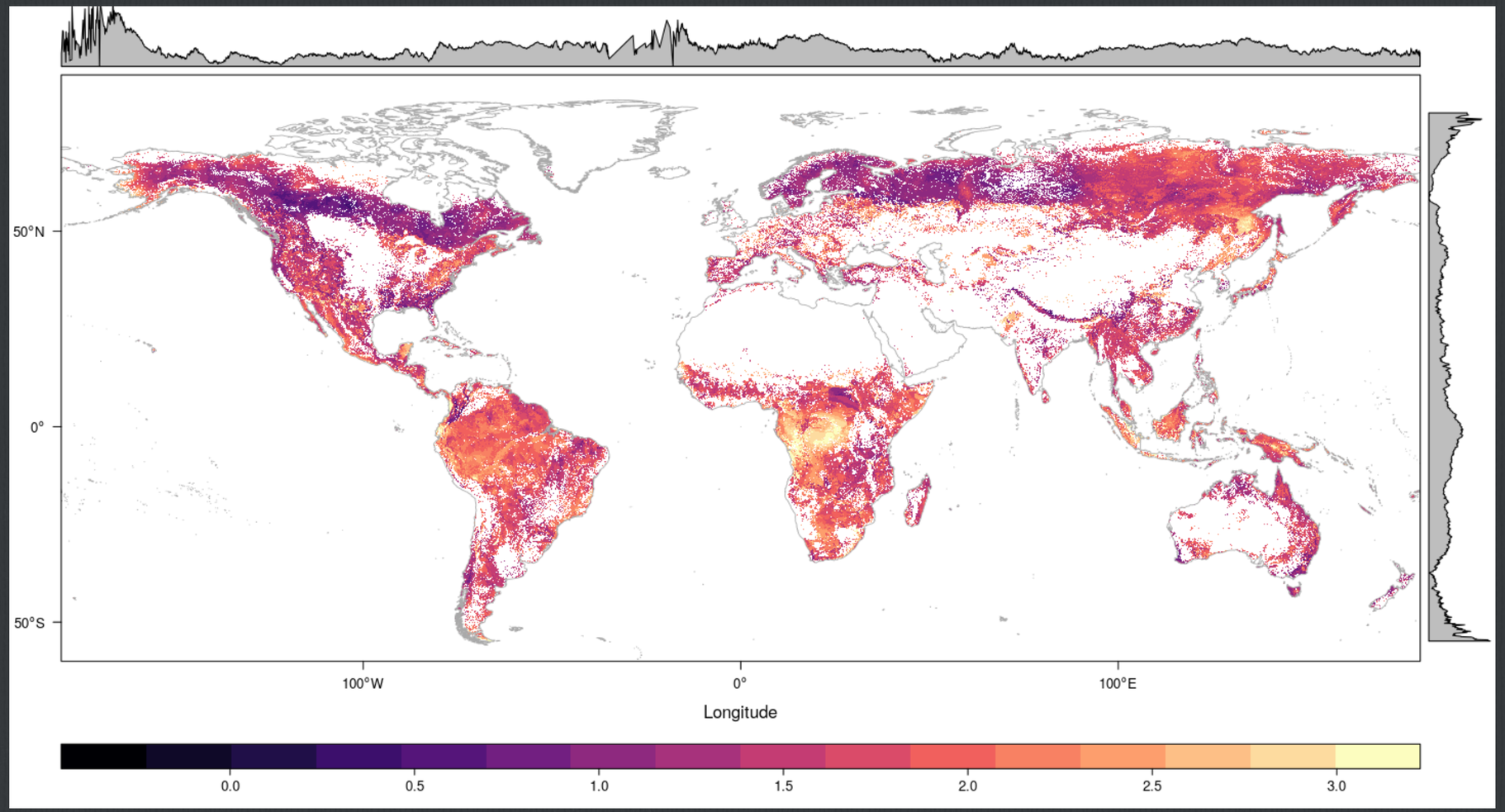
Variables response

Prediction maps

glm's

