Unlocking the Power of Crop Nutrient Data: Exploring Insights from the CPCN Database

Shai Sela, chief scientist, Agmatix

agmatix

agmatix™ At a Glance

Founded in 2021, Agmatix shapes the future of sustainable agriculture through data by digitizing field trails, standardizing field data and generating recommendations and models.

+50M

Field trials Measurements
The largest global standardized data set of field trials

100

Employees With Global Footprint
Top agronomy (17%), data scientist, and engineering talents (53%)

+1K

Agronomists On platform
Large community of agronomists and crop consultants

+20K

Farmers Supported
Impacting large scale and small holder farmers globally

15M

Acres covered globally
Wide geo location coverage including US, LATAM, Europe, Asia and Africa

60%

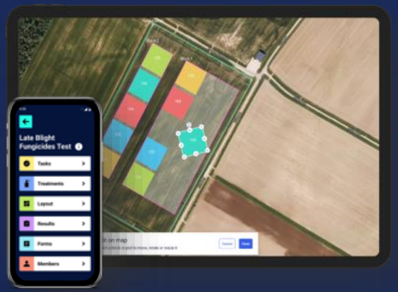
Of the leading ag Universities
Trusted by the leading Ag universities and scientists globally

Our Solutions

Translating data from field trials into crop nutrition plans and sustainable agriculture actions at field level

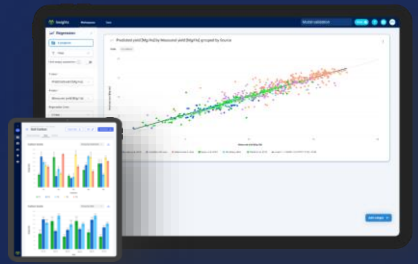
Agronomic Trial Management

Accelerate product development from trial operations to data collection



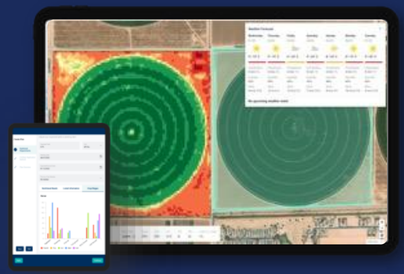
Insights & Models

Analyze big data for deeper insights and model visualizations



Digital Crop Advisor

Leverage big data insights for trusted field-level decision support



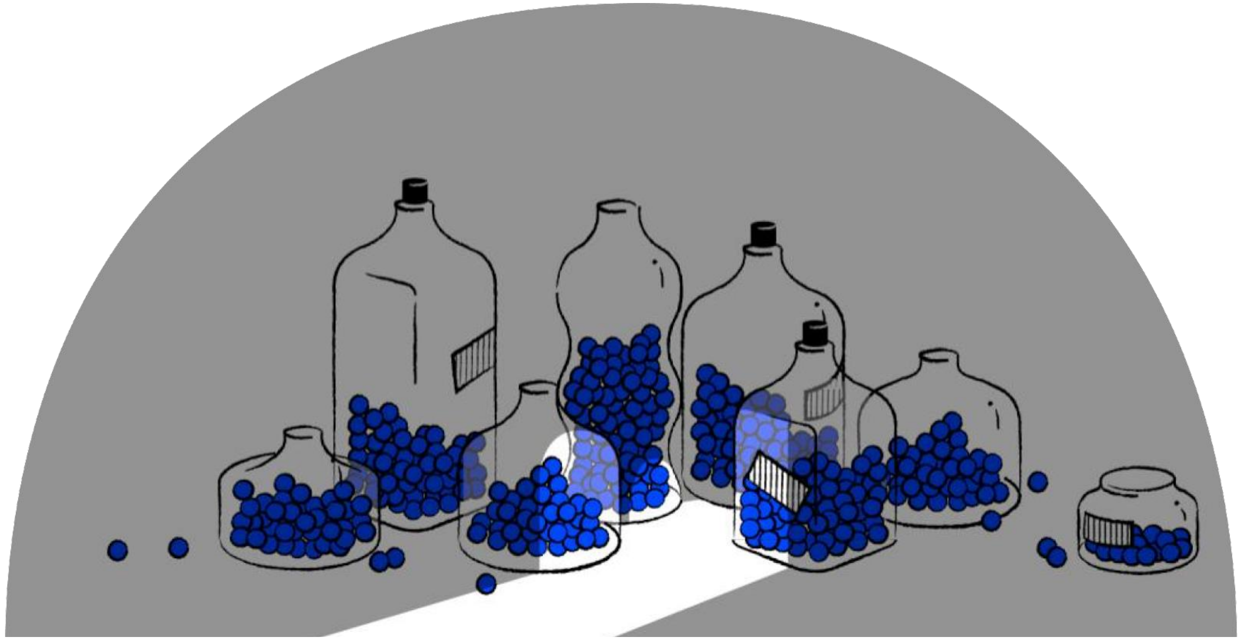
Sustainability Center

Industry-accepted scientifically based framework that defines sustainability at field-level

RegenIQ

Many high quality experimental research efforts are conducted world-wide

- Data collected using a variety of methods
- A lack of unified standardization & protocols
- significant amount of valid data are eventually not used
- Limited collaboration opportunities
- Limited ability to uncover new insights



Data Standardization challenge:
Researchers tend to save data in ways understandable to them

Calculated using function derived from experiments

VG parameters

Calculated using clay and sand %

BD – calculated using porosity estimated using a function

Correction for rock percent

correcting for aspect

P	O	N	M	L	K	J	I	H	G	F	E	D	B	A	
KsSoilShmuelExperiment	nSoil	AlphaSoil	tetaS	tetaR	porositySaxston	BulkDens	SiltPer	SandPer	ClayPer	RF2011	RadRatio2	Depth	CellNumber	Id	1
3.269329	1.660313848	0.010408961	0.483191543	0.03701466	0.483191543	1.369542412	54.8045	24.1894	21.0061	1.018099548	1.07985	27.2135	6376	1	2
3.194881	1.638108983	0.010586677	0.485538131	0.036846593	0.485538131	1.363323953	54.9404	23.3767	21.6829	1.289398281	1.1721	7.21862	5357	2	3
3.378933	1.683548637	0.010226583	0.480729943	0.037190964	0.480729943	1.376065651	56.12	23.8703	20.0097	1.004464286	1.03354	15.1096	6304	3	4
3.431777	1.718598051	0.009958233	0.477004865	0.03745776	0.477004865	1.385937108	53.3203	27.1504	19.5293	1.227830832	1.05518	13.5197	4473	4	5
3.163157	1.631339504	0.010641532	0.486252367	0.036795439	0.486252367	1.361431229	54.6272	23.4015	21.9713	1.066350711	1.02822	8.82848	3789	5	6
2.93087	1.578805414	0.01107822	0.491776529	0.036399789	0.491776529	1.346792199	53.1205	22.7965	24.083	1.005586592	1.07745	11.3035	3629	6	7
3.034292	1.586418772	0.011013709	0.490978016	0.03645698	0.490978016	1.348908257	56.0029	20.8543	23.1428	1.156812339	0.987323	5.72725	3256	7	8
2.997354	1.578536279	0.011080508	0.491804743	0.036397768	0.491804743	1.34671743	55.7063	20.8151	23.4786	1.055099648	1.01507	14.2521	2866	8	9
3.135822	1.610382673	0.010813381	0.488460031	0.036637322	0.488460031	1.355580918	56.5638	21.2164	22.2198	1.010452962	1.01526	10.8259	2561	9	10
3.158537	1.616336748	0.010764243	0.487833341	0.036682207	0.487833341	1.357241646	56.6196	21.3671	22.0133	1.012373453	1.01754	10.1643	2633	10	11
2.917692	1.565900433	0.011188535	0.493128428	0.036302964	0.493128428	1.343209665	54.4859	21.3113	24.2028	1.030927835	1.035	13.9504	3243	11	12
2.90722	1.559202108	0.011246277	0.493829327	0.036252764	0.493829327	1.341352282	55.0573	20.6447	24.298	1.2482066	0.936226	11.3365	3185	12	13
3.281044	1.652923119	0.010467738	0.483973231	0.036958674	0.483973231	1.367470939	56.3775	22.7229	20.8996	1.098901099	0.990597	17.0152	1781	13	14
3.208796	1.632110128	0.010635271	0.486171087	0.03680126	0.486171087	1.36164662	56.387	22.0566	21.5564	1.118012422	1.00267	15.7019	1640	14	15

