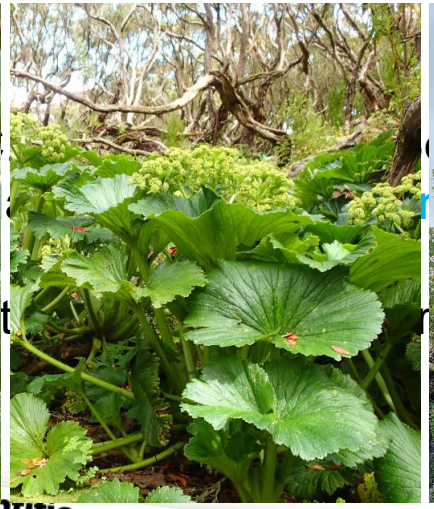
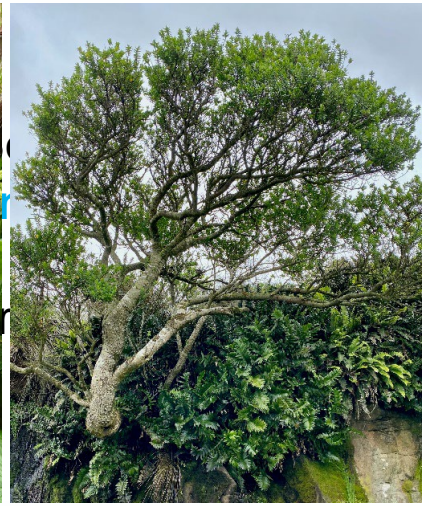
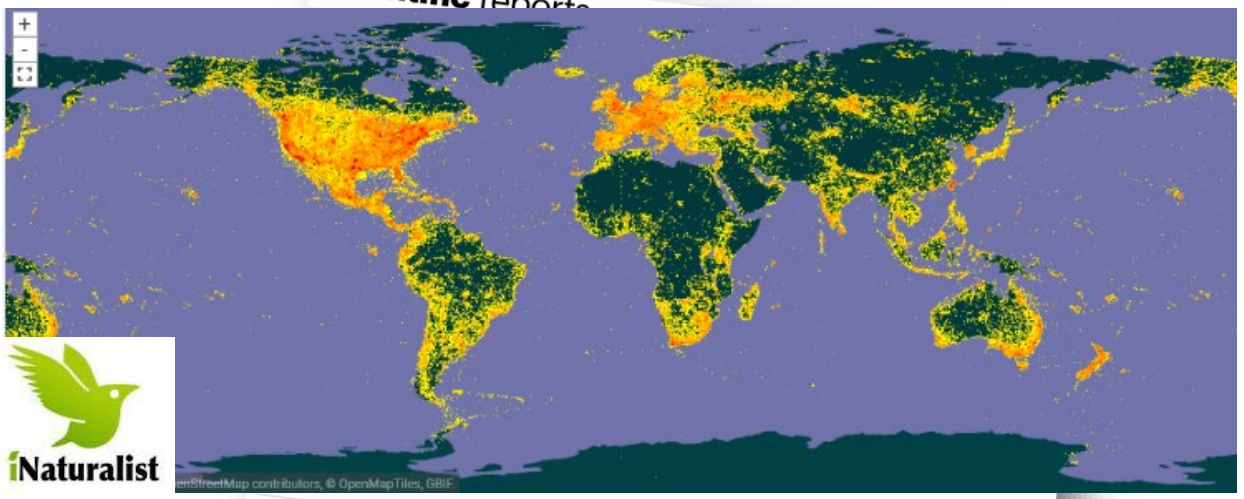
Mapping global distributions of plant functional traits from crowd-sourced plant photographs

Height?
Nitrogen?
Dry matter content?
…







Model approach

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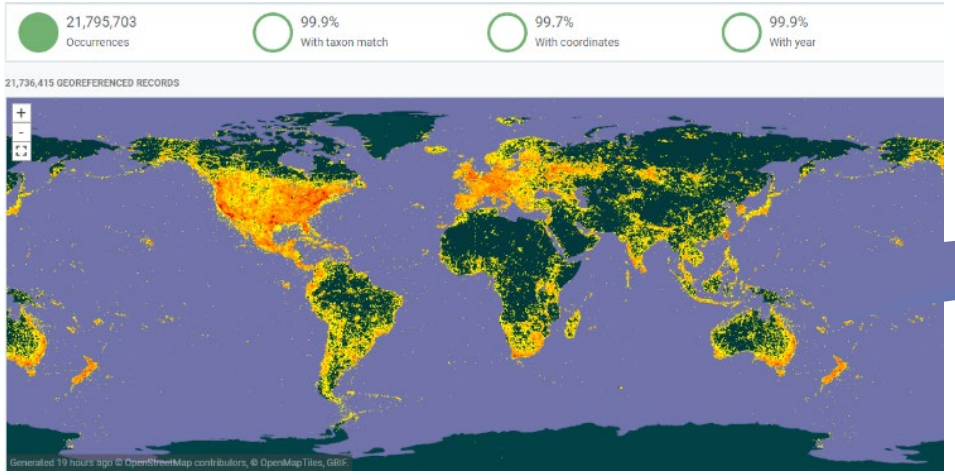
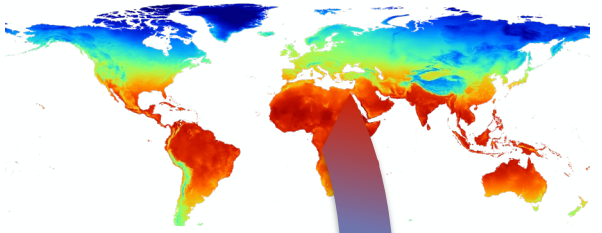
iNaturalist