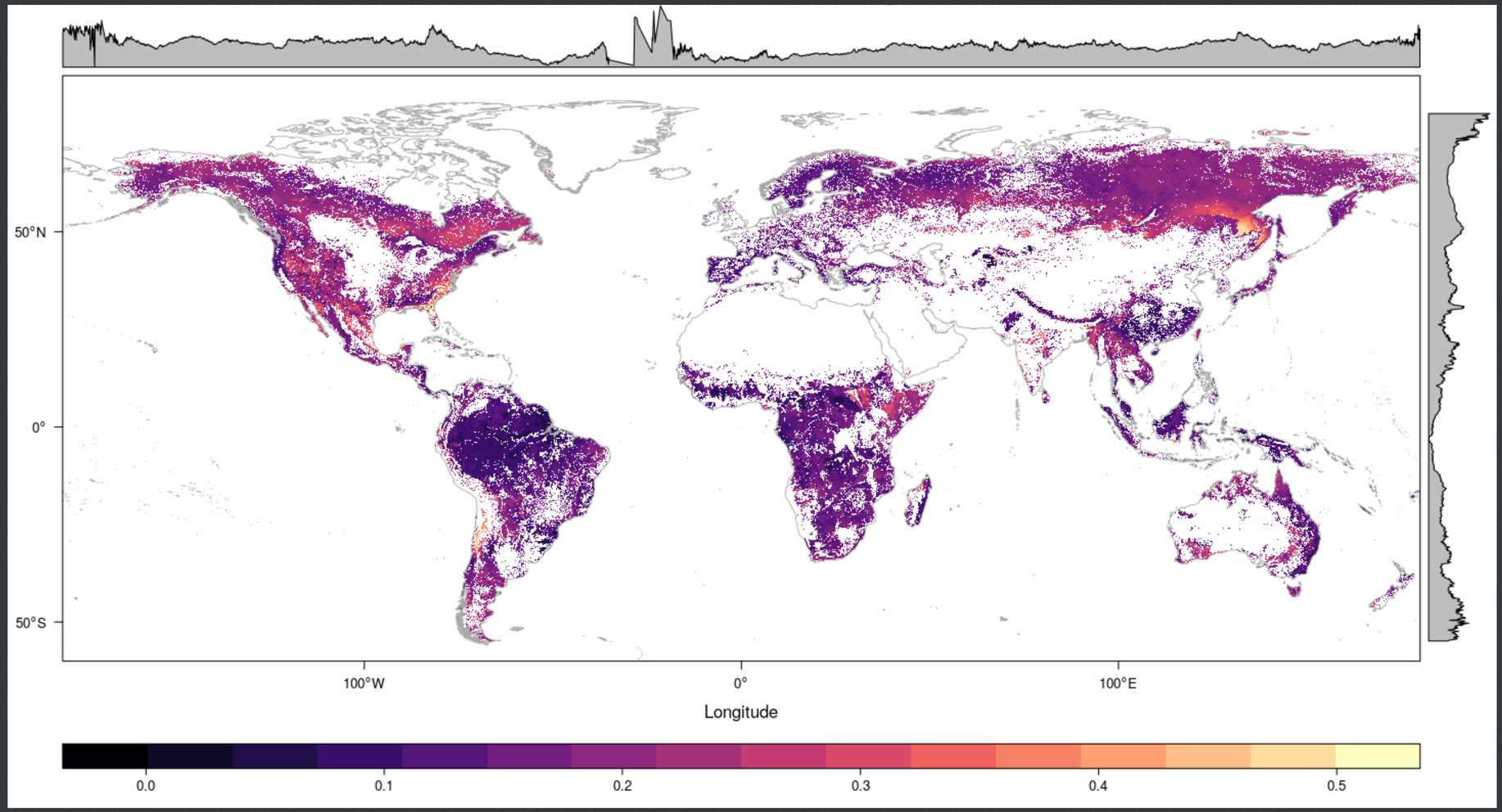
x 100

Results: Nitrogen



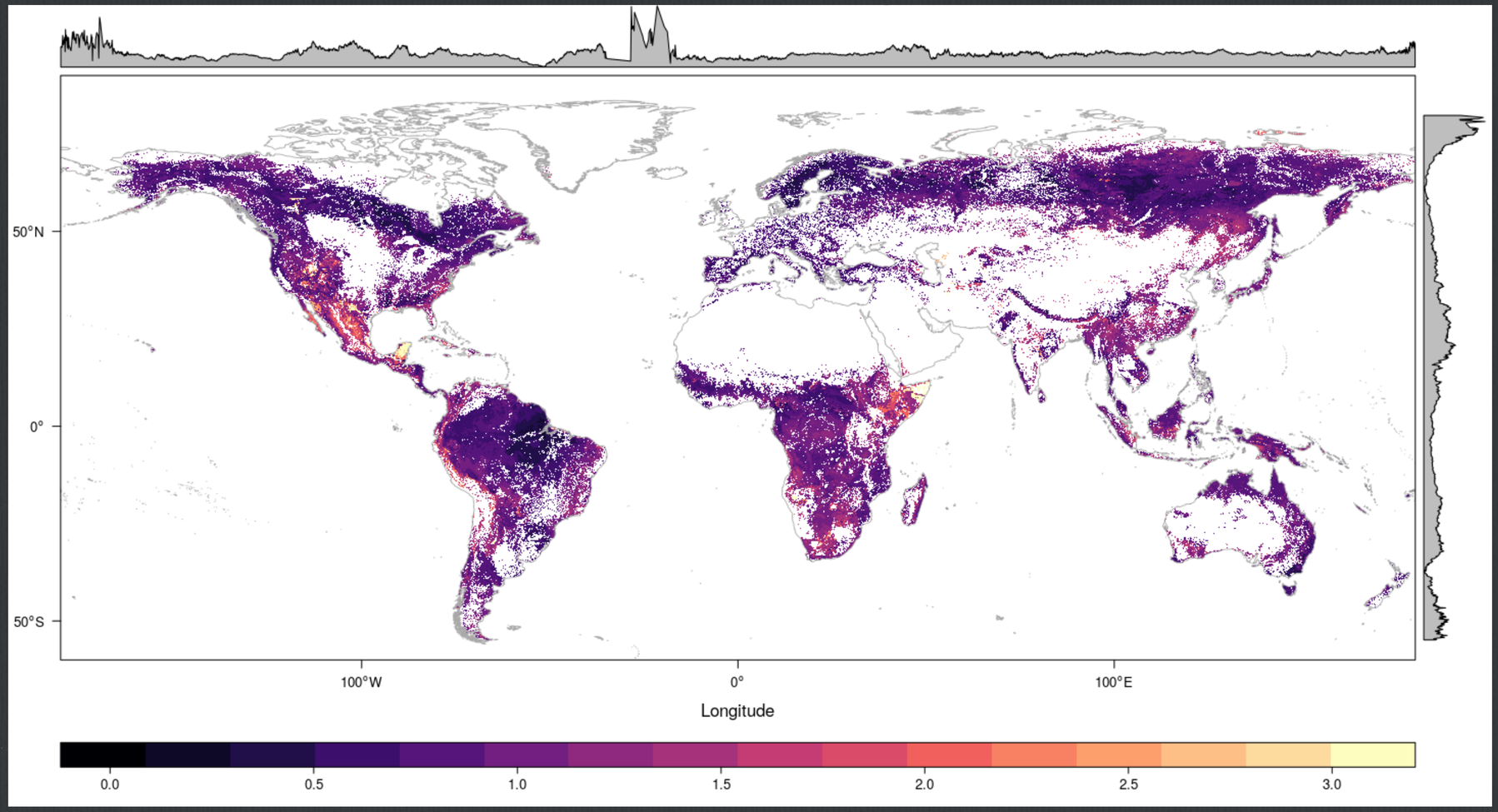
Bioma	R^2
Bor	0.42
TempDB	0.39
TempEB	0.34
TempC	0.45
TropD	0.35
TropE	0.35