An excerpt from Shai's PhD work. If I give this file to you, it will be challenging for you to understand it

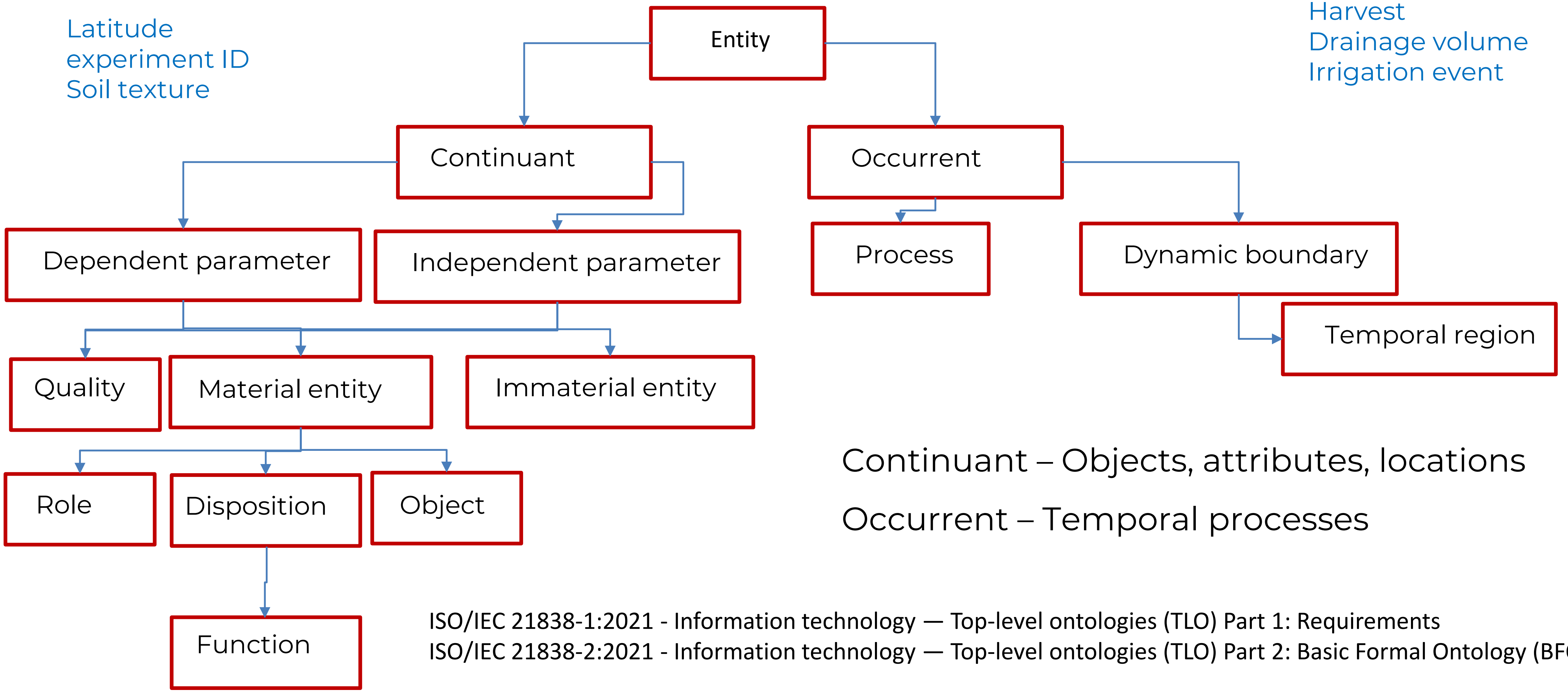
Basic Formal Ontology

An ontology is a description of things, relationships, and their characteristics, usually in a well-bounded domain

(Powell and Hopkins, 2015)

Latitude
experiment ID
Soil texture

Harvest
Drainage volume
Irrigation event



Continuant – Objects, attributes, locations

Occurrent – Temporal processes

ISO/IEC 21838-1:2021 - Information technology — Top-level ontologies (TLO) Part 1: Requirements
ISO/IEC 21838-2:2021 - Information technology — Top-level ontologies (TLO) Part 2: Basic Formal Ontology (BFO)

No standards for Ag ontolgy content

AGROVOC - https://www.fao.org/agrovoc/

Ontology for Biomedical Investigations (OBI)- https://obi-ontology.org/

Crop Ontology - https://cropontology.org/

Plant Ontology (PO) - https://www.plantontology.org/

Agro Ontology - https://bigdata.cgiar.org/resources/agronomy-ontology/

Relation Ontology - https://oborel.github.io/

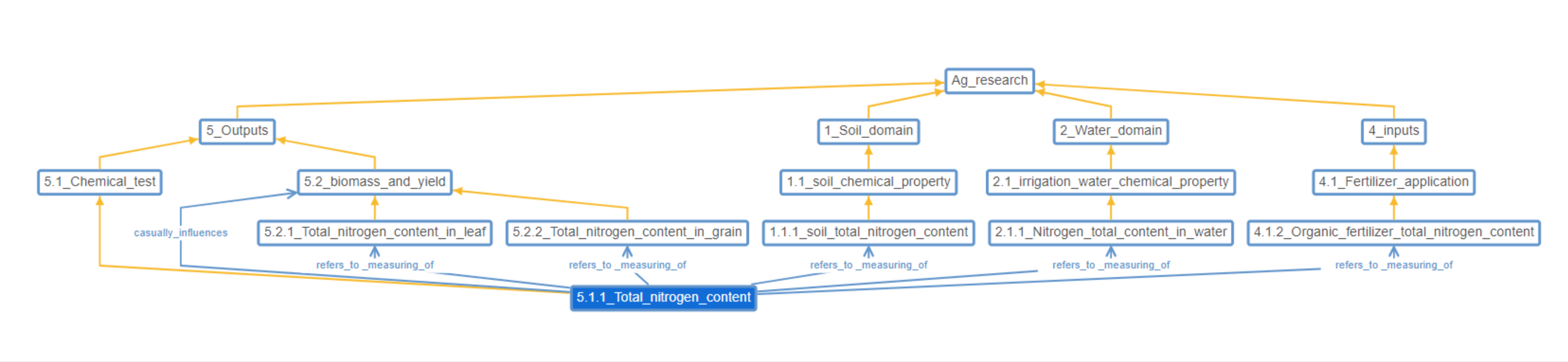
Environment Ontology - https://sites.google.com/site/environmentontology/

Chemical methods ontology - https://github.com/rsc-ontologies/rsc-cmo

Ontology search engine : https://ontobee.org/

Current agronomic ontologies are limited in scope, and fragmented

Growers Universal Agronomic Research Data Standard (GUARDS)



The GUARDS ontology library covers 40k concepts, and covers 9 domains:

1. **Research Definitions**
2. **Soil**
3. **Water**
4. **Inputs and Explanatory Parameters**
5. **Climate**
6. **Enriched/Unique Features**
7. **Sampling Protocols**
8. **Measurement Units**
9. **Outputs**

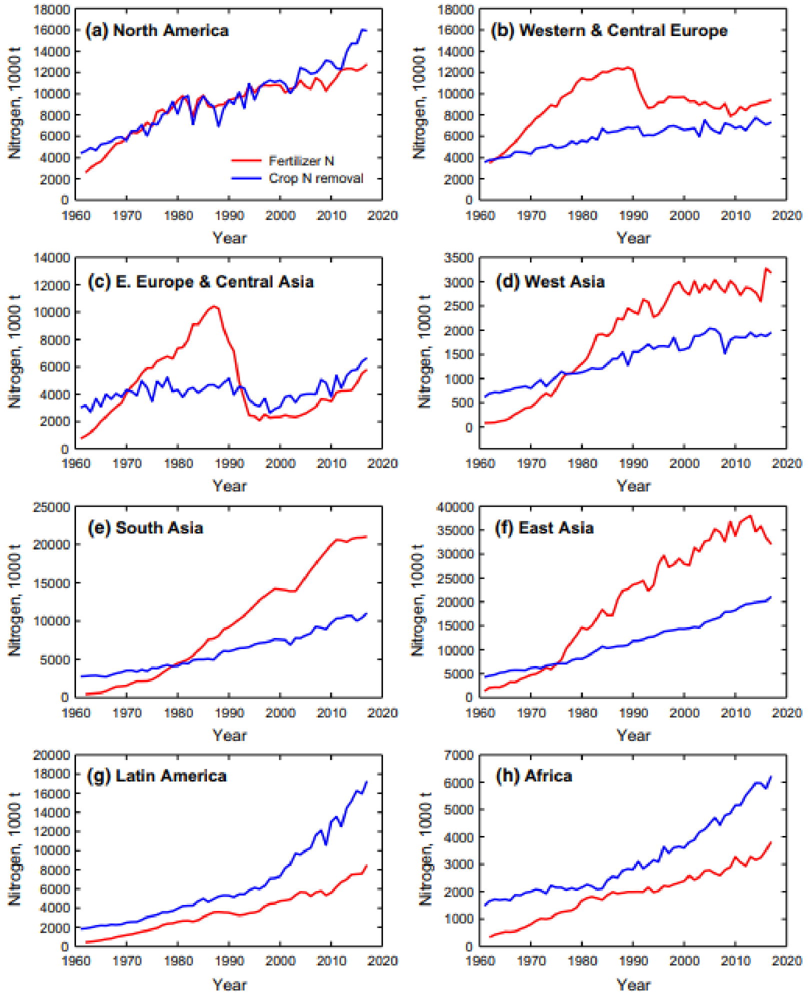
Agmatix has developed ontology matching algorithms that enable data unification at scale (patent pending)

There is a need to understand the factors affecting the nutrient use in different spatial scales

- Better understanding of the factors affecting nutrients inputs and crop uptake
- Optimization of resources, nutrients efficiencies and farmers ROI
- Reduction of environmental pollution

There is a need for a high quality, standardized global databases

Fertilizer N and crop N removal trends



Cassman and Dobermann (2021), *Ambio*

Establishment of the CPCN

The Consortium for Precision Crop Nutrition (CPCN) was established in 2020

CPCN aims to provide a platform that facilitates and stimulates collaboration through open exchange of information, data, algorithms, and ideas to accelerate the development and rapid dissemination of digital crop nutrition advisory tools.

- 34 Members:

Research/Education Institution or University 12
Private Sector Company 10
Association / International or National Organization 5
Startup / Small Enterprise 3
NGO / Not-for-Profit 1
Research / Education 3

- Three large datasets are under development:
  - GCNRD - Global Crop Nutrient Removal Database
  - NOT – Nutrient Omission Trials
  - IPI – International Potash Institute

https://www.precisioncropnutrition.net/

Coordinating partners:

CPCN data

- 17k trials
- 300 different projects
- 35 countries
- 400 users

https://www.precisioncropnutrition.net/

The GCNRD database on the insights tool

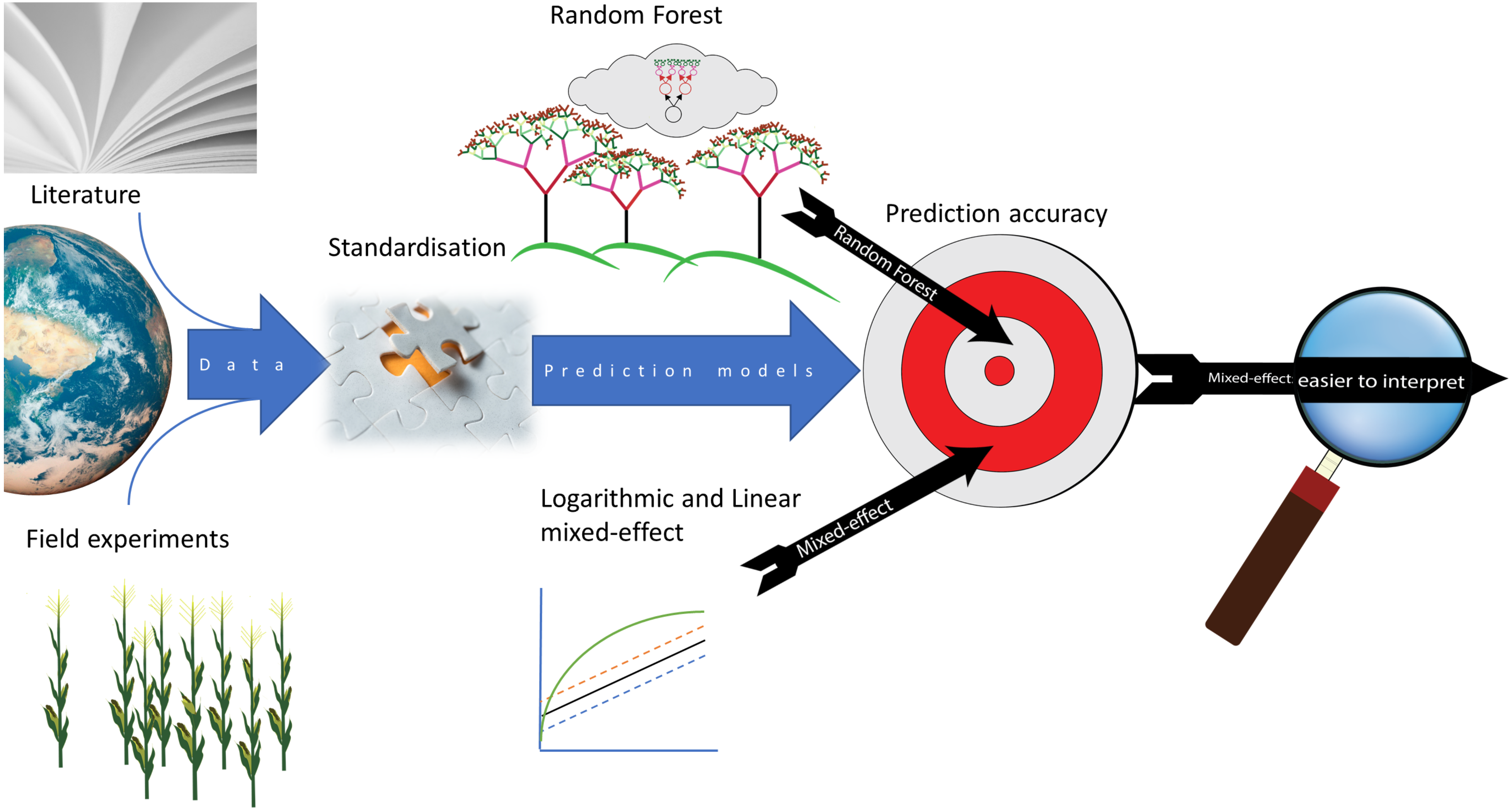
From data to insights

As part of Global Crop Nutrient Removal project funded by International Fertilizer Association:

Cameron Ludemann[1],Marloes van Loon[1], Renske Hijbeek[1], Martin van Ittersum[1], Scott Murrell[2] and Achim Dobermann[3]

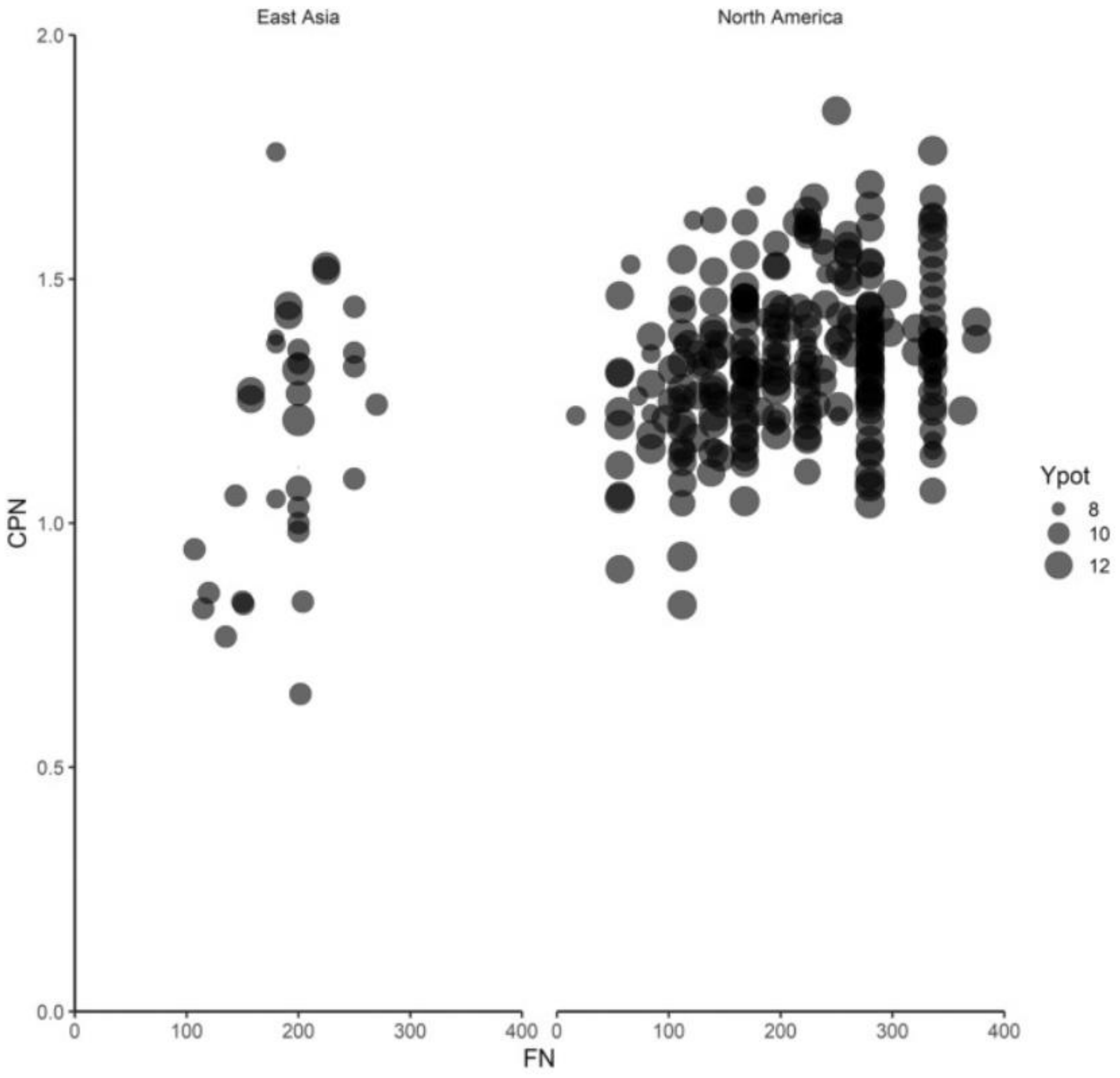
[1]Wageningen University & Research, Netherlands
[2] African Plant Nutrition Institute, Morocco
[1]International Fertilizer Association, France

From data to insights



Ludemann et al (2022) Field Crops Research
https://doi.org/10.1016/j.fcr.2022.108578

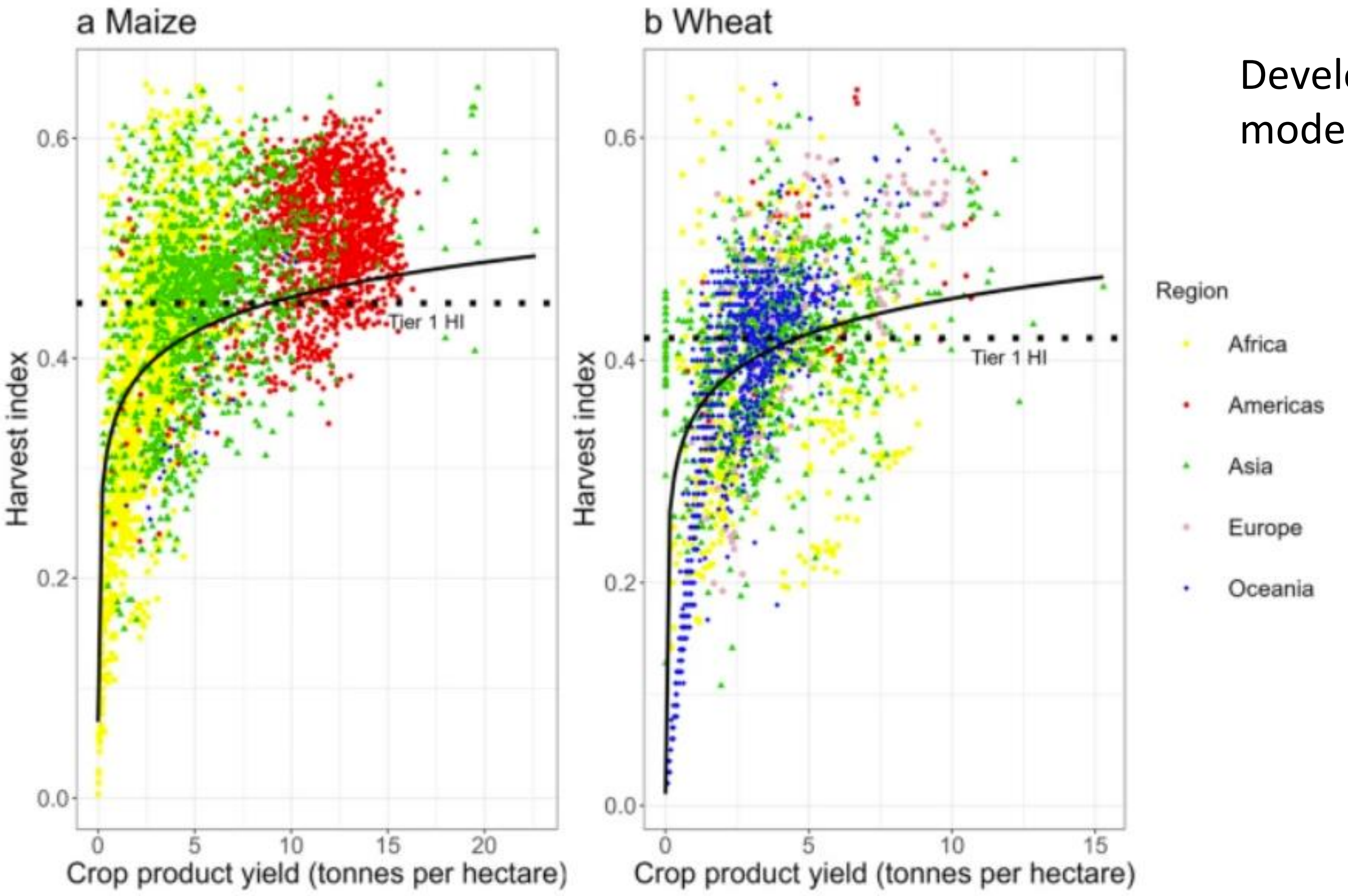
Can we assess relationships among different predictor variables?