Crowd-sourced plant photographs
+lat/long +species name



WorldClim

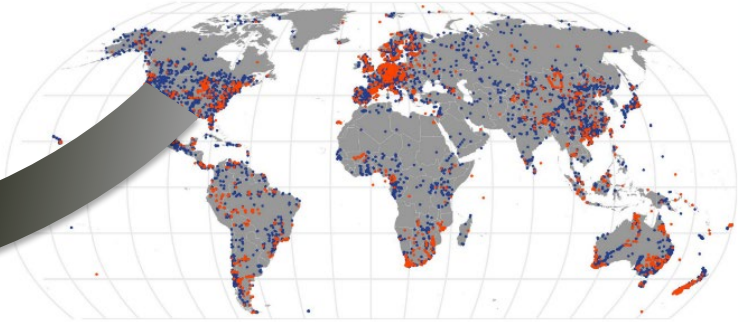
Climate data
+lat/long



X

TRY

Functional traits
+species names



Y

FIGURE 6 Geographic coverage of measurement sites in TRY version 1 (red) and additional measurement sites in TRY version 5 (blue)

Convolutional Neural Networks

(weakly supervised training)

...predict traits from photos

- CNN Ensembles
- Trait plasticity
- With/without climate

TABLE 4 Most often requested traits. The 30 traits with the highest number of requests (status 1 October 2019). Number of requests and in parentheses the percentage relative to all 7,330 requests

Trait	Data type	Number of requests

- Specific Leaf Area
- Leaf area
- Growth height
- Stem density
- Seed mass
- Nitrogen concentration

TABLE 5 Species with best trait coverage. The 30 species with the highest number of traits in the TRY database version 5 and number of traits represented for these species in TRY version 1 and 5. Sorted by the number of traits in TRY 5

Species	Plant growth form	Number of traits	
		TRY 1	TRY 5
Pinus sylvestris	Tree	264	569
Fagus sylvatica	Tree	237	517
Picea abies	Tree	252	475
Quercus robur	Tree	194	435
Acer saccharum	Tree	139	430
Betula pendula	Tree	265	429
Achillea millefolium	Herb	209	403
Acer pseudoplatanus	Tree	186	397
Trifolium pratense	Herb	181	395
Quercus rubra	Tree	190	388
Dactylis glomerata	Herb	193	387
Plantago lanceolata	Herb	156	386
Vaccinium vitis-idaea	Shrub	189	382
Trifolium repens	Herb	173	380
Fraxinus excelsior	Tree	196	378
Acer platanoides	Tree	186	378
Quercus petraea	Tree	194	368

