The National Academies of SCIENCES ENGINEERING MEDICINE

Exploring a Dynamic Soil Information System: A Workshop

A Virtual Workshop

Introductory remarks

Bruno Basso

March 2nd, 2020

Planning Committee

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Thank you to the Workshop Sponsors

- National Academy of Sciences’ Arthur L. Day Fund
- National Corn Growers Association
- National Science Foundation
- The Nature Conservancy
- U.S. Department of Agriculture, National Institute of Food and Agriculture
- U.S. Department of Agriculture, Natural Resources Conservation Service
- U.S. Department of Energy, Advanced Research Projects Agency–Energy

Some of the questions we want to address:

- What should we measure?
- Why should we measure it?
- Where should we measure it?
- When and how frequently do we measure?
- What can’t we measure well?
- How accurate do we have to be?
- How can we best harmonize data?
- How do we measure it?
- How do we store the sample/data
- How do we retrieve the information
- How do we deliver the data/information
- When we can’t measure, what proxies can we use?
- What can we model well?
- What can we not model well?

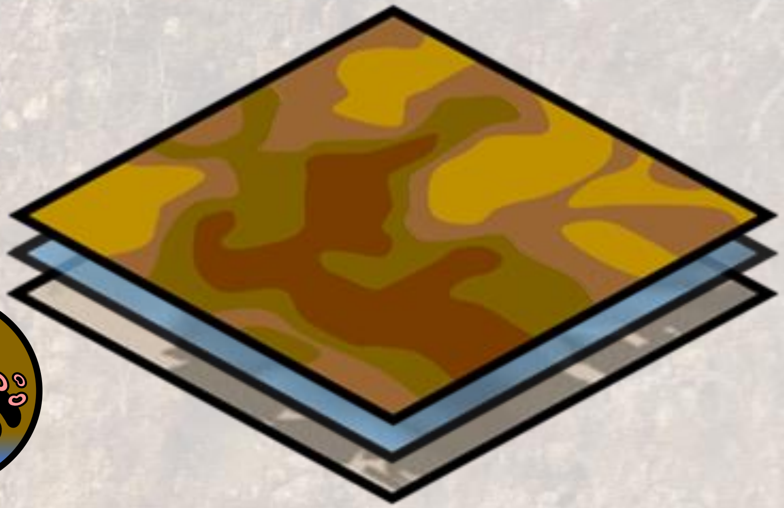
What makes soils dynamic?

Weather

- Atmospheric water demand
- Solar Radiation
- Temperature
- Wind
- Precipitation

Geomorphology

- Texture
- Topography
- Hydrology
- Parental material
- Drainage
- Weathering



Plants & Microbes

- Carbon input (residues + exudates)
- Plant species
- Respiration
- Nutrient uptake
- Root action on weathering
- N fixation

Management

- Biocides
- Land-use
- Biomass removal
- Fallowing
- Nutrient additions
- Tillage
- Pollutants
- Cover Crops
- Irrigation
- Compaction

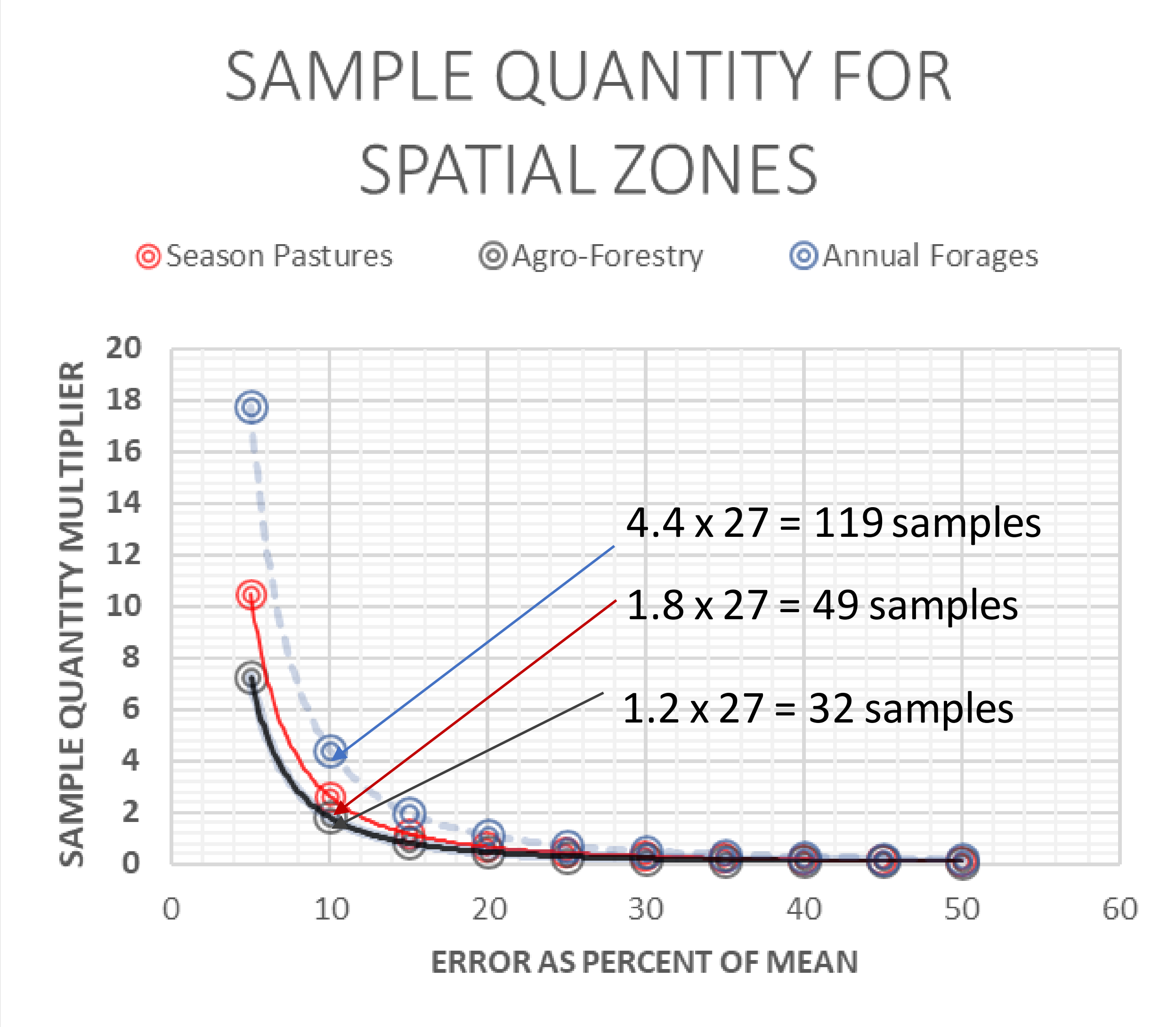
Sources of uncertainty

- Spatial variability: from μm to km;
- Number of samples, depth of samples, volume of samples/mass
- Temporal variability: from seconds to century; frequency
- Stakeholders: farmers, scientists, managers, policy makers
- Quantity of soil to sample (minimum amount for reliable and reproducible biology test)
- Method of sampling: hand-core, semi-automatic and fully automated coring
- Spectroscopy (pressure on the cylinder/density of sample)
- Sample processing (physical disruption vs homogenization; sieving extent)
- Chemistry (interferences (chloride in nitrates), duration of extraction)
- Instrumental effects (TOC temperature 900 C vs 1350 C), frequency of calibration

Spatial variability determines sample quantity

	Seasonal Pasture	Agro-Forestry	Annual Forages
Rep 1 n=27	**1.153**	**1.200**	**1.297**
Rep 2 n=27	**1.310**	**1.315**	**1.441**
Rep 3 n=27	**1.082**	**1.415**	**1.112**
Mean	**1.182**	**1.310**	**1.283**
SD	**0.117**	**0.108**	**0.165**

** Source: Will Brinton, Woods End Labs*



Statistics Model: Snedecor, G.W., and W.G. Cochran. 1980. Statistical methods. 7th ed. Iowa St. Univ. Press. Ames, Iowa.

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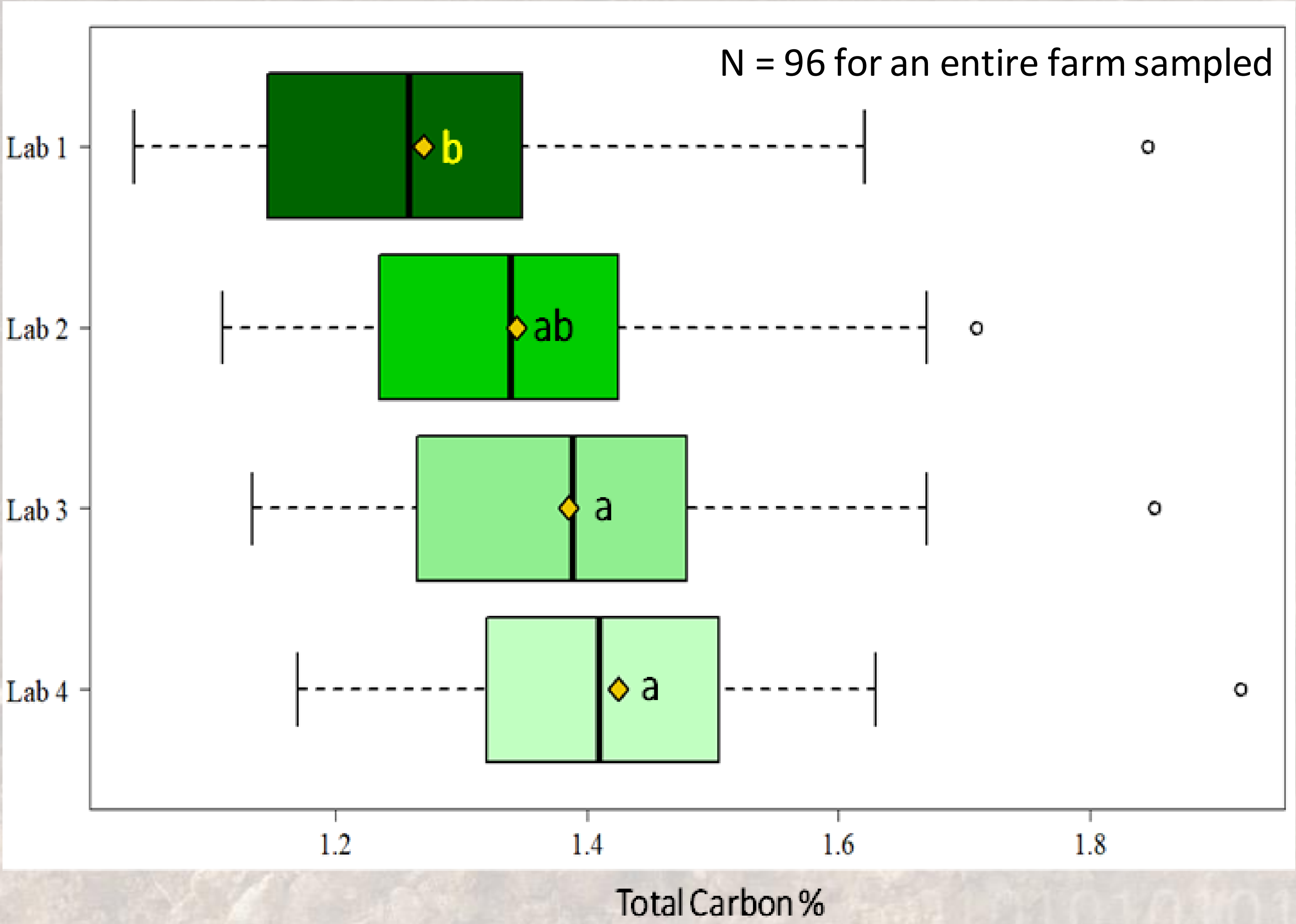
Variability from Laboratories