Results: Phosphorus



Bioma	R^2
Bor	0.12
TempDB	0.42
TempEB	0.40
TempC	0.36
TropD	0.28
TropE	0.50

Results: Potassium



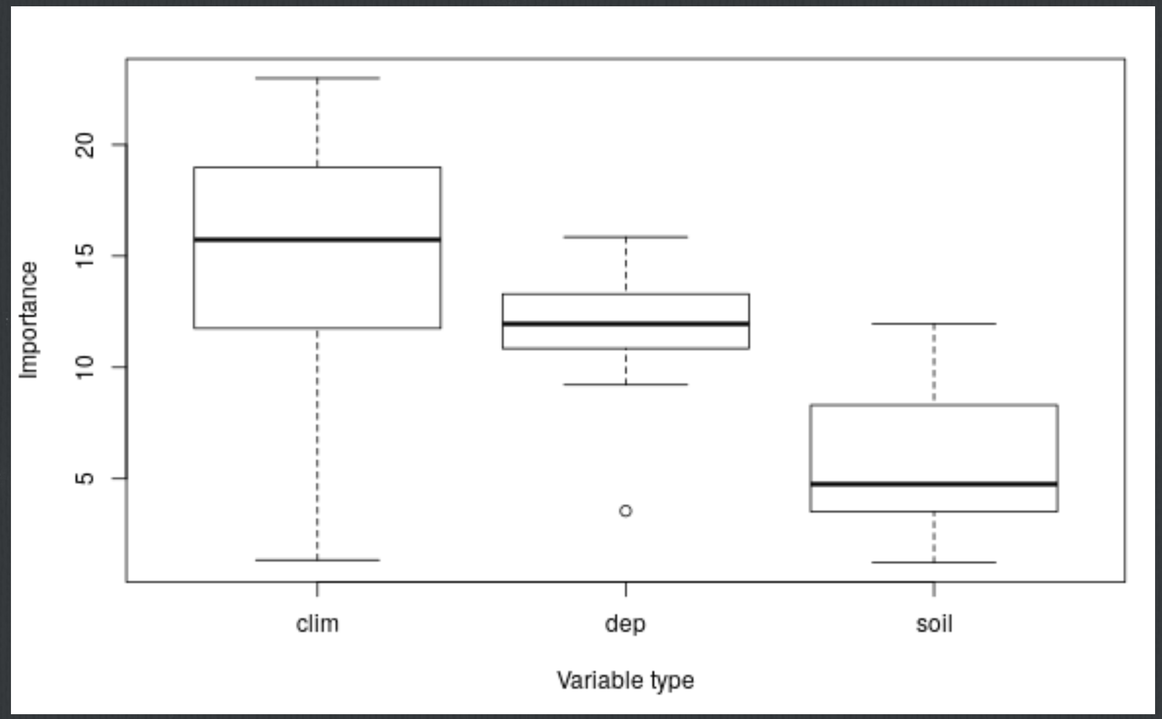
Bioma	R^2
Bor	0.14
TempDB	0.14
TempEB	0.14
TempC	0.11
TropD	0.14
TropE	0.18

Results: Glm's, general issues

- Tropical: influenced by seasonality (both, temperature and precipitation)
  - N: + seasonality = ↓ N
  - P: + seasonality = ↑ P
  - K: + seasonality = ↓ K
- Temperate: influenced by the aridity, high temperatures and water availability
  - N: + aridity = ↓ N
  - P: + aridity = ↓ P
  - K: + aridity = ↑ K (if enough water to K absorption)
- Boreal: N and P very influenced by summer temperature and precipitation conditions and K by N deposition
  - N: + precipitation and temperature = ↑ N
  - P: + temperature = ↑ P
  - K: + N deposition = ↓ K

Discussion

Which kind of variables is more important?