e.g. between fertilizer nitrogen application (FN), crop product nitrogen concentration (CPN) and yield potential (Ypot)

Ludemann et al (2022) Field Crops Research
https://doi.org/10.1016/j.fcr.2022.108578

Relating harvest index and yield

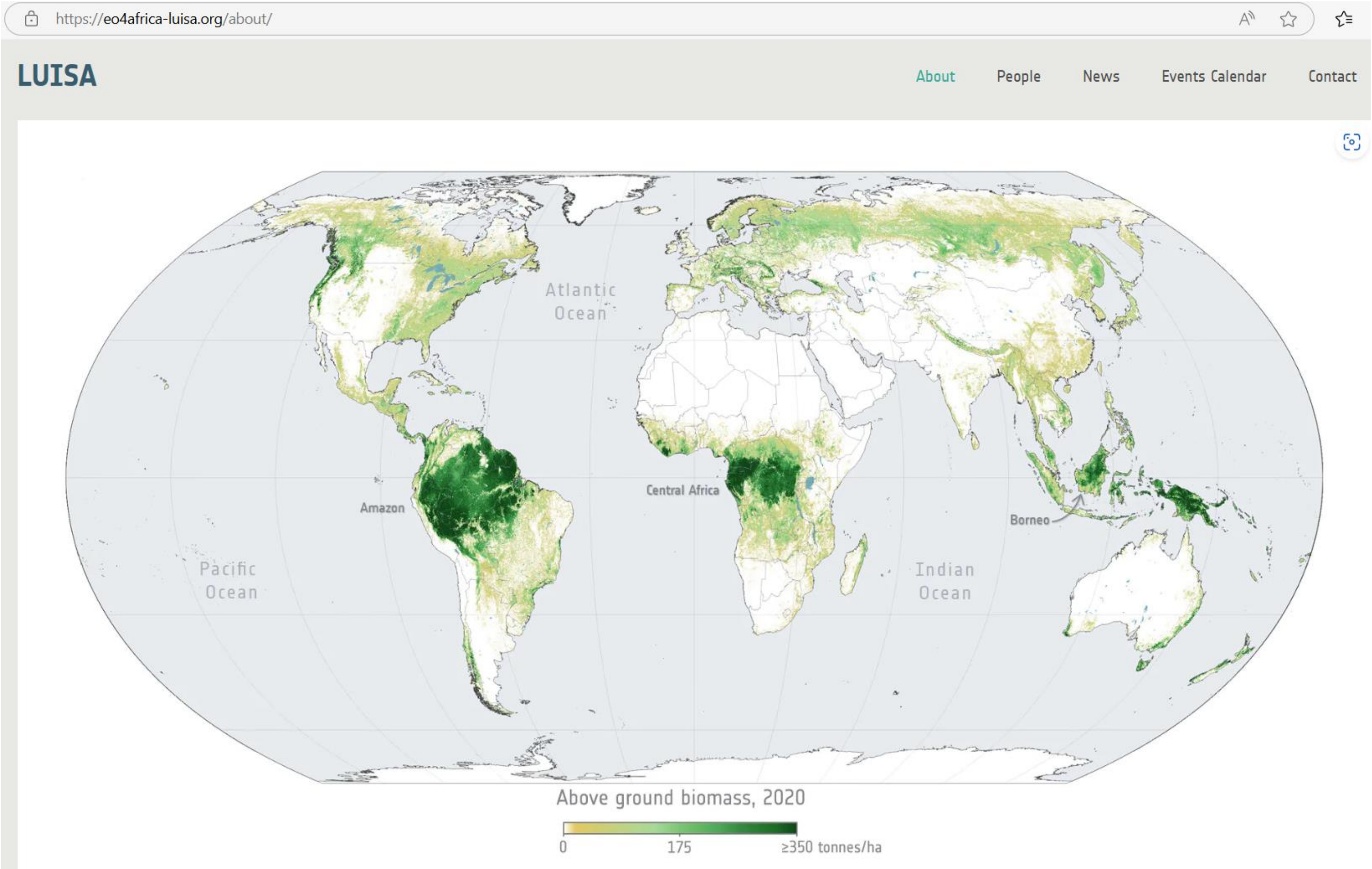


Developed improved prediction models for harvest index

Ludemann et al (2025) Nutrient Cycling in Agroecosystems
https://doi.org/10.1007/s10705-024-10381-6