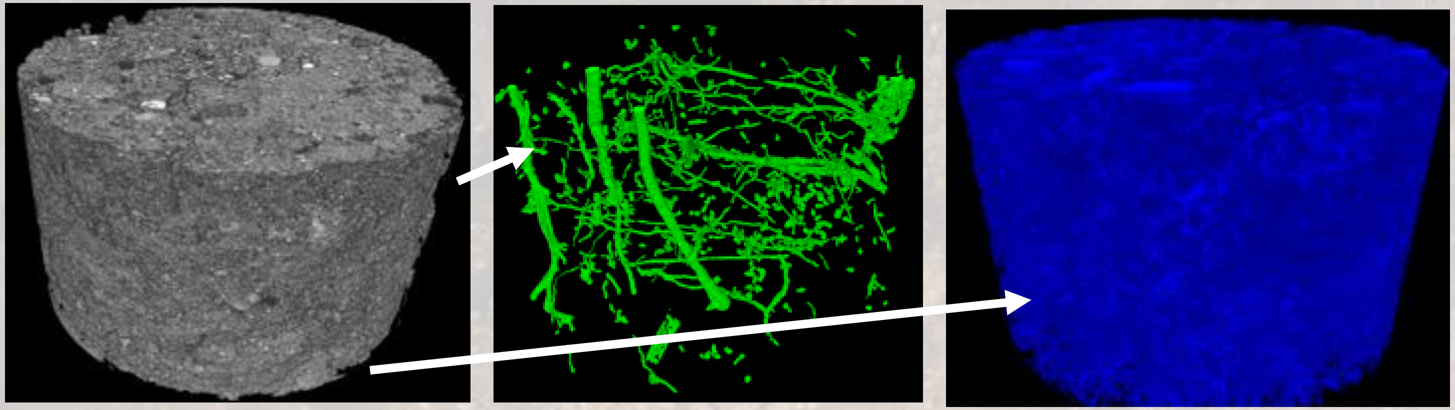
A 0.15 % error is equivalent to **5850 kg SOC/ha error** (1.3 BD, 30 cm)

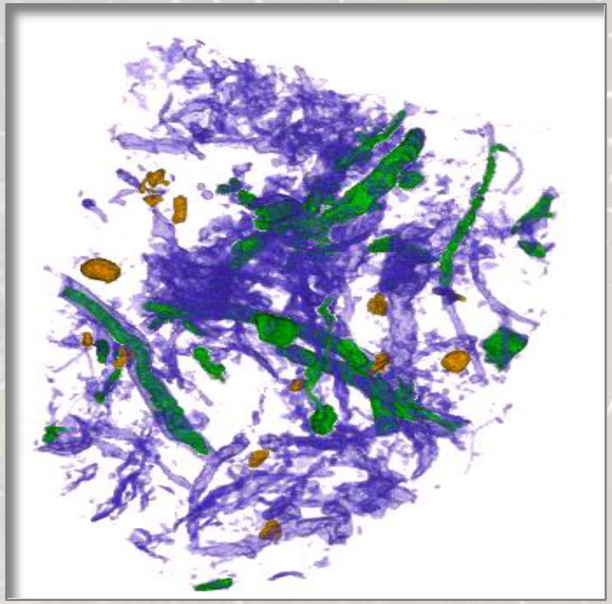
And 0.2 m^3/m^3 difference in bulk density is equivalent to **8400 kg SOC/ha error**

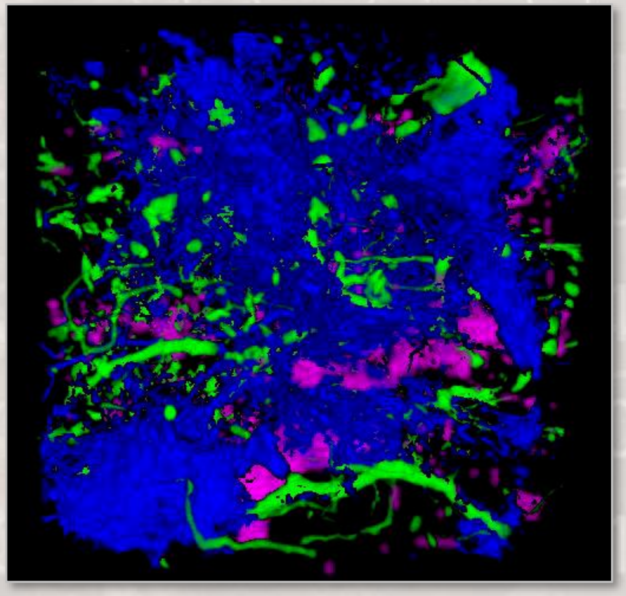
Source: Will Brinton

Soil processes studied at micro-scale in intact soil *in situ* by combining X-ray computed, micro-tomography, phosphor imaging and 2D zymography

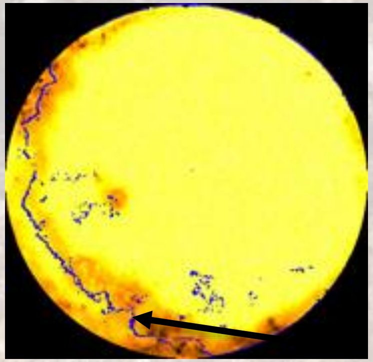
Grayscale image | Particulate organic matter | Pores



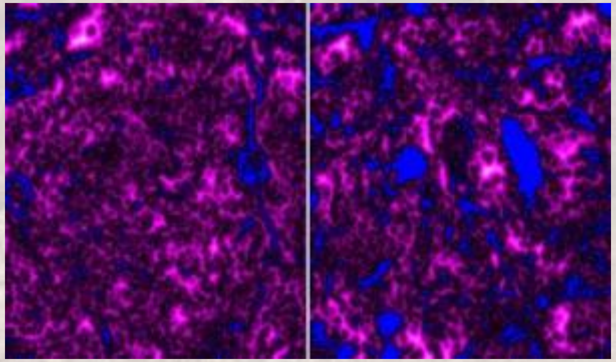


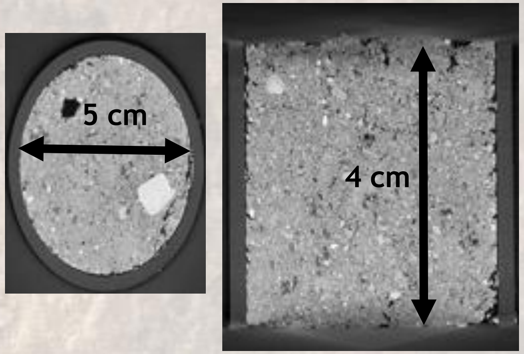


Fate of new soil carbon



Hot-spots of denitrification and N_2O production





X-ray µCT scanning

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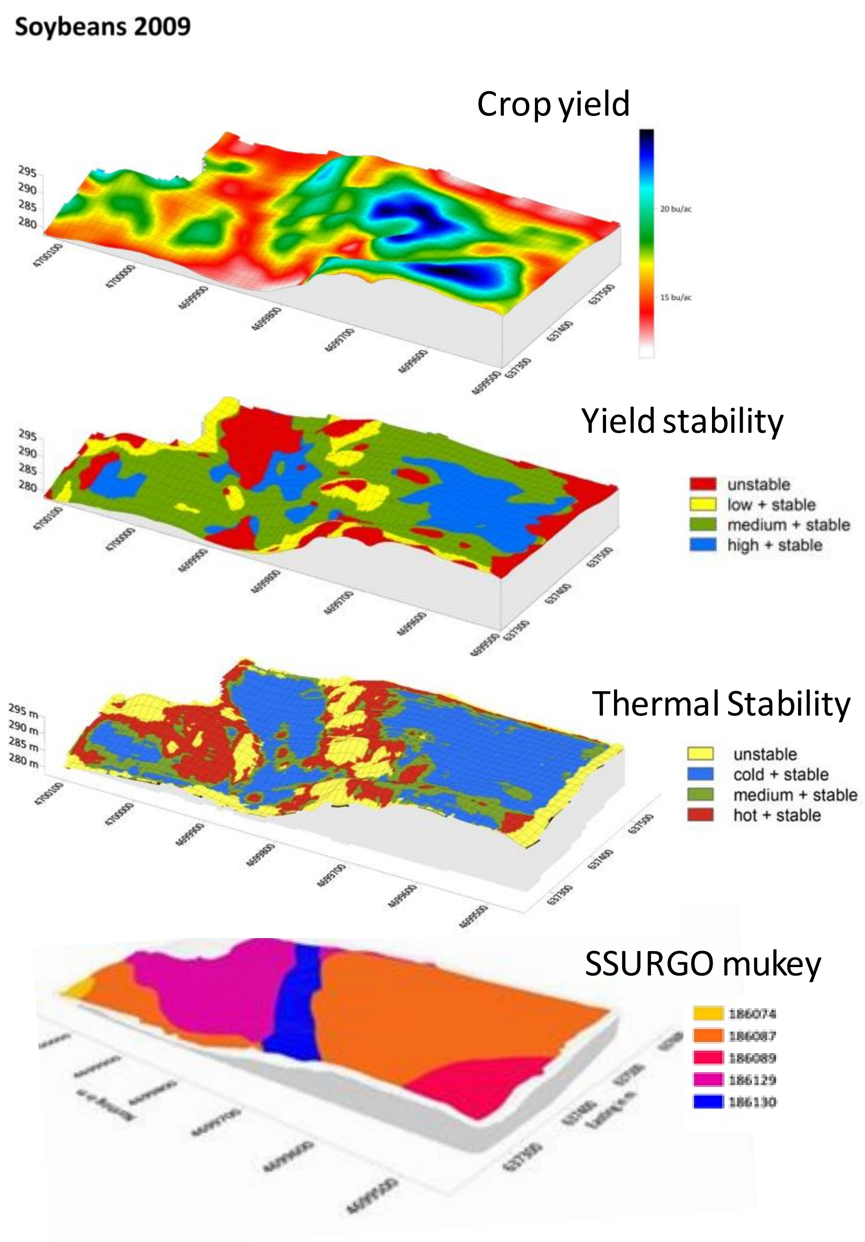
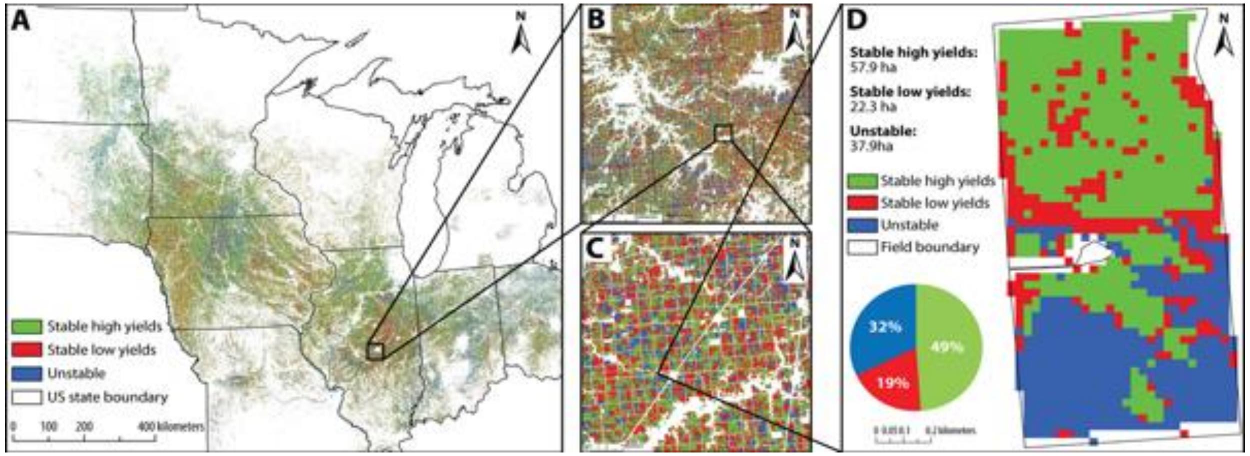
Source: Alexandra Kravchenko