Model Evaluation

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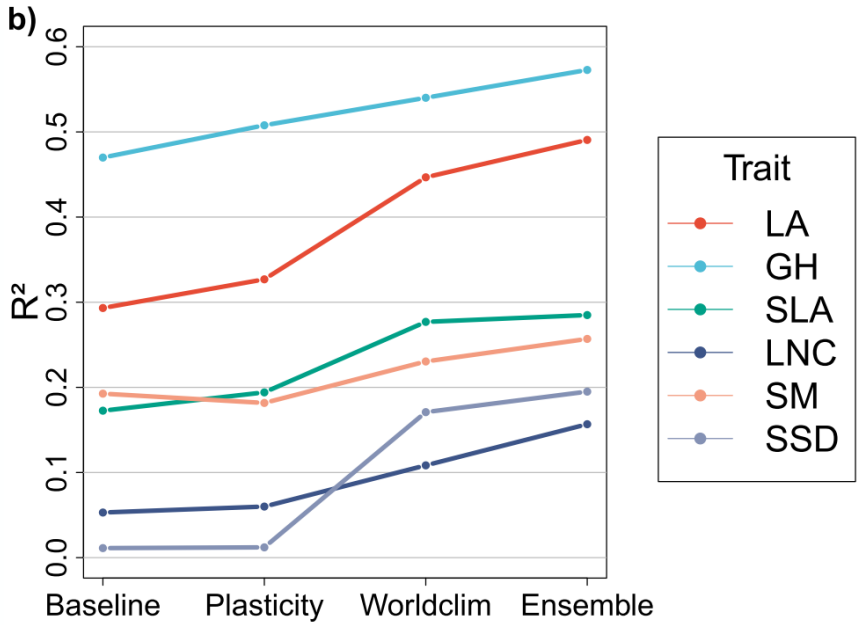
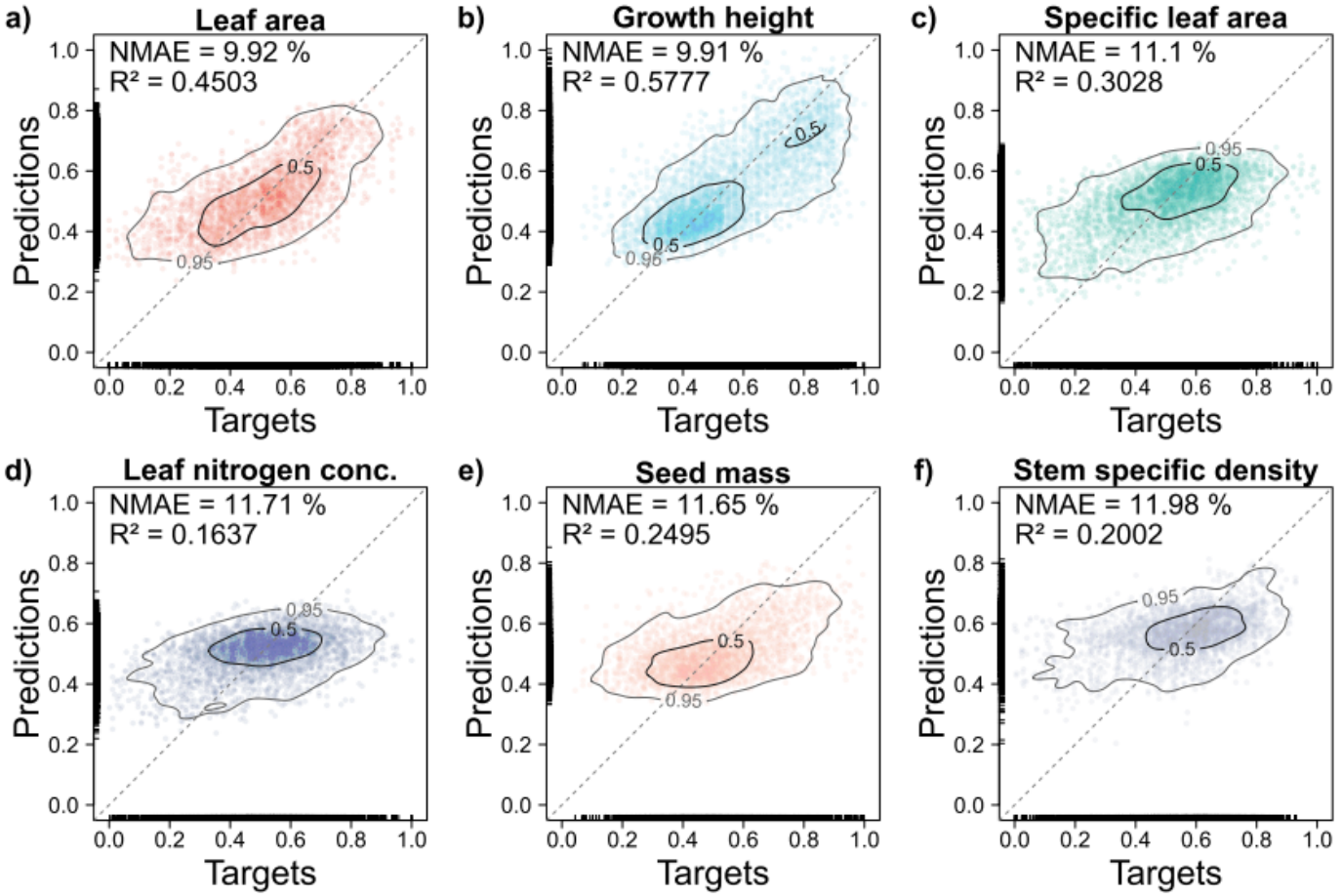
Leaf area = 23.2 cm²
Growth height = 23.7 cm
Specific Leaf Area = 70.2 cm²/mg
…

Leaf area = 12.6 cm²
Growth height = 31.1 cm
Specific Leaf Area = 87.8 cm²/mg
…

Leaf area = 3.9 cm²
Growth height = 6.3 cm
Specific Leaf Area = 45.1 cm²/mg
…





…but its just a weak validation.