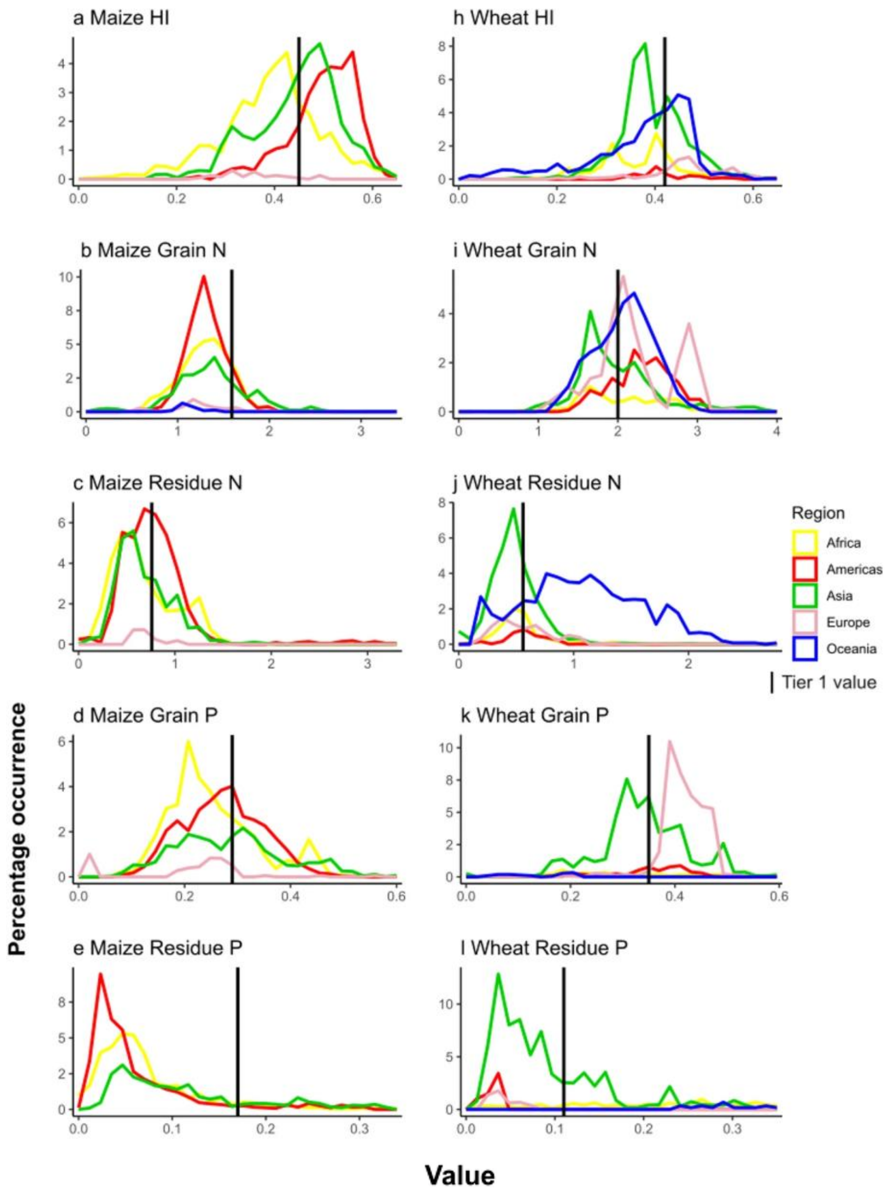
Above ground biomass predictions

Harvest index models developed using www.cropnutrientdata.net data used to turn satellite data for above ground biomass into estimates of crop product yield



Work is still in progress

Global data versus regional variations



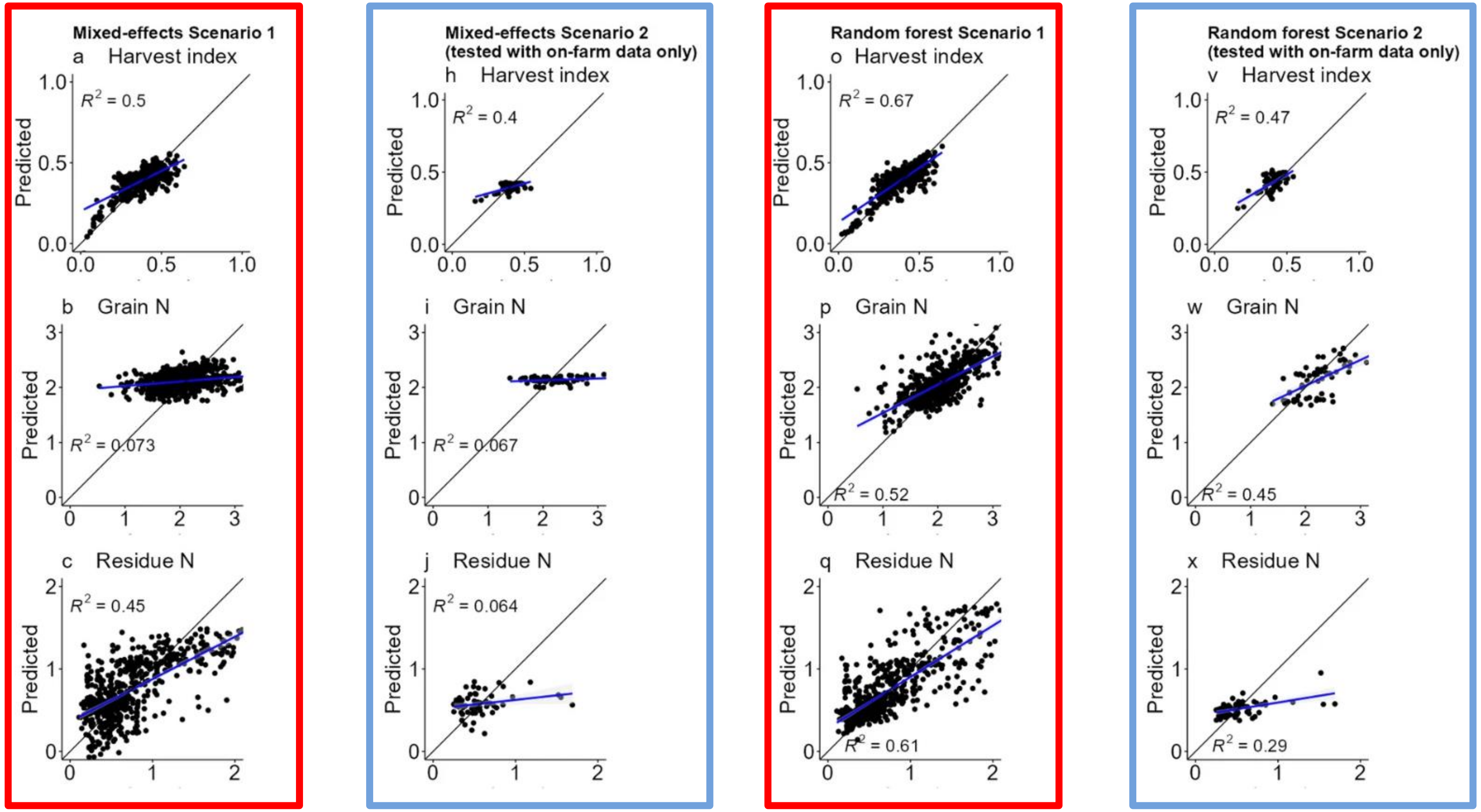
(Potassium results not included in this slide for brevity)

- Currently the FAO Cropland Nutrient Budget uses Tier 1 (world average) nutrient concentration values for crop nutrient removal (see black vertical lines).

- Collated data from experiments and on-farm allowed us to quantify the variation in values across the world (see coloured lines)

Ludemann et al (2025) Nutrient Cycling in Agroecosystems
https://doi.org/10.1007/s10705-024-10381-6