Integrating spatial and temporal variability



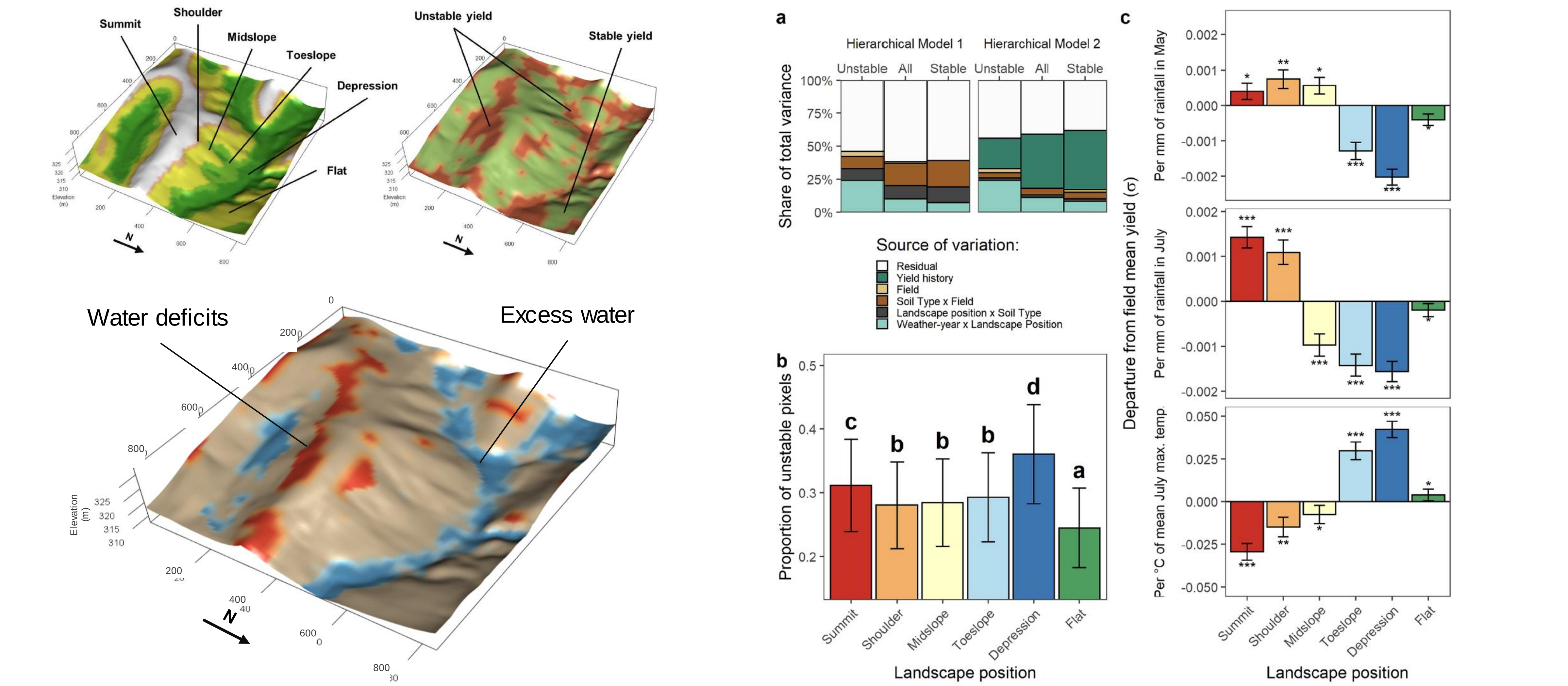


Subfield productivity across 80 M acres (~ 8 Million fields)

Yield Stability	Share of area	Nitrogen-use efficiency
Stable, High yields	48%	75%
Stable, Low yields	25%	45%
Unstable	27%	58%

Basso et al., 2019; Basso and Antle, 2020

Landscape position modulates interactions between soil, weather and crops



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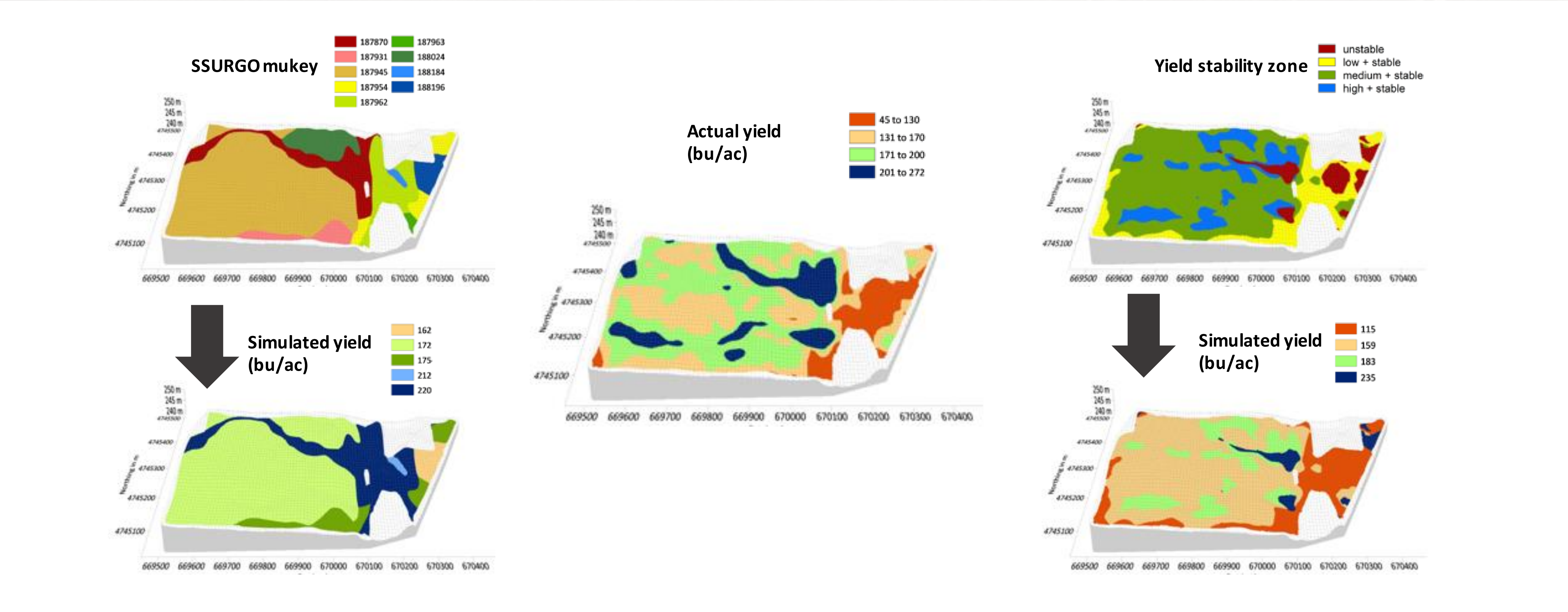
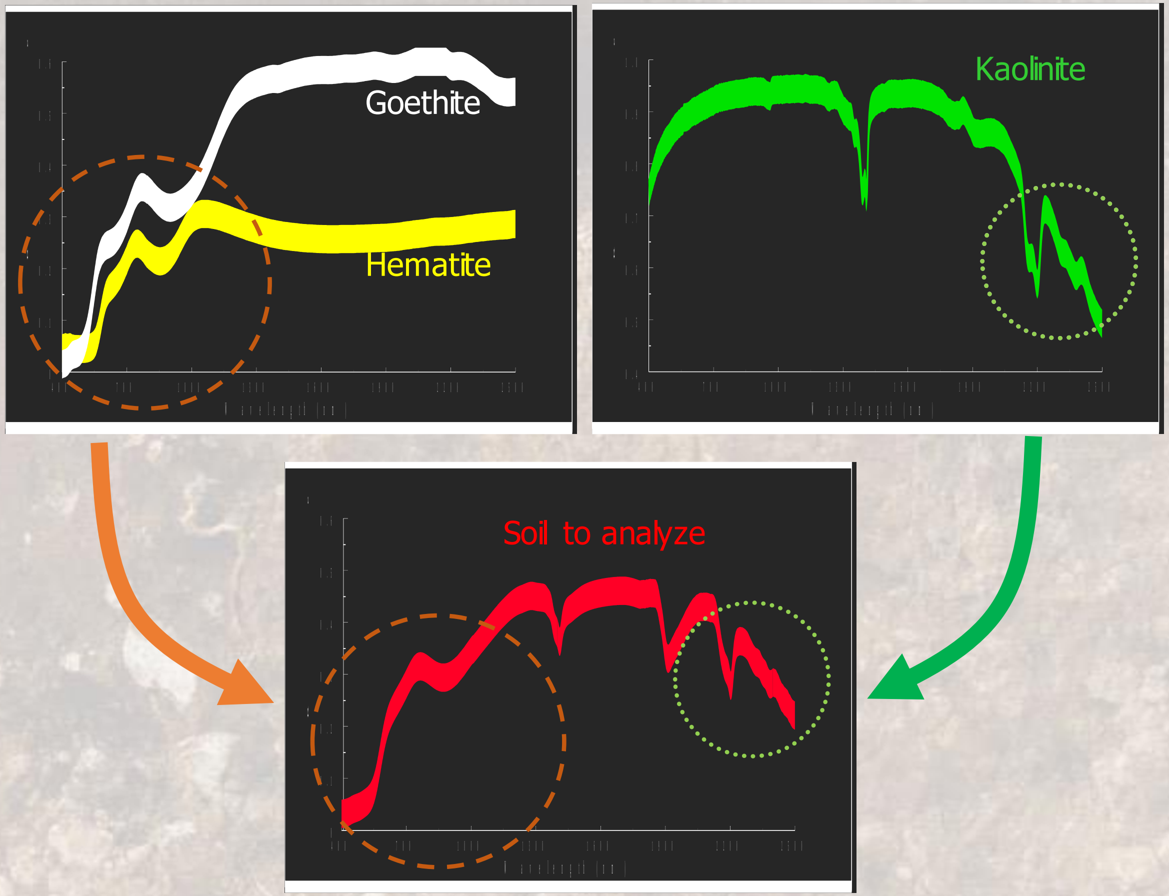
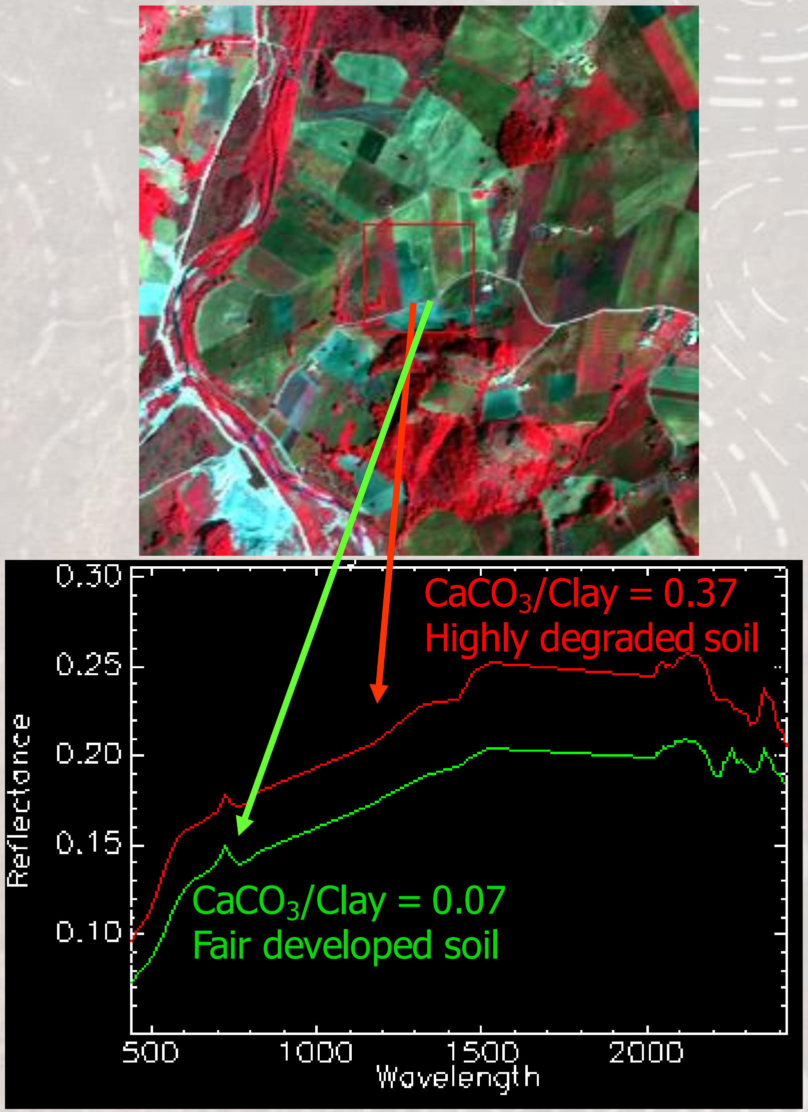
Martinez-Feria and Basso, 2020; Maestrini and Basso, 2018

Capturing the variability requires looking beyond statics soil properties.