Model Evaluation

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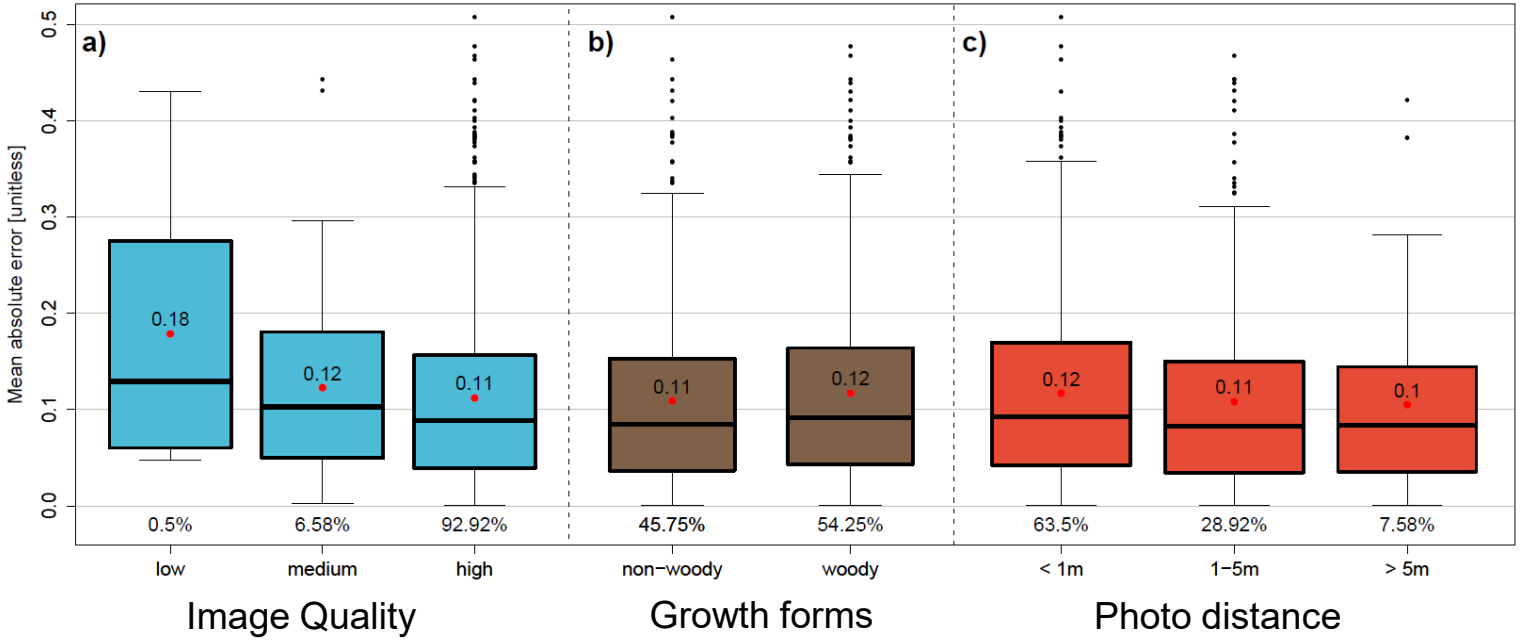
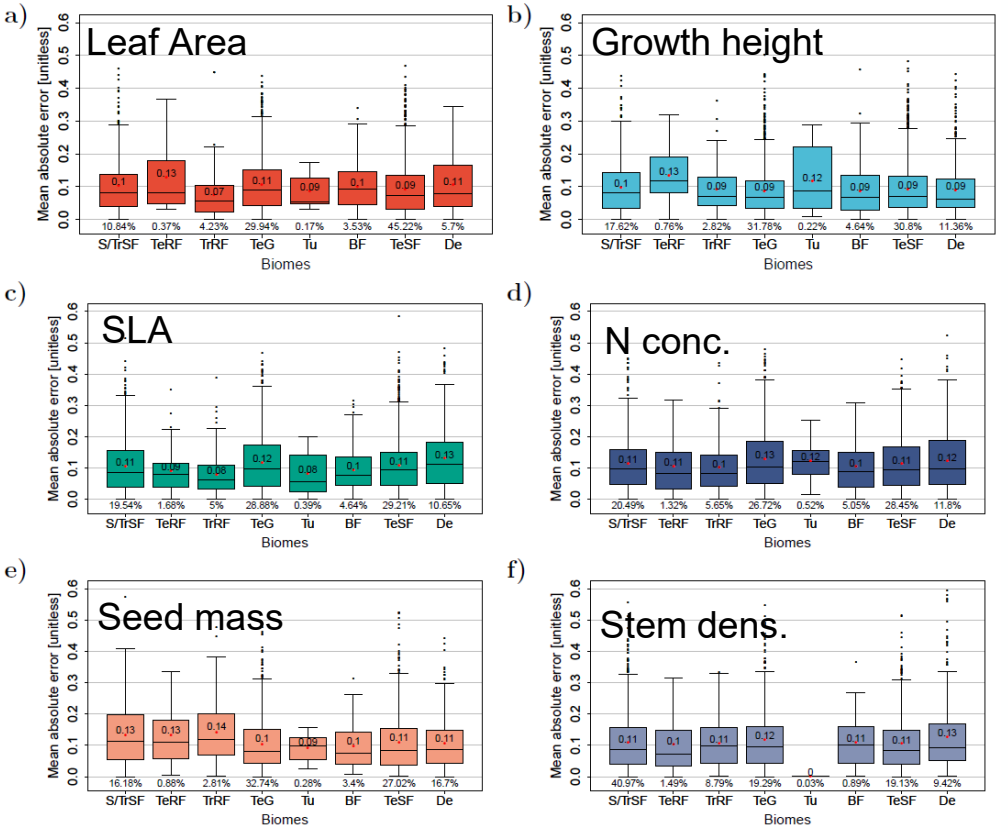
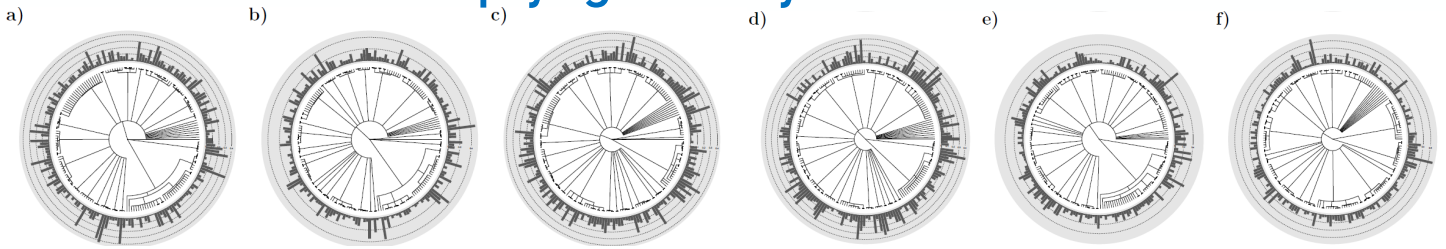
Generalization across image quality, growth form or image target distance...