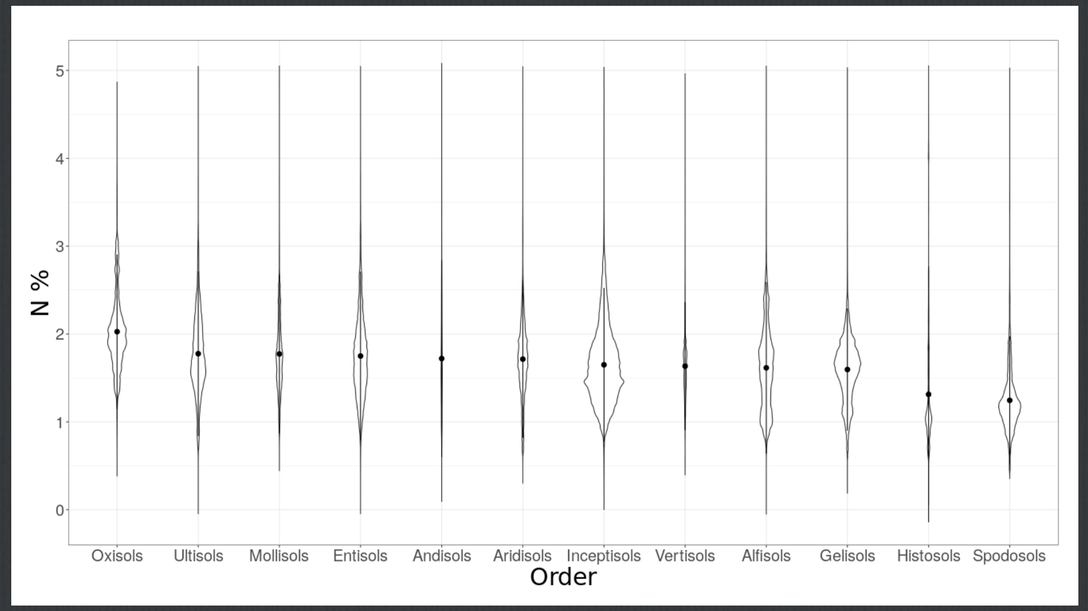


Mean by group of the weighted importance of the variables by eigenvalue of the 5 more important axes in a PCA

1. Climate variables
2. Deposition variables
3. Soil variables

Discussion

Does leaves follow the soil age hypothesis?



Violin plots of the predicted values of N and P gathered by USDA Soil Taxonomy orders (1999)

Older the soil, ↑ N and ↓ P ✓

Conclusions

With our models it is possible to:

- Obtain **global maps at 1km resolution** of N,P,K % in leaves of woody plants with **R^2 between 0.11 and 0.50**
- Which **variables determine the global patterns** of N,P,K distribution in leaves of woody plants and **how**
- **Leaves stoichiometry follows** the **soil age hypothesis**
- Determine that **climatic conditions** are generally **more important than deposition or soil** characteristics to determine leaves stoichiometry

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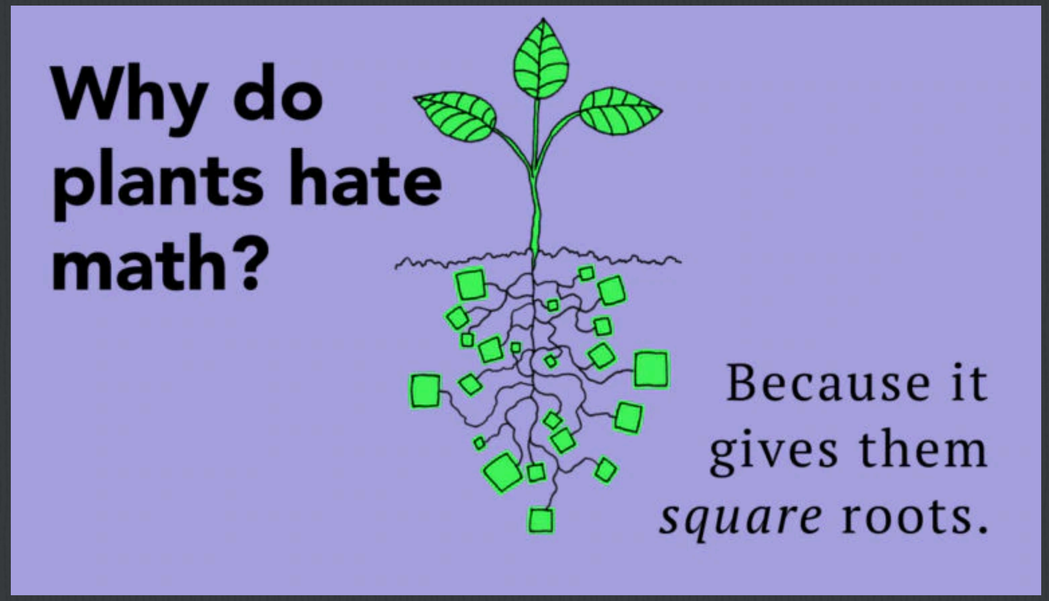
Thank you



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