Spectral signature of soil minerals





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Source: Leone

High-resolution 2D resistivity tomography

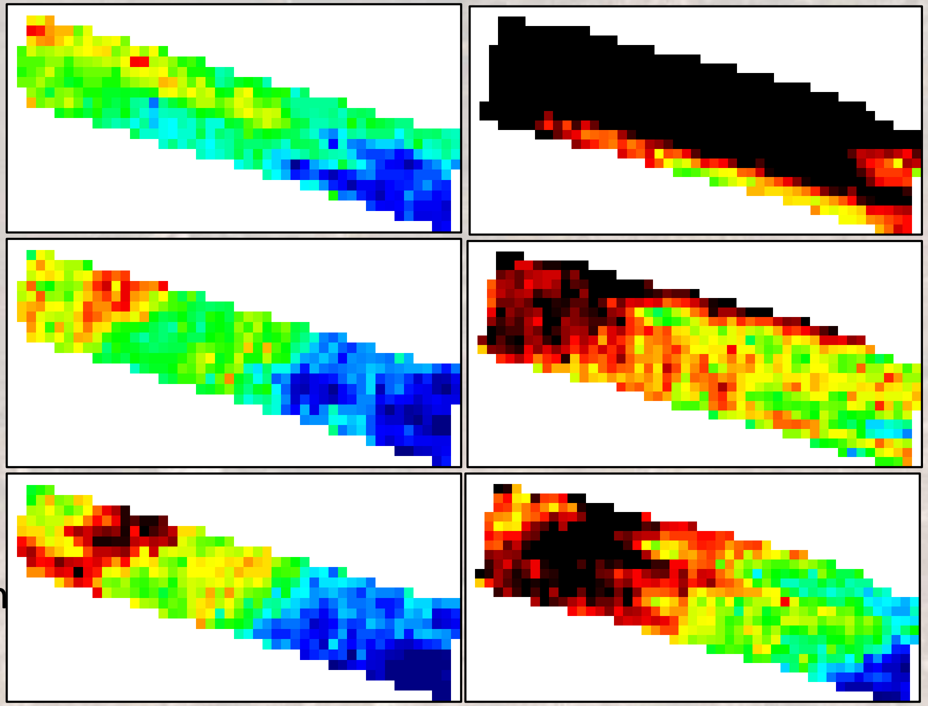
Before tillage

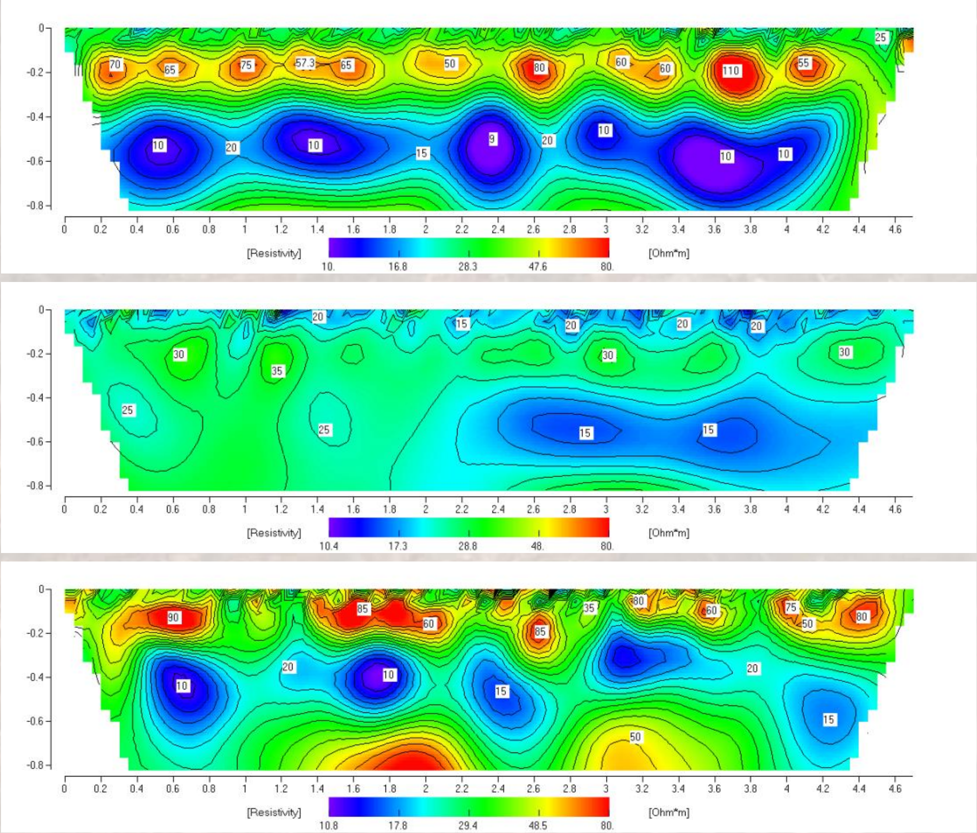
After tillage

0-25cm

0-50cm

0-100cm





Conv. till

No-till

No-till after one tillage event

(Basso et al., 2010)

AUDIENCE PARTICIPATION

Join the conversation and ask questions using our Slack Workspace Channel:

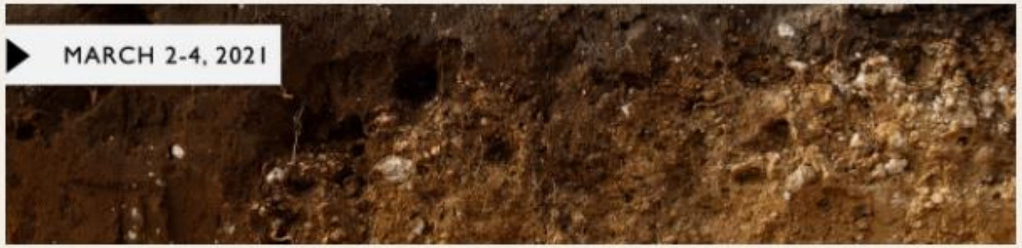
#Plenary-Day1

Soil Repository Survey

https://www.nationalacademies.org/event/03-02-2021/exploring-a-dynamic-soil-information-system-a-workshop

Exploring a Dynamic Soil Information System: A Workshop

SHARE



- About
- Webinar
- Meeting Materials
- Contact

Soils are a critical natural resource that support a wide range of human activities, but current systems for monitoring soils do not provide an accurate picture of changes in the soil resource over time. A successful dynamic soil information system would overlay important chemical, physical, and biological information about soil samples taken across a wide range of geographies with information on influences on soils, such as land use and land management, soil moisture, and weather. It would be useful for policy makers and land managers as well as for scientists and other practitioners in a wide range of disciplines, including hydrology, climate science, agriculture, and geology. This workshop will examine the level of detail needed by these potential users and envision how data on soils and other parameters can be most effectively collected, combined, and curated over time.

This workshop is sponsored by the Department of Energy, the National Academy of Sciences Arthur L. Day Fund, the National Corn Growers Association, the National Science Foundation, The Nature Conservancy, and the U.S. Department of Agriculture's National Institute of Food and Agriculture and Natural Resources Conservation Service.

Soil Repository Survey

As part of this work, the workshop planning committee is constructing a list of soils repositories/soil archives in the world. Please contribute to this effort by completing this quick survey for each of the soil repositories/archives with which you are familiar HERE. The list will be posted on the workshop's website when complete and included in the workshop's proceedings.

REGISTER

AGENDA

DATE(S)
Mar 2 - 4, 2021
11:00AM - 4:00PM ET
Add to Calendar

PROJECT
Exploring a Dynamic Soil Information System: A Workshop

DIVISIONS
Division on Earth and Life Studies
Policy and Global Affairs

UNITS
Board on Agriculture and Natural Resources
Board on Earth Sciences and Resources
Board on International Scientific Organizations

TOPICS
Agriculture
Earth Sciences
Environment and Environmental Studies

Webinar

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Keynote Speakers

Joe Cornelius
Bill & Melinda Gates Ag One

Innovative Technology for Managing Soils

Jerry Hatfield
USDA Agricultural Research Service (retired)

Soil in Agricultural Systems

Alison Hoyt
Max Planck Institute for Biogeochemistry

The Importance of Data Archiving and Data Integration

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Innovative Technologies for Managing Soils

2 March 2021

Joe Cornelius, Ph.D., Bill & Melinda Gates Ag One

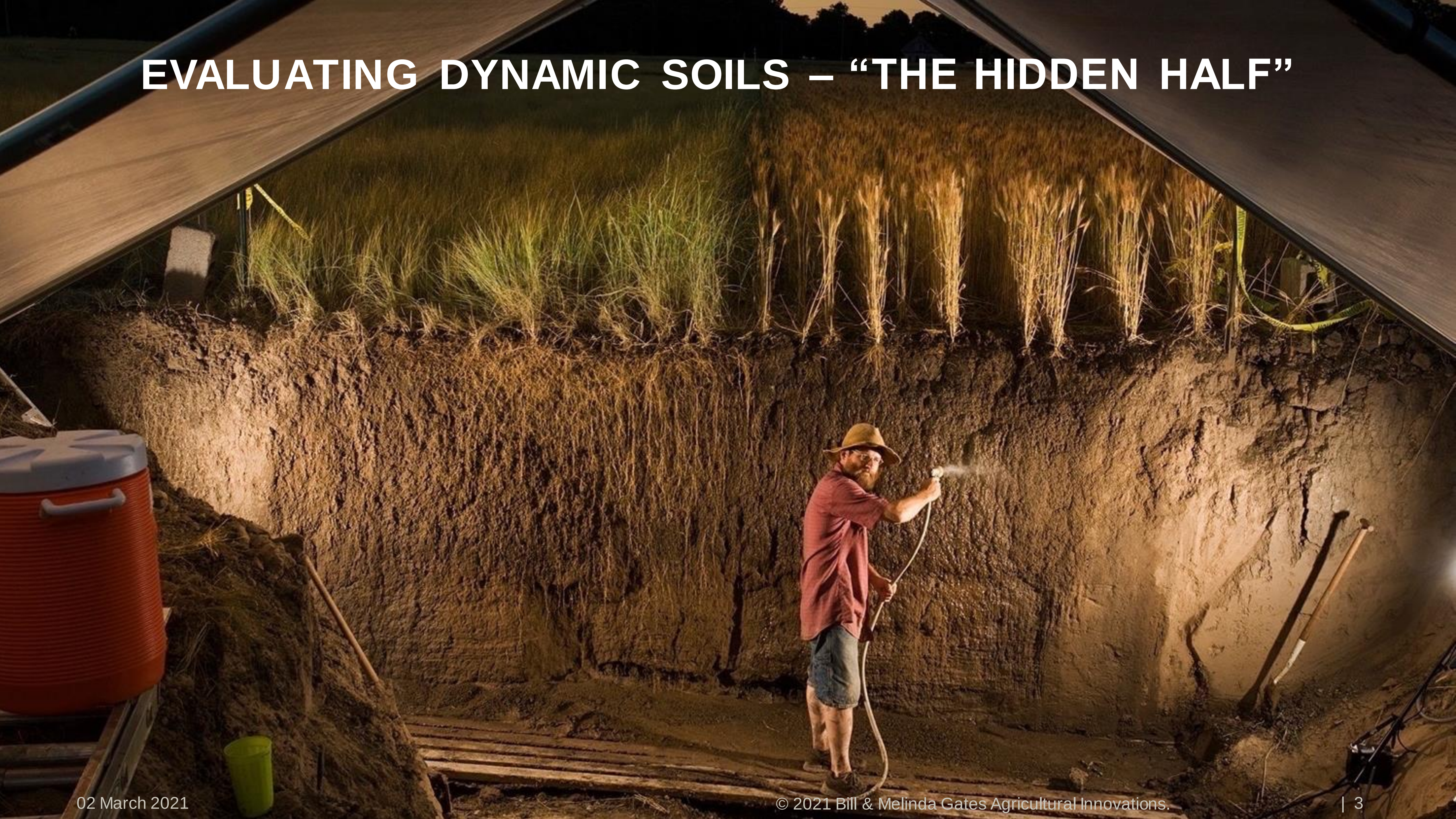
David Lee, Ph.D., Booz Allen Hamilton/ARPA-E