Prediction errors are not phylogenetically autocorrelated.



...low bias across biomes indicates global generalization.

…from photos to global trait maps

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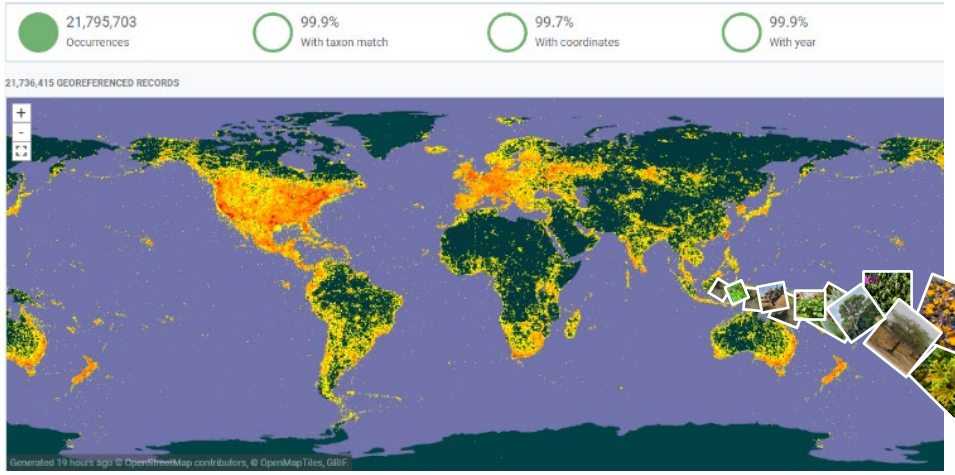
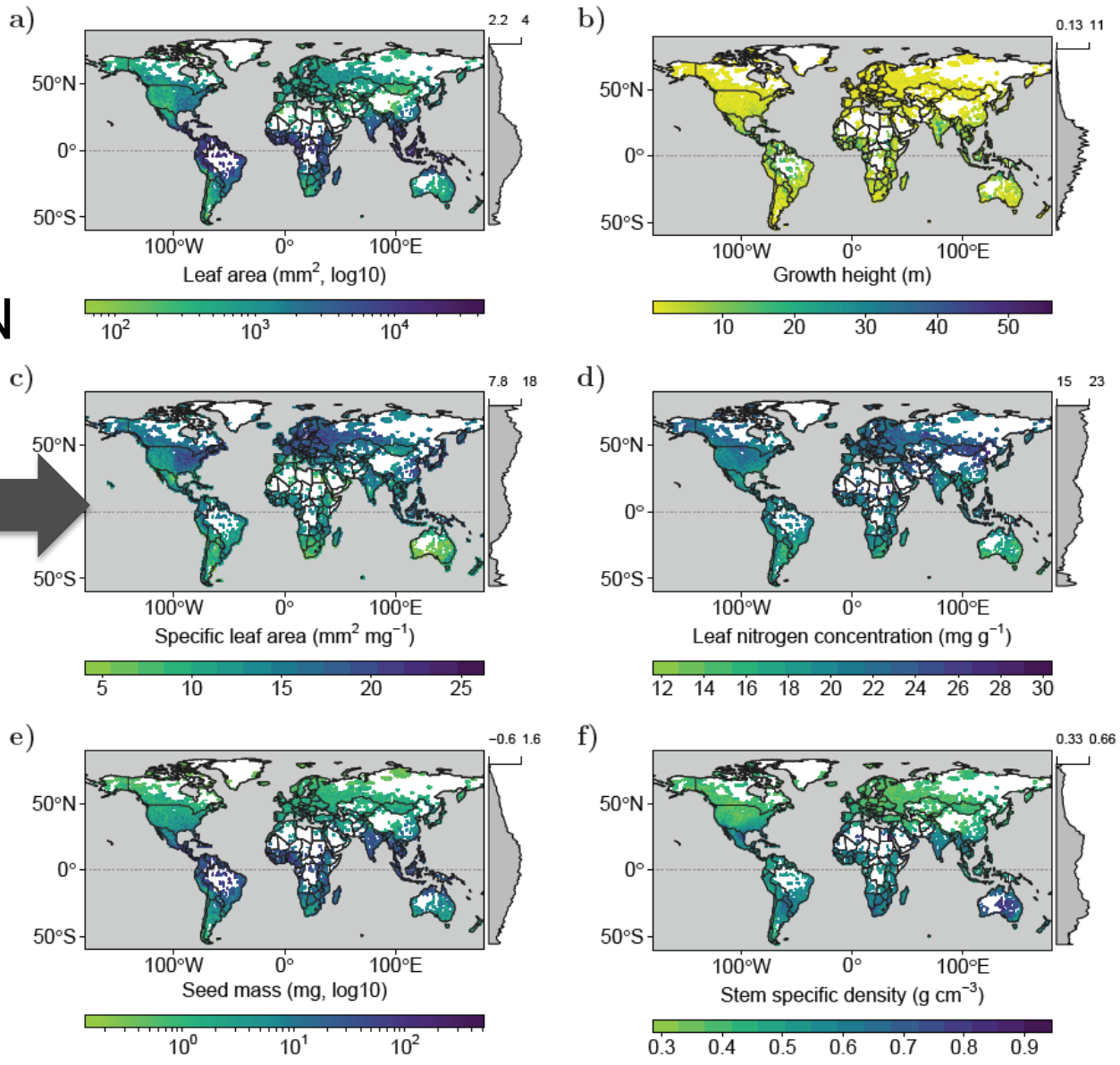
iNaturalist