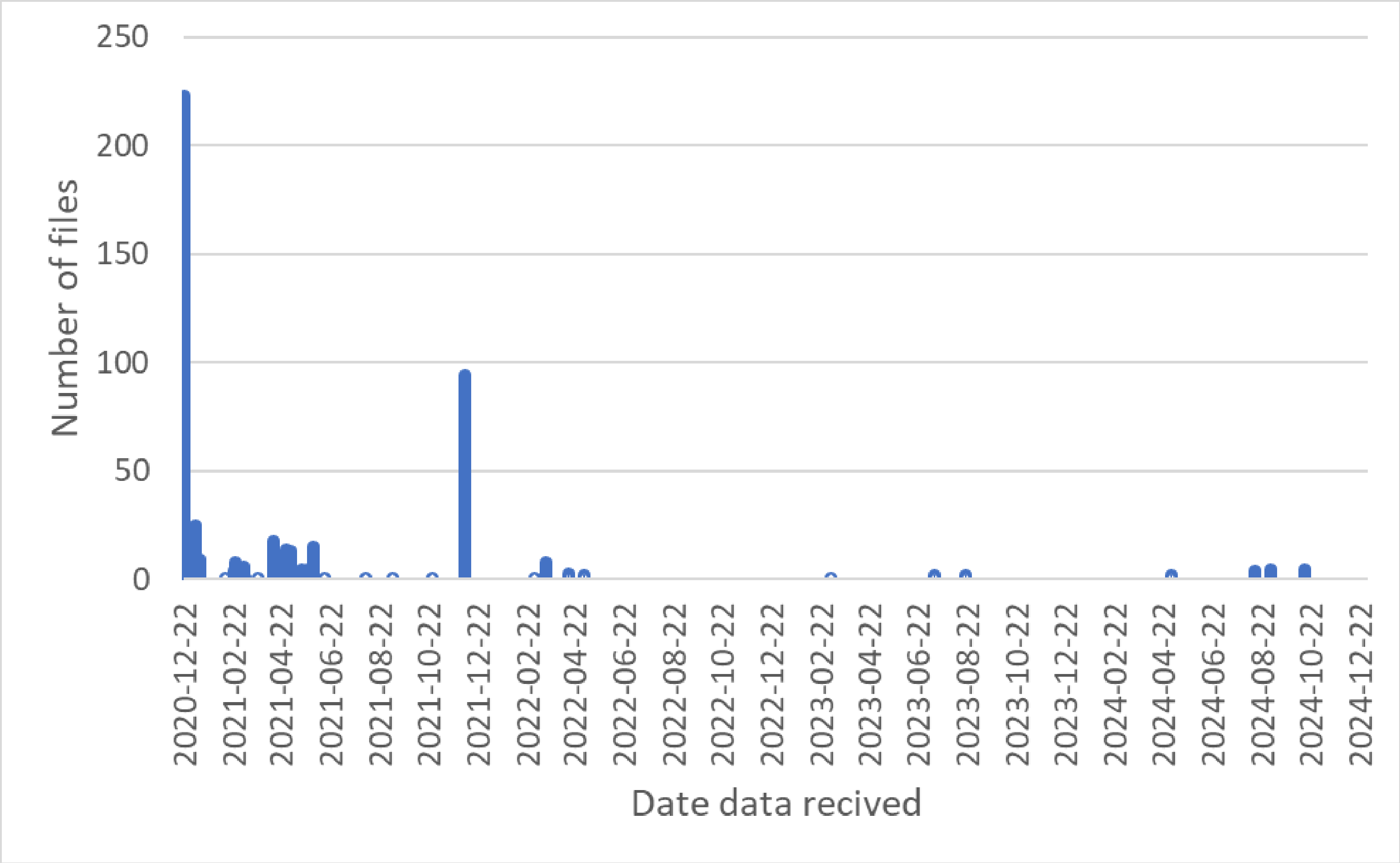
Model predictions using ML



- Mixed-effects and random forest models (usually) gave reasonable prediction accuracies when applied to replicated field experiment data (outlined red)
- But the models did not perform well when applied to an independent set of data from on-farm (outlined blue)
- Highlights need for collecting more on-farm data so values used in tools like the FAO Cropland Nutrient Budget better reflect what happens in the real world.

Ludemann et al (2025) Nutrient Cycling in Agroecosystems https://doi.org/10.1007/s10705-024-10381-6

Data contributions to the CPCN are declining over time



At the same time, there are many new databases published (some examples in the next slides)

FRST – extensive trial data used to create fertilizer recommendations

Agricultural & Environmental Letters OPEN ACCESS

ASA American Society of Agronomy | CSSA Crop Science Society of America | SSSA Soil Science Society of America

RESEARCH LETTER | Open Access

Development of a soil test correlation and calibration database for the USA

Sarah E. Lyons, Dan K. Arthur, Nathan A. Slaton, Austin W. Pearce, John T. Spargo, Deanna L. Osmond, Peter J. A. Kleinman

First published: 14 December 2021 | https://doi.org/10.1002/ael2.20058 | Citations: 9

1,295 trials from 1949 to 2018, representing 17 crops

https://soiltestfrst.org/

FAO nutrient budgets

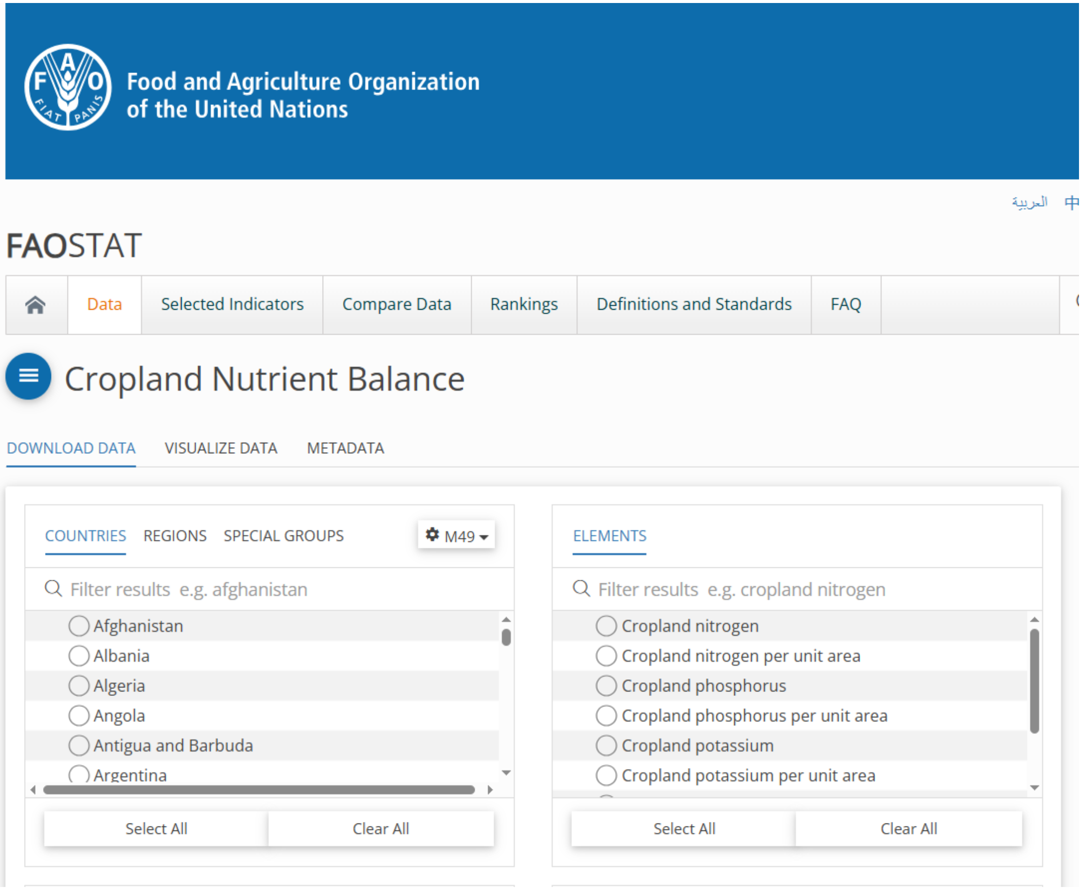
Earth Syst. Sci. Data, 16, 525–541, 2024
https://doi.org/10.5194/essd-16-525-2024

Open Access Earth System Science Data

A global FAOSTAT reference database of cropland nutrient budgets and nutrient use efficiency (1961–2020): nitrogen, phosphorus and potassium

Cameron I. Ludemann[1], Nathan Wanner[2], Pauline Chivenge[3,a], Achim Dobermann[4], Rasmus Einarsson[5], Patricio Grassini[6], Armelle Gruere[4], Kevin Jackson[7], Luis Lassaletta[8,9], Federico Maggi[10], Griffiths Obli-Laryea[2], Martin K. van Ittersum[1], Srishti Vishwakarma[7,b], Xin Zhang[7], and Francesco N. Tubiello[2]