Daniel Northrup, Ph.D., Benson Hill

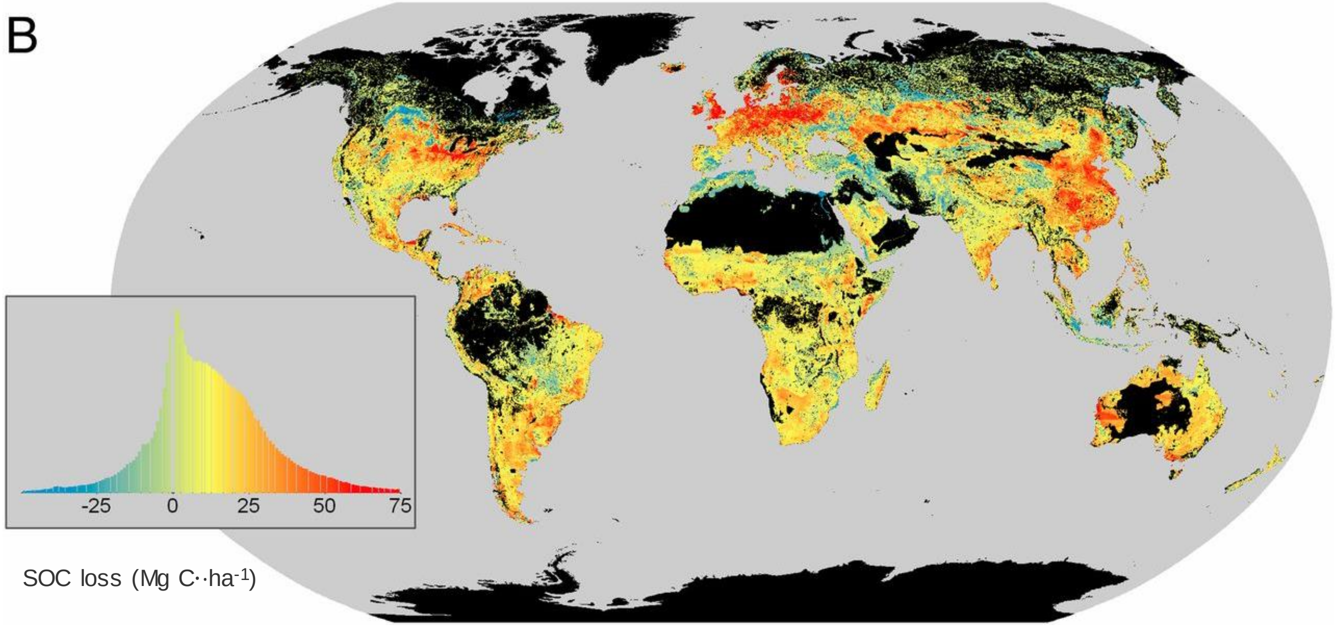
Science is informed by what it is possible to measure, and it takes a great leap forward when we can measure something new.

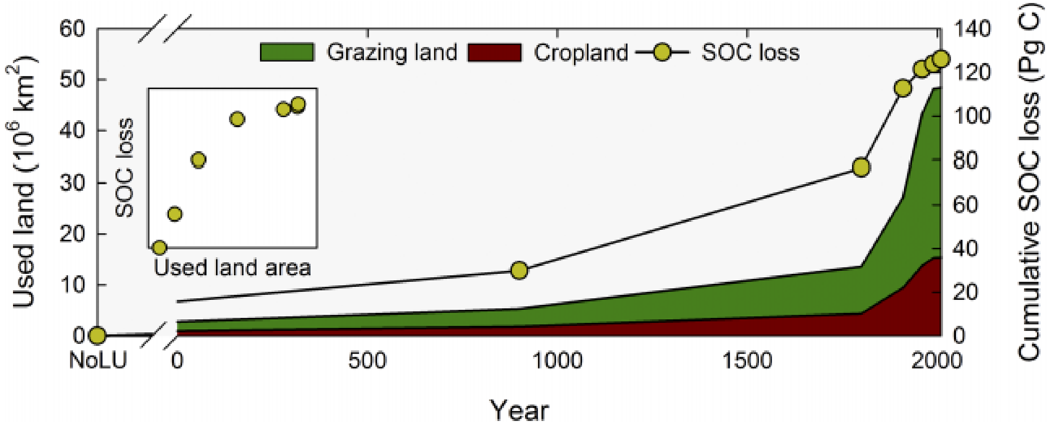
— Nature, 2017

EVALUATING DYNAMIC SOILS – “THE HIDDEN HALF”



SOIL CARBON LOSSES INDICATE ENORMOUS POTENTIAL





Sanderman et al., PNAS (2017) 114 (36) 9575-9580

- Historical models were developed based on soil profile observations and samples to quantify the significant loss of soil organic carbon;
- A global carbon debt due to agriculture of 133 Pg C for the top 2 m of soil, with the rate of loss increasing dramatically in the past 200 years.

SOIL HEALTH IS FOUNDATIONAL TO ACHIEVING SDG'S

World Business Council for Sustainable Development (WBCSD)

15.3
Land degradation neutrality

12.4
Environmentally sound management of chemicals and waste

2.4
Sustainable food production systems

3.9
Reduce deaths and illnesses from hazardous chemicals and air water and soil pollution and contamination

THE RANGE OF SOIL CHARACTERIZATION APPROACHES

SCALE

Lab	Greenhouse	Field	Landscape

mm	cm	m	km

RESOLUTION

High resolution and accuracy, but labor intensive, expensive, and not scalable.

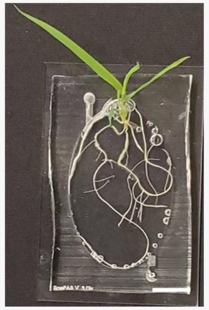
Large scale, rapid, and inexpensive, but low resolution and uncertainty.

CONTROLLED ENVIRONMENT CHARACTERIZATIONS

Fabricated ecosystems provide very high-resolution measurements of plant:soil interactions.

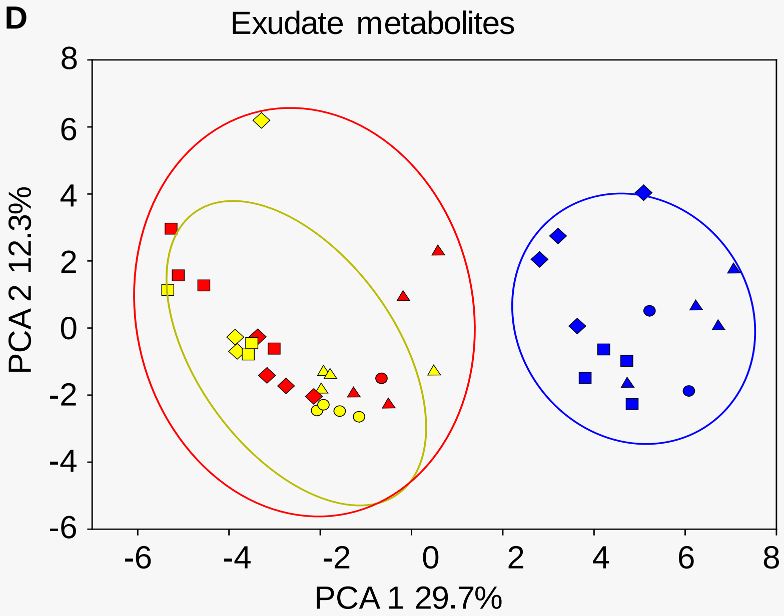
The EcoFAB system developed by LBNL has been utilized with a number of plants, and is scalable to test multiple characteristics simultaneously such as plant root exudates.

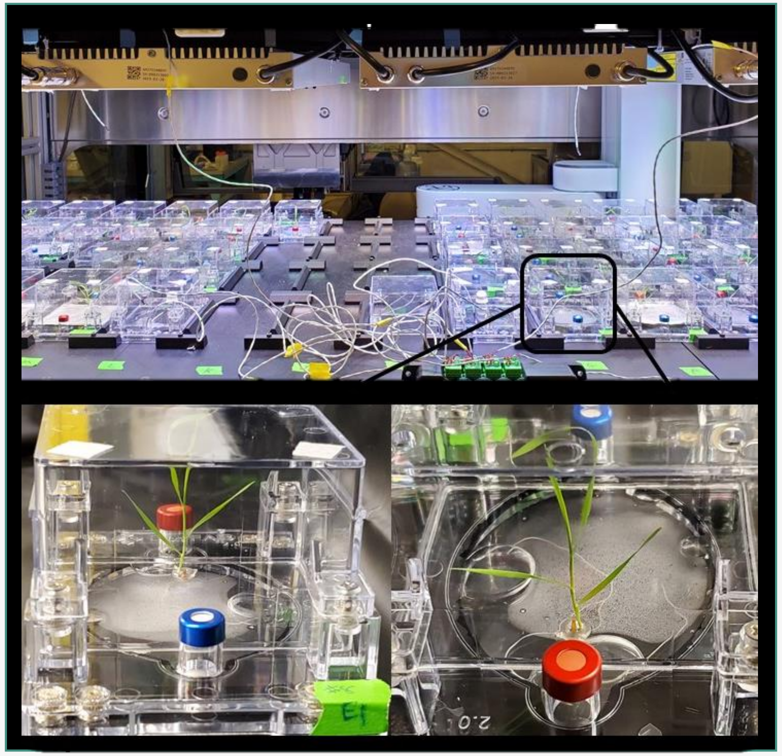
Medicago



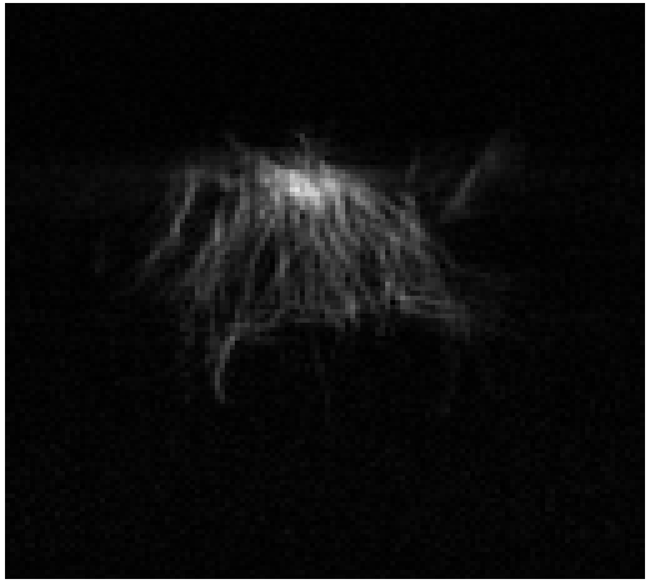
Brachypodium

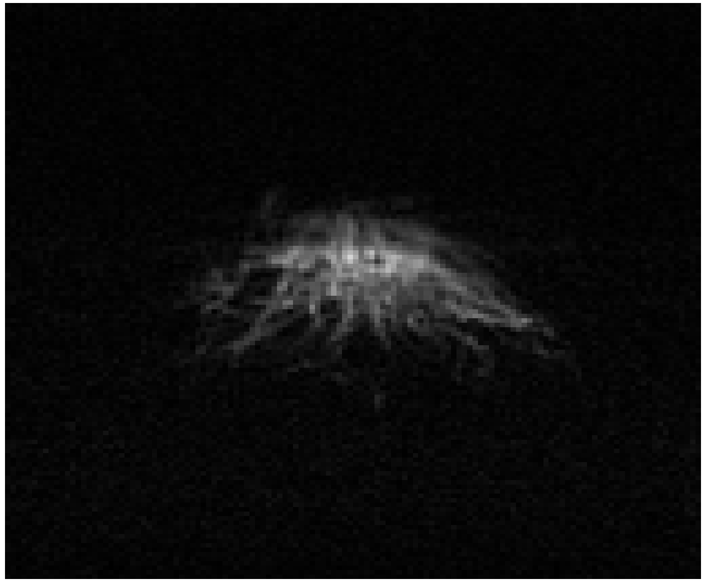
Sorghum





DIRECT ROOT IMAGING (LOW FIELD MRI)