Crowd-sourced plant photographs
+ lat/long + species name



Trained CNN Ensemble



Evaluation of global trait maps

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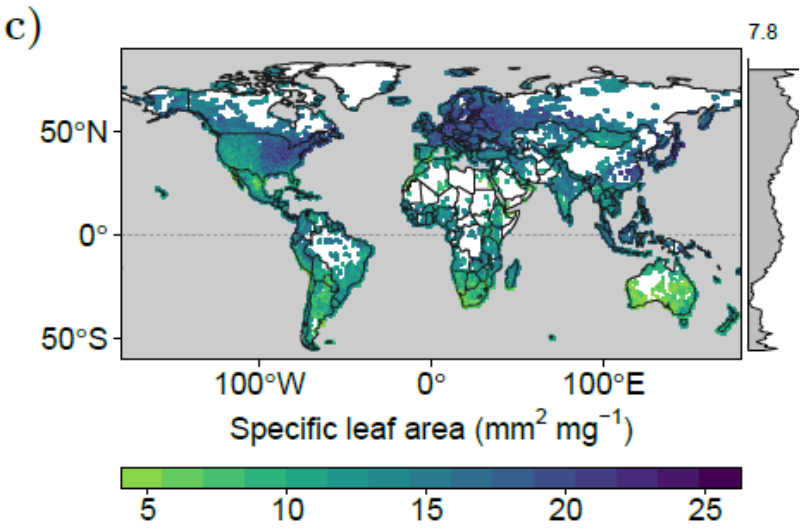
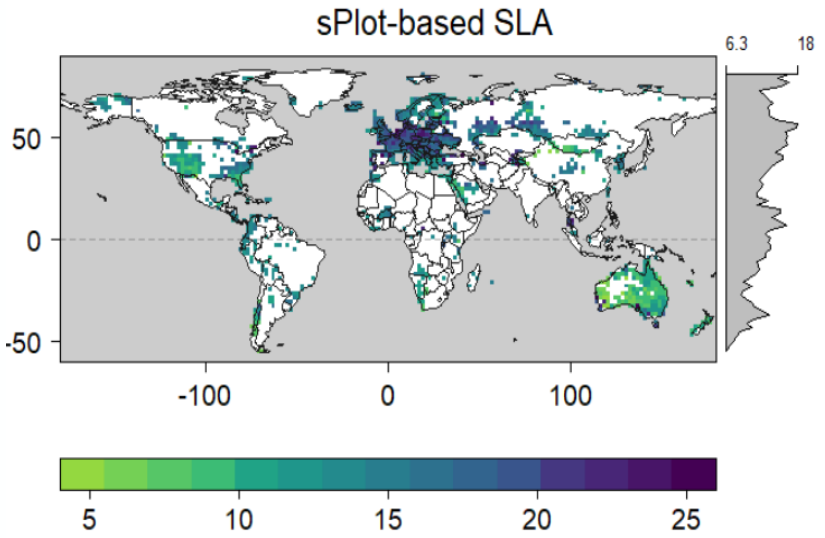
… can we really trust our trait products? (Schiller et al. 2021)

sPlot

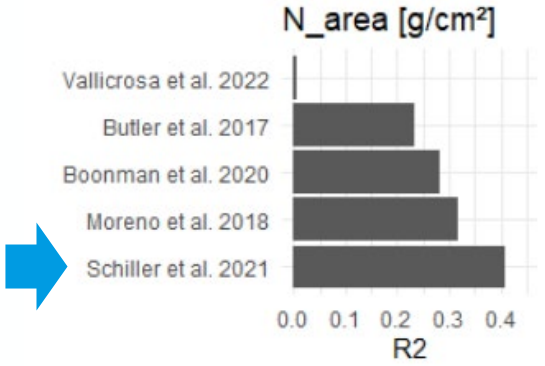
… community data of 95104 vegetation plots
… linked with trait data (TRY data)
→ Gridded trait community weighted mean

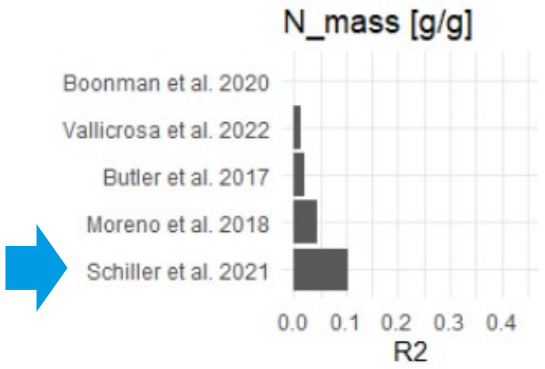


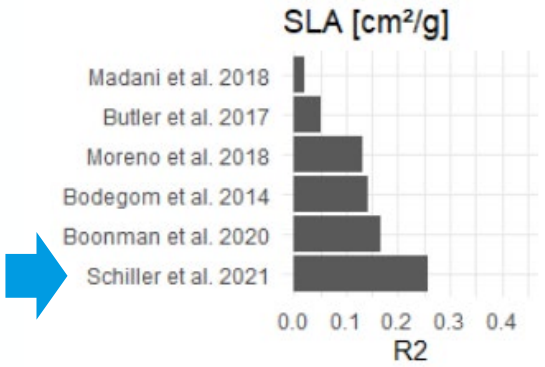
vs



Sabatin et al. 2021, *Biogeography*
Bruelheide et al. 2019, JVS.