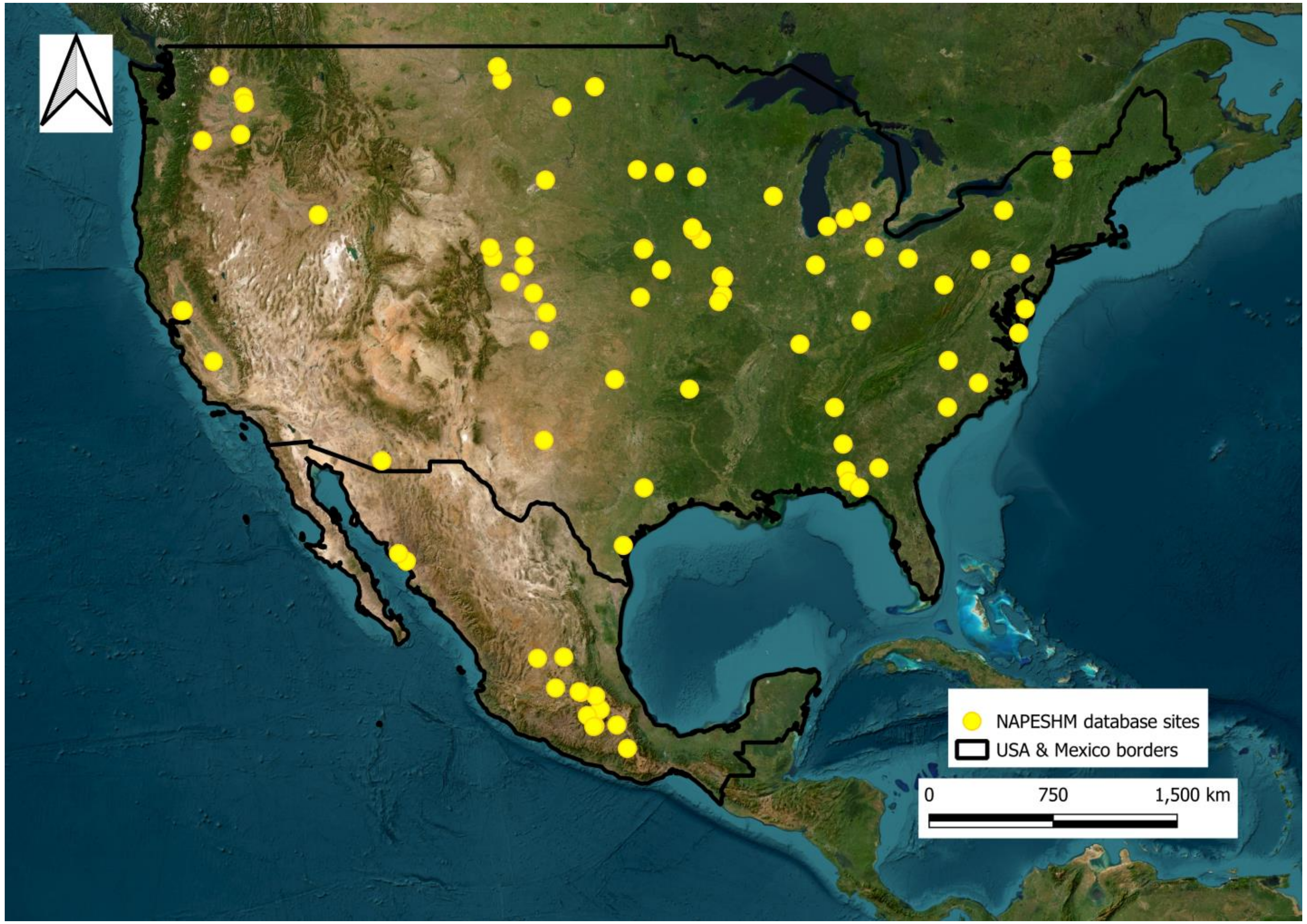
https://www.fao.org/faostat/en/#data/ESB



The North American Project to Evaluate Soil Health Measurements (NAPESHM)

~100 long term experiments testing the effect of different factors, such as tillage, rotation and others on soil health indicators

The database is presented in Norris et al. 2020, Agronomy Journal.



The database is publicly available

https://agdatacommons.nal.usda.gov/articles/dataset/North_American_Project_to_Evaluate_Soil_Health_Measurements_Dataset/25632270?file=46794877

SHAPE – The Soil Health Assessment Protocol and Evaluation tool

Soil Science Society of America Journal

SSSA
Soil Science Society of America

ORIGINAL ARTICLE | Open Access

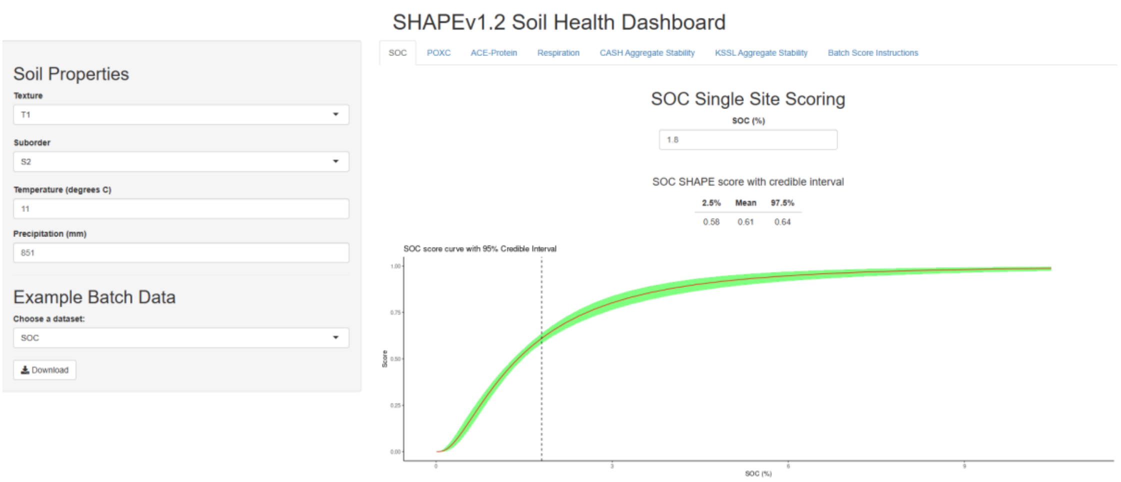
SHAPEv1.0 Scoring curves and peer group benchmarks for dynamic soil health indicators

Márcio R. Nunes, Kristen S. Veum, Paul A. Parker, Scott H. Holan, Joseph P. Amsili, Harold M. van Es, Skye A. Wills, Cathy A. Seybold, Douglas L. Karlen

First published: 11 April 2024 | https://doi.org/10.1002/saj2.20668 | Citations: 4

R shiny dashboard allows easy querying

https://paparker.shinyapps.io/shape_app/



SHAPE – The Soil Health Assessment Protocol and Evaluation tool – a spatial version

Soil Science Society of America Journal

SSSA
Soil Science Society of America

ORIGINAL ARTICLE | Open Access

Spatially explicit heteroskedastic modeling for the Soil Health Assessment Protocol and Evaluation version 1.0S

Kristen S. Veum, Paul A. Parker, Scott H. Holan, Namitha V. Pais, Skye A. Wills, Joseph P. Amsili, Márcio R. Nunes, Harold M. van Es, Cathy A. Seybold, Douglas L. Karlen

First published: 04 May 2025 | https://doi.org/10.1002/saj2.70065

Summary

- The CPCN enables the development of public databases
- Proved the potential that researchers can leverage public databases to generate new scientific insights
- CPCN data enables the use of regional averages instead of global ones
- It is important to collect different types of data, including on-farm data
- How can we increase the rate of data contribution to the CPCN?
- How can we bring in new databases?
- Thank you for your time.
- Happy to discuss and answer any questions – sela.shai@agmatix.com