Belk clay


Weswood silt loam

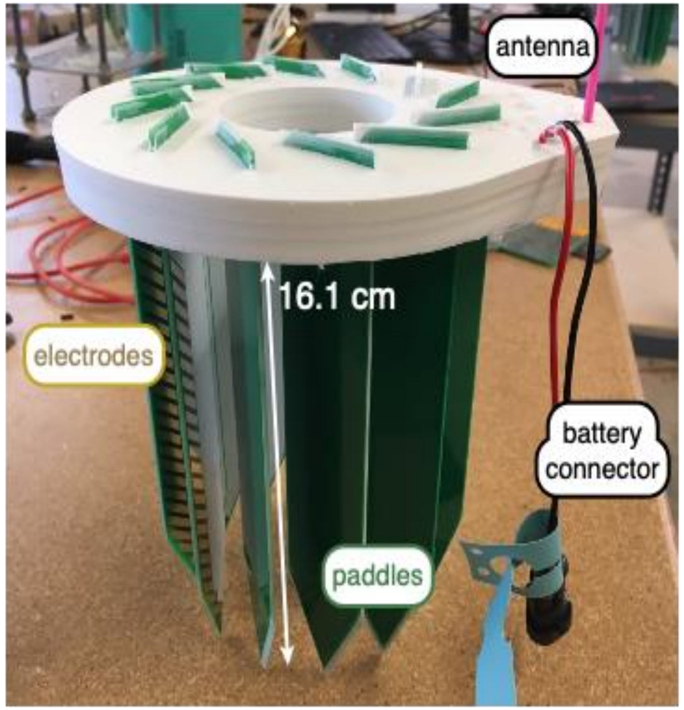
LF-Magnetic Resonance Imaging allows non-destructive imaging of roots in the field

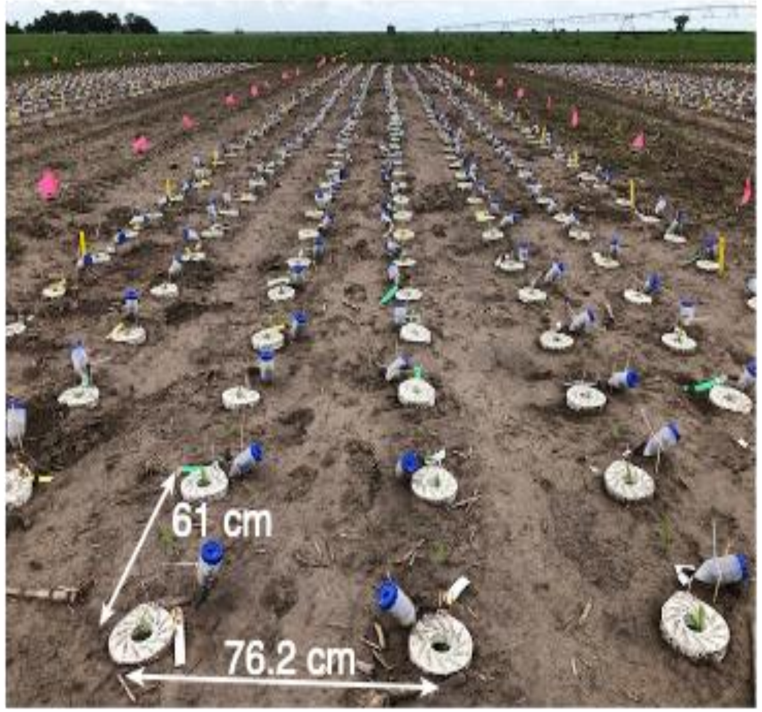
Zhu, B., Liu, J., Cauley, S. *et al.* Image reconstruction by domain-transform manifold learning. *Nature* **555,** 487–492 (2018)
Bagnall, C., *et al*. Low-field magnetic resonance imaging of roots in intact clayey and silty soils. *Geoderma* **370**, 144356 (2020)

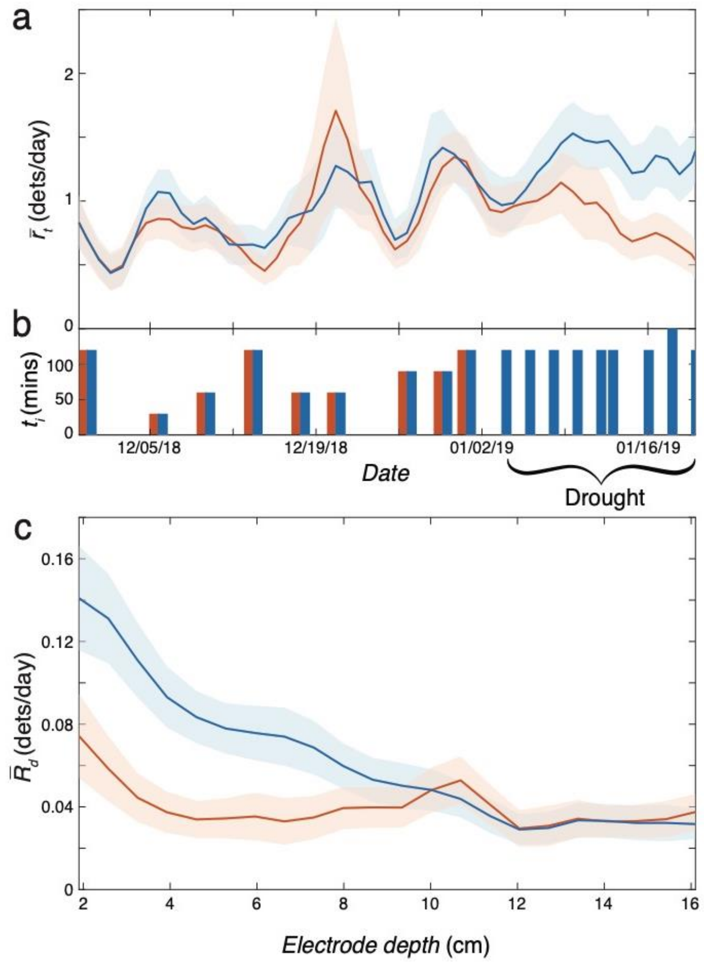
ROOT TRACKERS: TOUCH SENSING AT FIELD SCALE

Hi-Fidelity Genetics
HFG

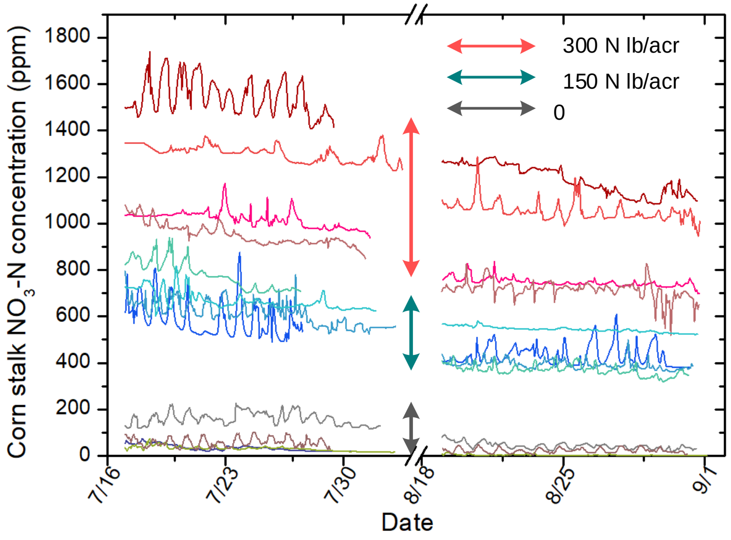
Measuring dynamic root growth and depth in response to environment







CONTINUAL NITROGEN DETECTION IN PLANTS AND SOIL



The ISU ROOTS team demonstrated continual plant nitrate measurements using microneedle based nitrate sensors in maize fields, in Ames, IA during 2019 and 2020. It also has the capacity to measure levels in soil and groundwater.

The sensor allows growers to optimize nitrogen application rates, or breeders to identify crop varieties with improved nitrogen use efficiency.

EnGeniousAg

Nebraska Lincoln

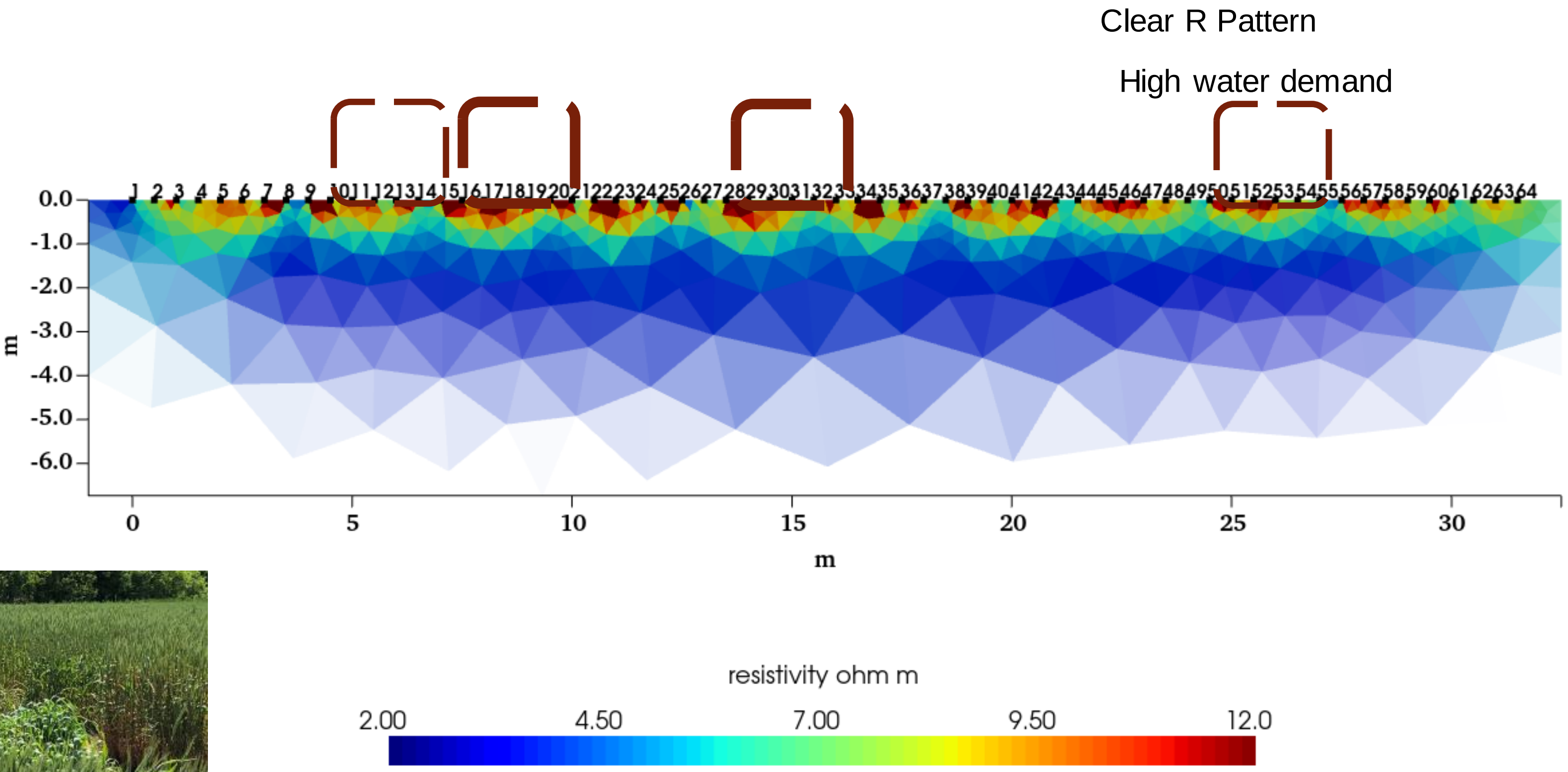
IOWA STATE UNIVERSITY

Table 1: Comparison between EnGeniousAg (EGA) sensors and state-of-the-art commercial sensors

	Horiba Ion-Selective Sensor	Hach UV Absorption	Colorimetric Nitrate Strip	EGA Sensor
Direct measurement without sampling	No	No	No	Yes
Dynamic range NO_3-N (ppm)	23–2200	0.1-50	10-50	1-5000
In situ continuous?	No	No	No	Yes
Measurement accuracy % of reading	±10%	±10%	±25%	±8%
Major non-target ion interferences (SO_4^{2-}, Cl^-, K^+, PO_4^{3-}) (% of reading value)	Severe (> ±25%)	No	N/A	±10%
Response time	2 min	15 sec	20 sec	2 sec

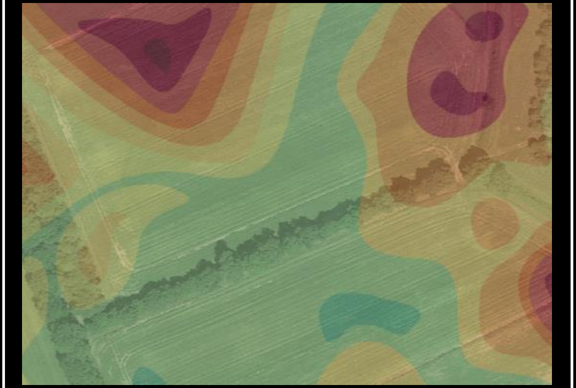
IN SITU SOIL AND ROOT CHARACTERIZATION

- Electrical Resistance Tomography allows the continual determination of root depth and water use over time.
- 2020 field results indicate differences between roots of different wheat lines based on soil moisture levels down to six meters.