…many thanks to Ben Dechant and the sTrait (iDiv) consortium!

Summary

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- **We can ‘see’ traits in (crowd-sourced) plant photographs**

  … Model performance increased with integrating trait variation, climate data, and model ensembles

- **Geocoordinates and excessive coverage (constantly increasing) enable global mapping**

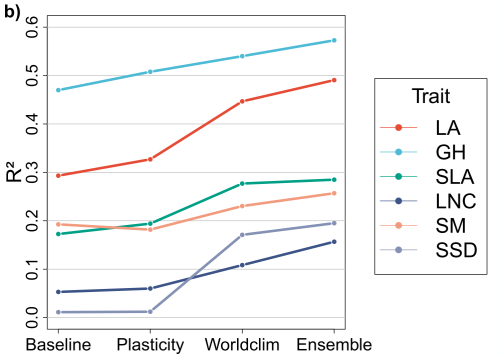
  … appears to be more accurate than previous maps based on extrapolation methods (according to sPlot data)

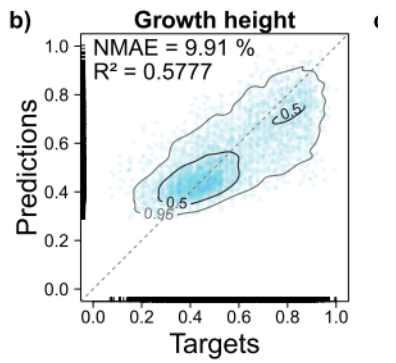
- **All resources are openly available:**

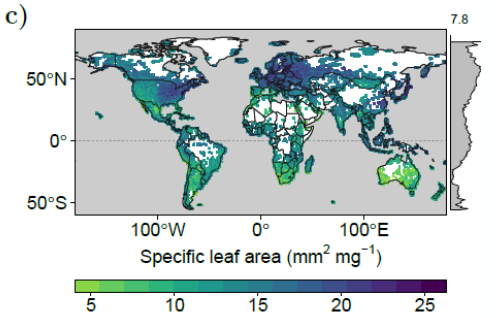
  … Code: github.com/ChrSchiller/cnn_traits

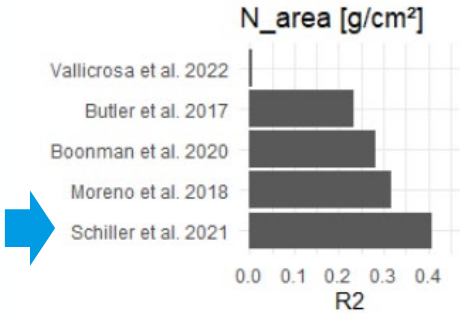
  … Trait maps: tinyurl.com/schiller-trait-maps

  … Manuscript: www.nature.com/articles/s41598-021-95616-0









Thank you!