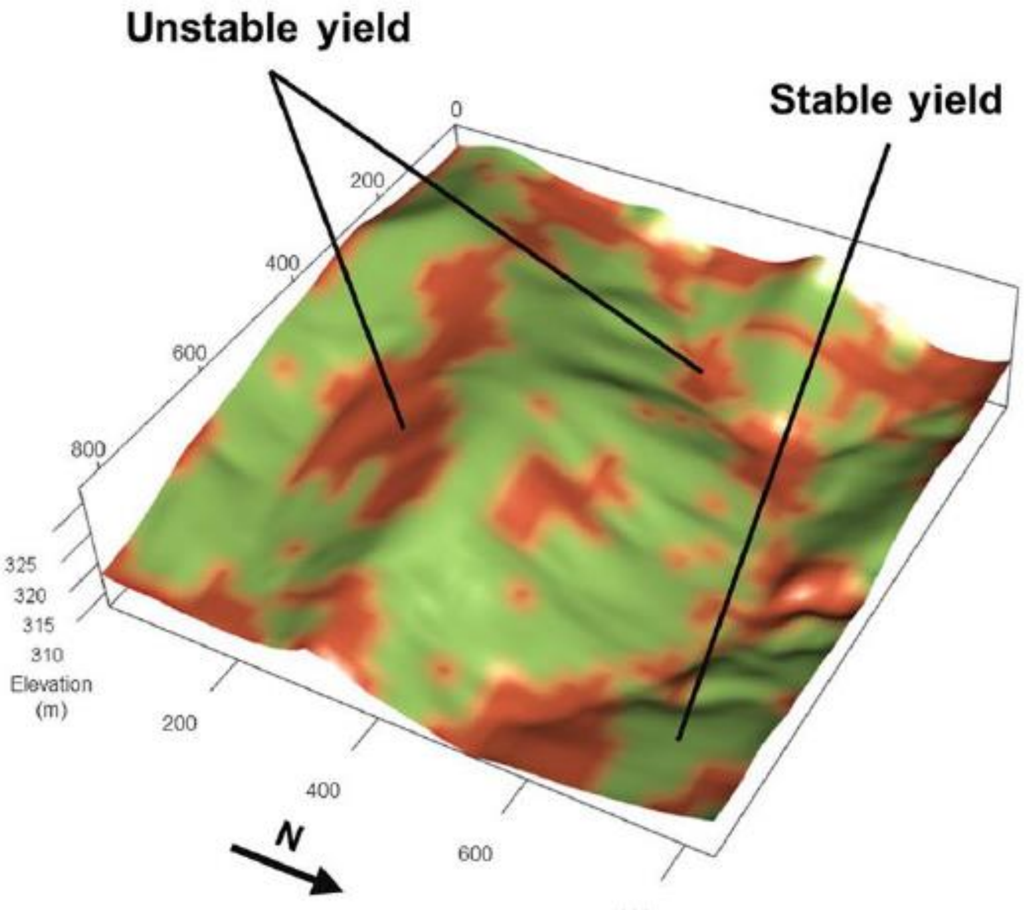


PLANTS AS SENSORS

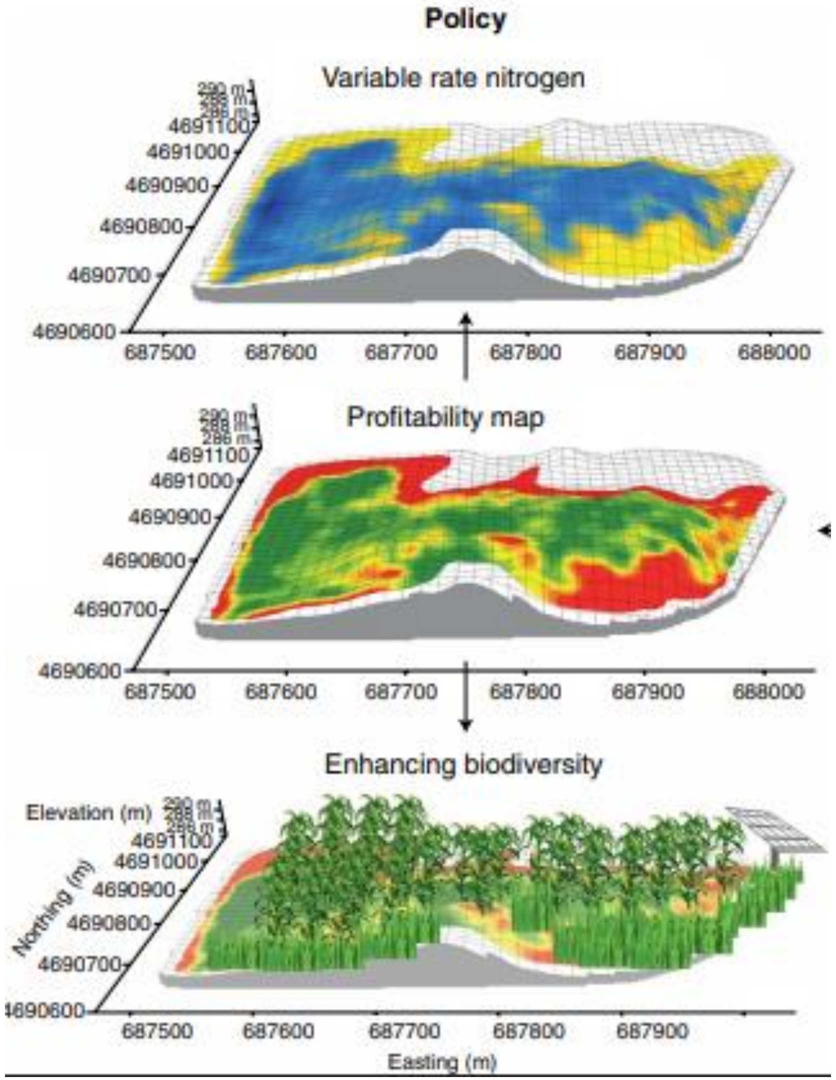
INNERPLANT

Plants communicate biotic and abiotic stress responses	Fluorescent proteins in leaves signal when stressed	Fluorescent signature - drought, pathogens, nutrients	Signals detected by phones, tractors, drones, & satellites
			

DIGITAL AGRICULTURE IS A SCALABLE SOLUTION TO INTEGRATE SOIL SENSING AND PLANT RESPONSES



Stability Zones inferred from historical yield maps
And result from + Terrain + Soil Properties