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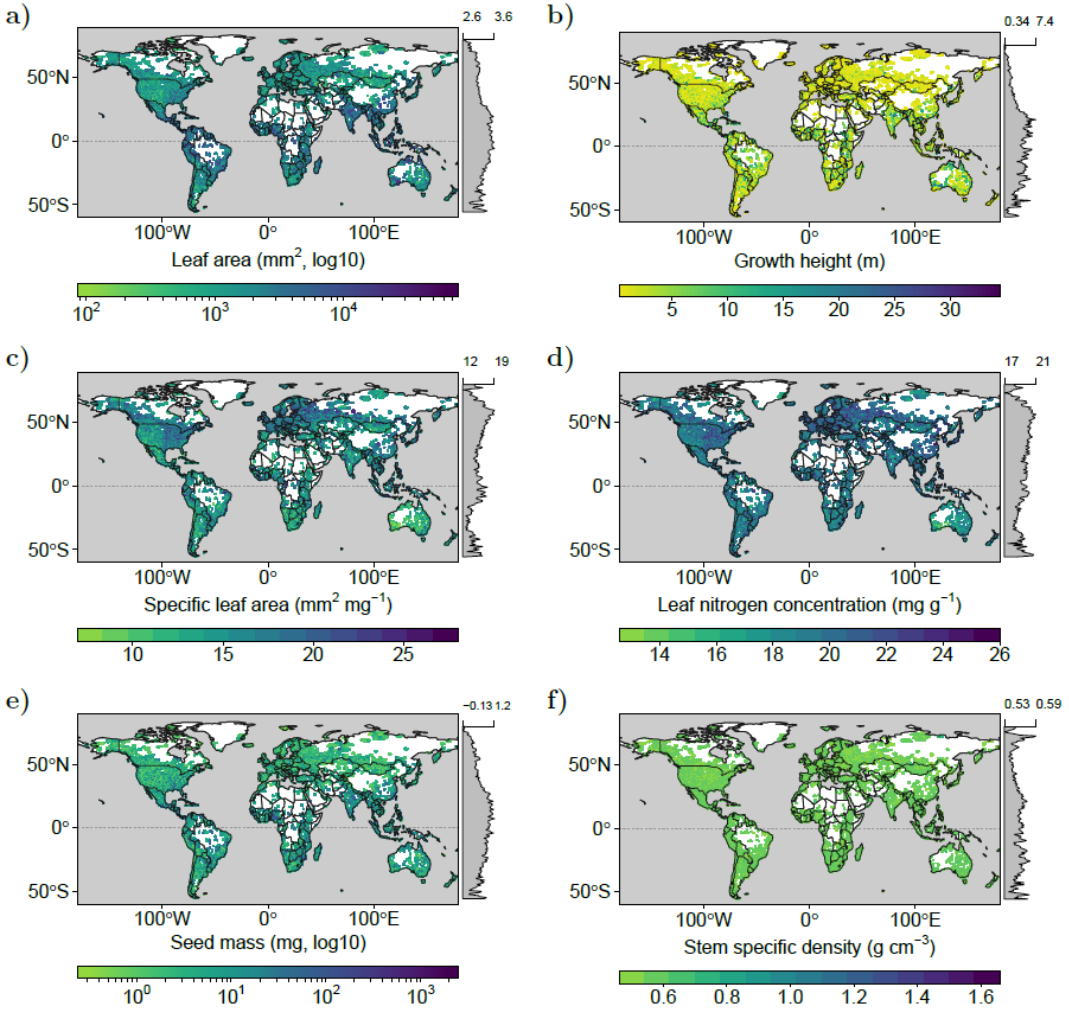
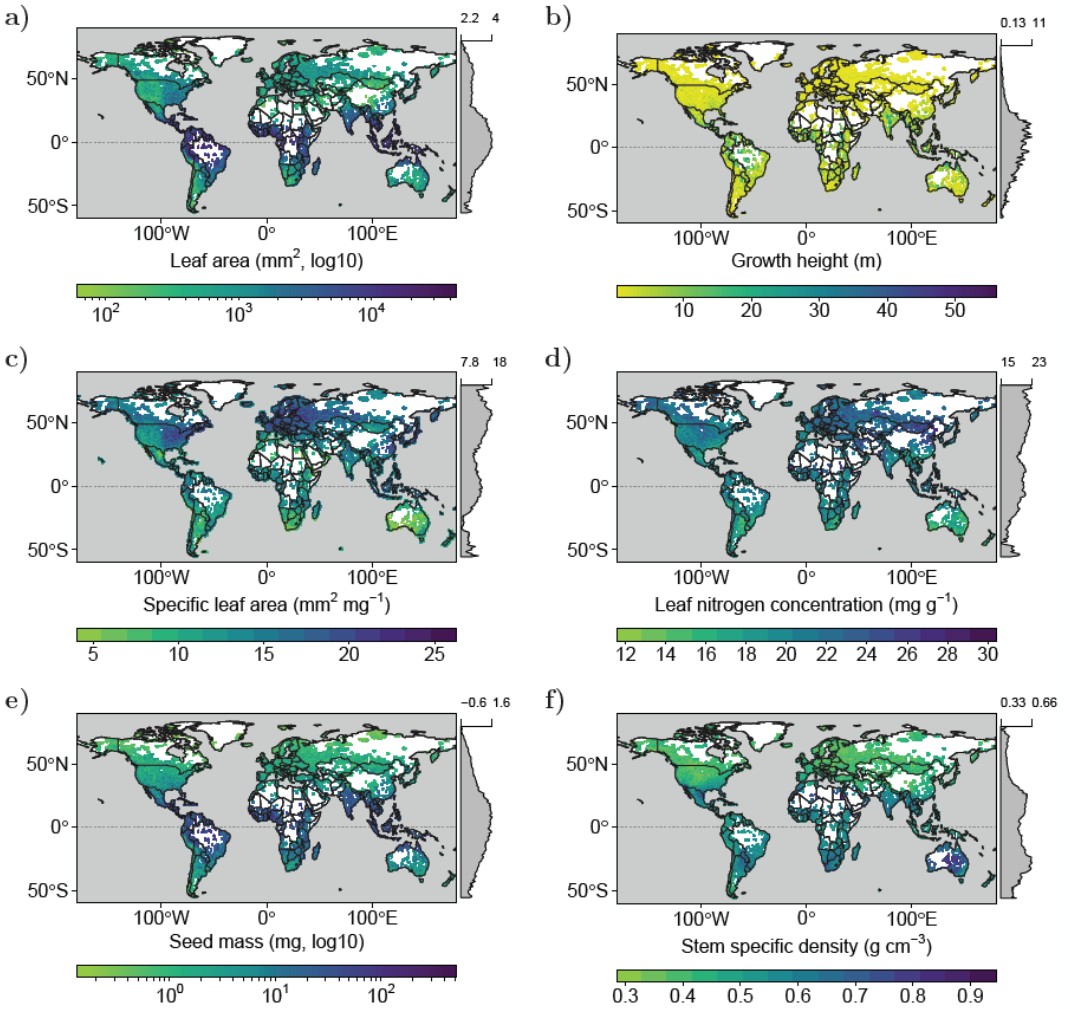
More interest in global trait maps?
Poster Sophie Wolf (A2.01 Biodiversity, today!)

…from photographs to global maps

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