Martinez & Basso, Unstable Crop Yield, Nature Research, 2020

EXPANDING THE VALUE PROPOSITION TO CLIMATE STEWARDSHIP – SOIL CARBON MONITORING

arpa-e CHANGING WHAT'S POSSIBLE

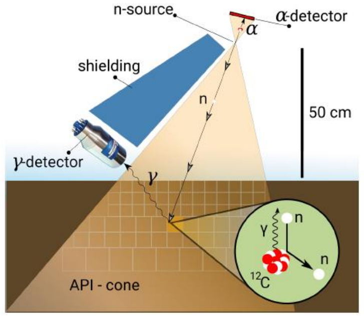
Yard Stick

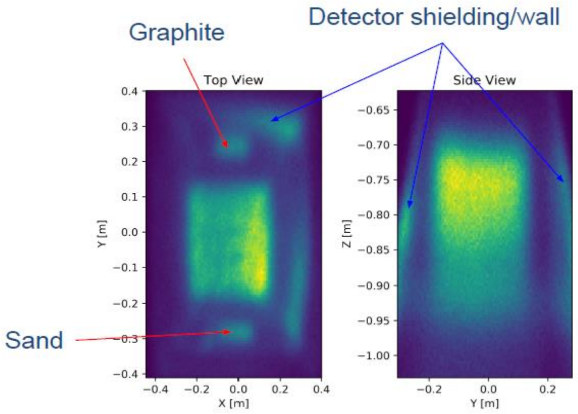
Vis NIR

Soil Carbon
Bulk Density

BERKELEY LAB

Associated Particle Imaging

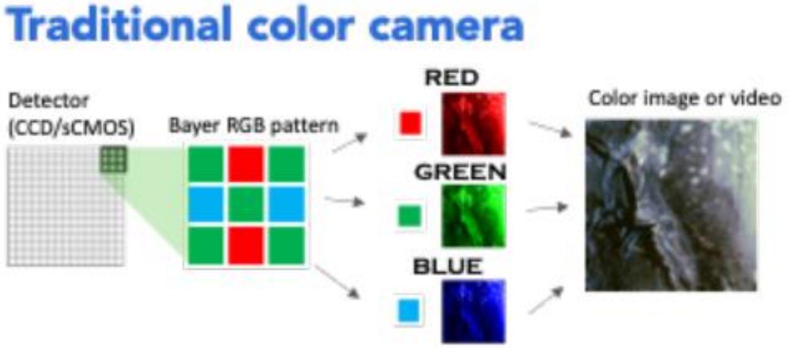


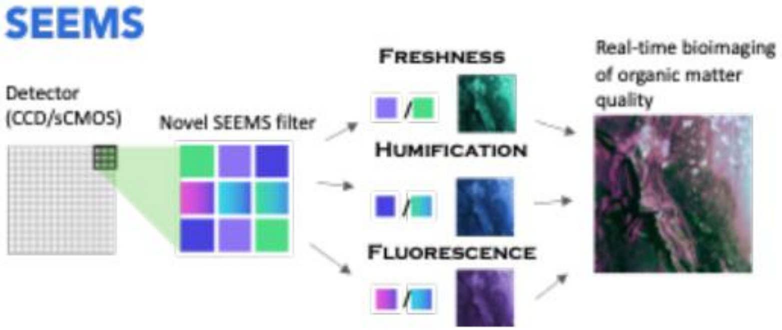


Non-Invasive Elemental Profiling

IMPOSSIBLE

Visual – Multi-modal



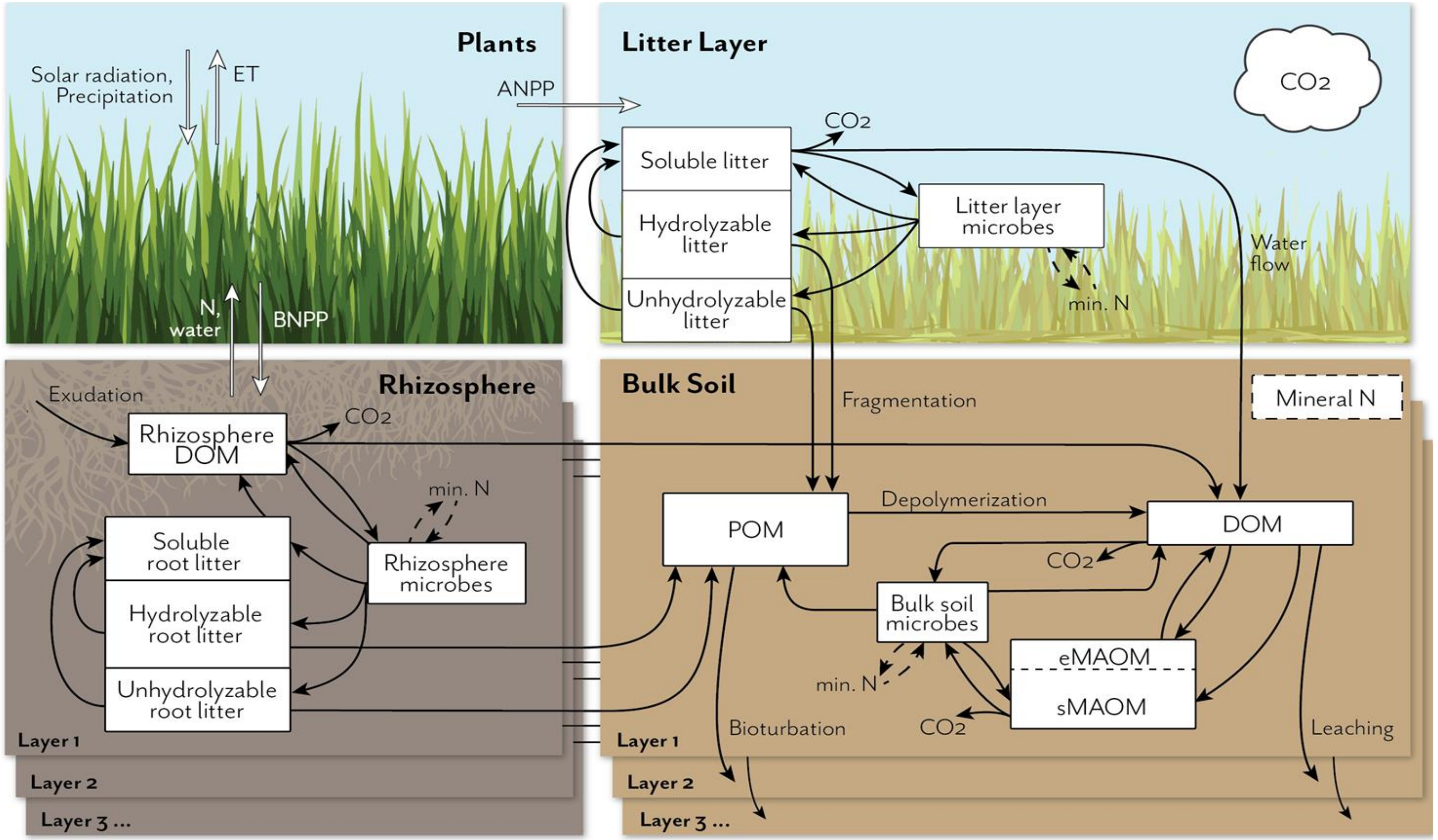


Soil Carbon Species

ECOSYSTEM LEVEL MODELING

arpa·e CHANGING WHAT'S POSSIBLE

- The Microbial Efficiency-Matrix Stabilization model simulates the transport and conversion of organic matter in the soil based on microbial and chemical processes.
- MEMS 2.0 expands the model to simulate plant growth above and belowground.
- Models like MEMS are key to establishing correlations between high resolution ground truthing measurements and landscape level insights from remote sensing.

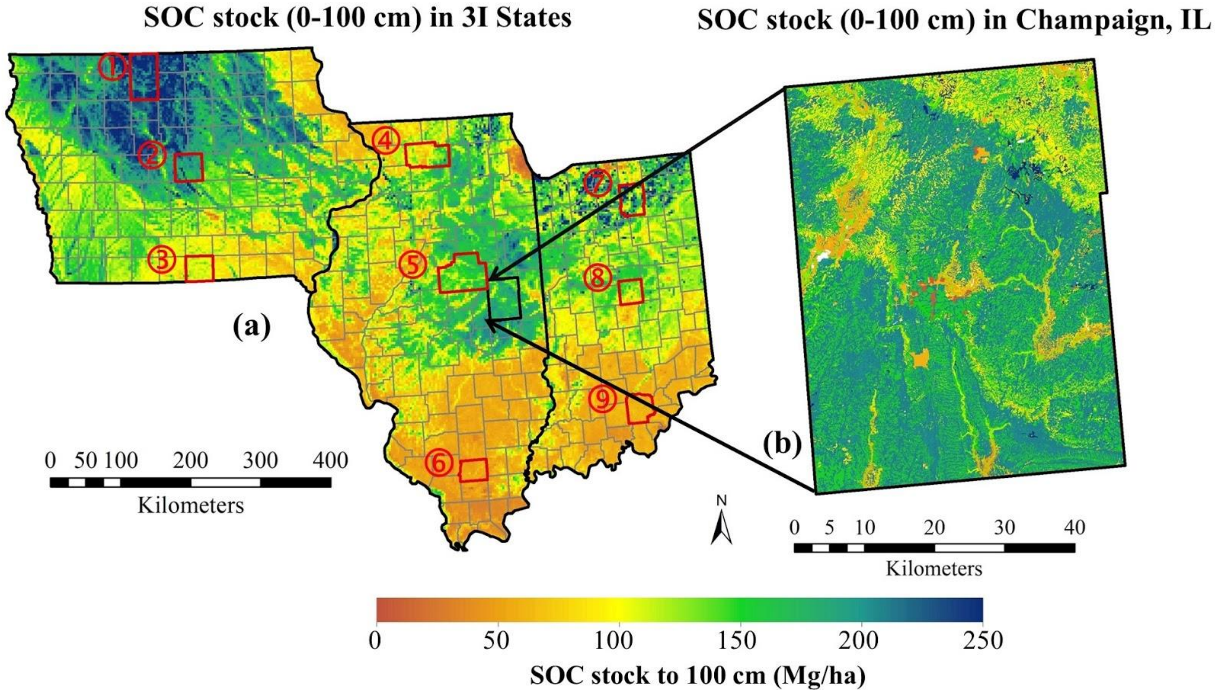


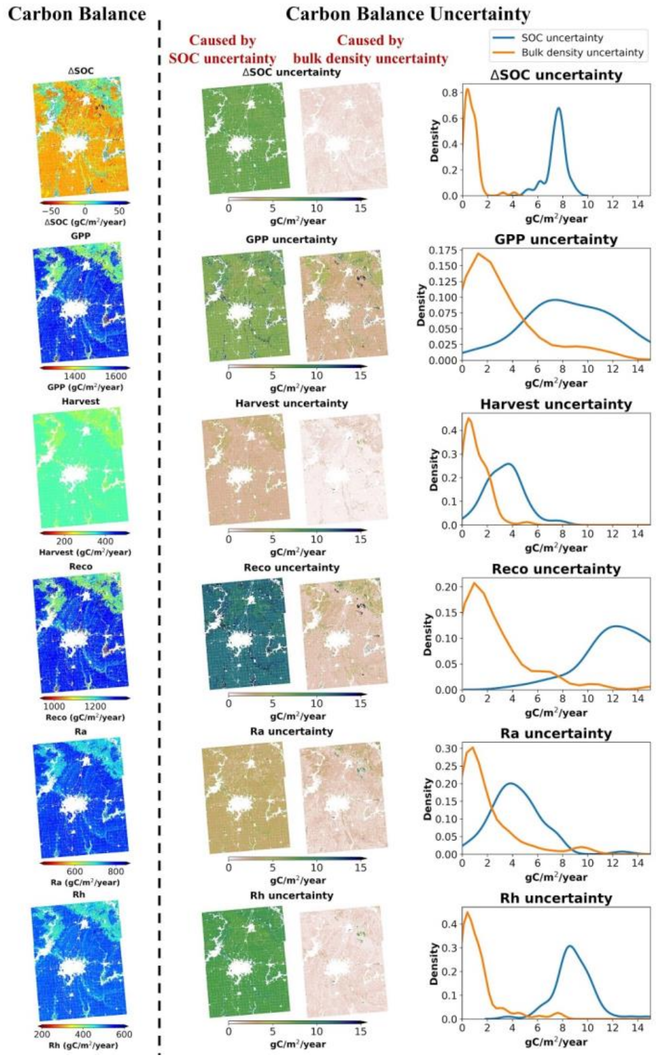
Zhang et al., 2021. Biogeosciences Discussions, 1–37

COLORADO STATE UNIVERSITY

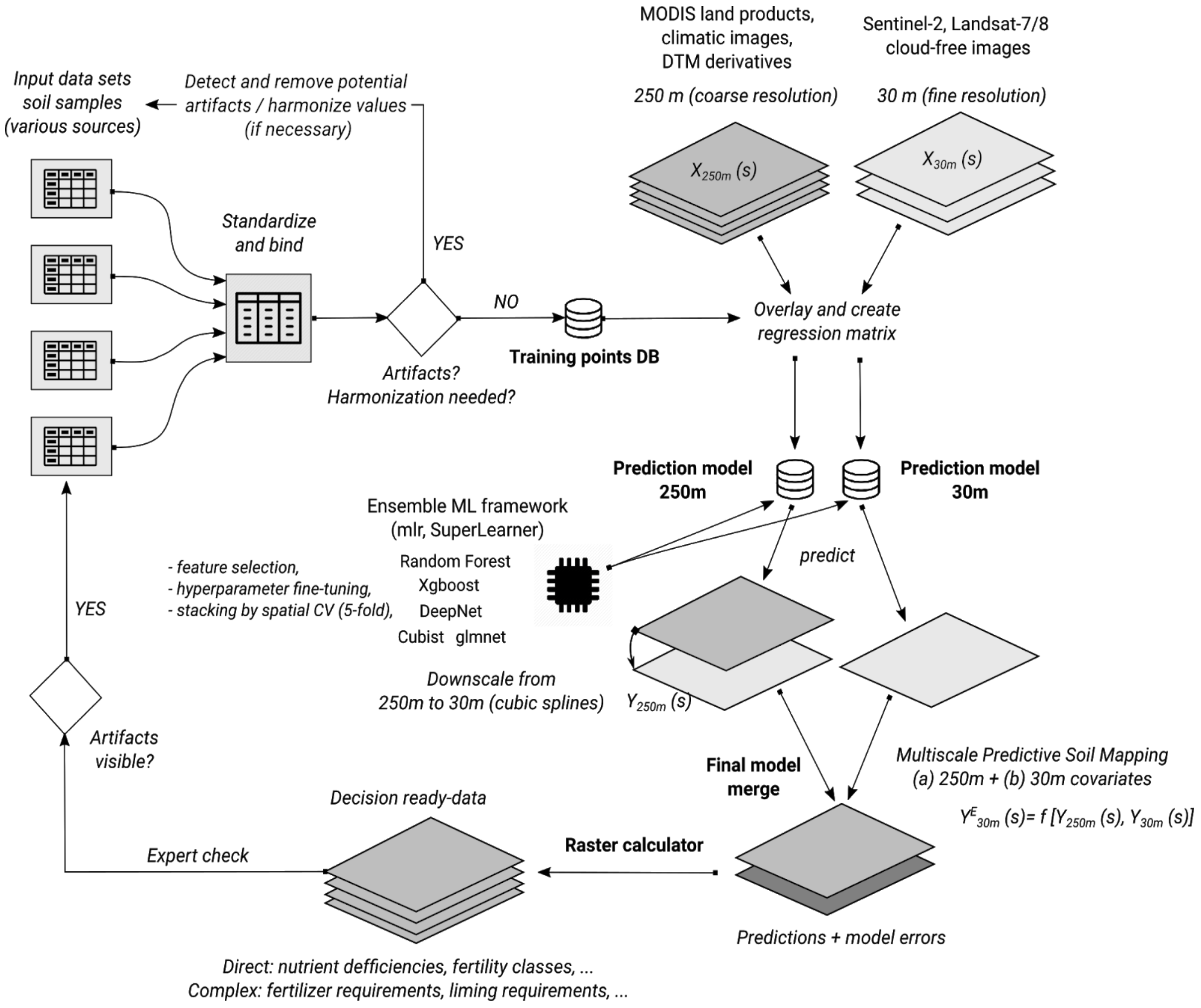
SATELLITE BASED LANDSCAPE CHARACTERIZATION

Carbon balance and its uncertainty caused by SOC concentration measurements uncertainty or bulk density measurements uncertainty in the U.S. Midwest cropland.





INNOVATIVE SOLUTIONS FOR DECISION AGRICULTURE



DIGITAL MAPPING APPROACH

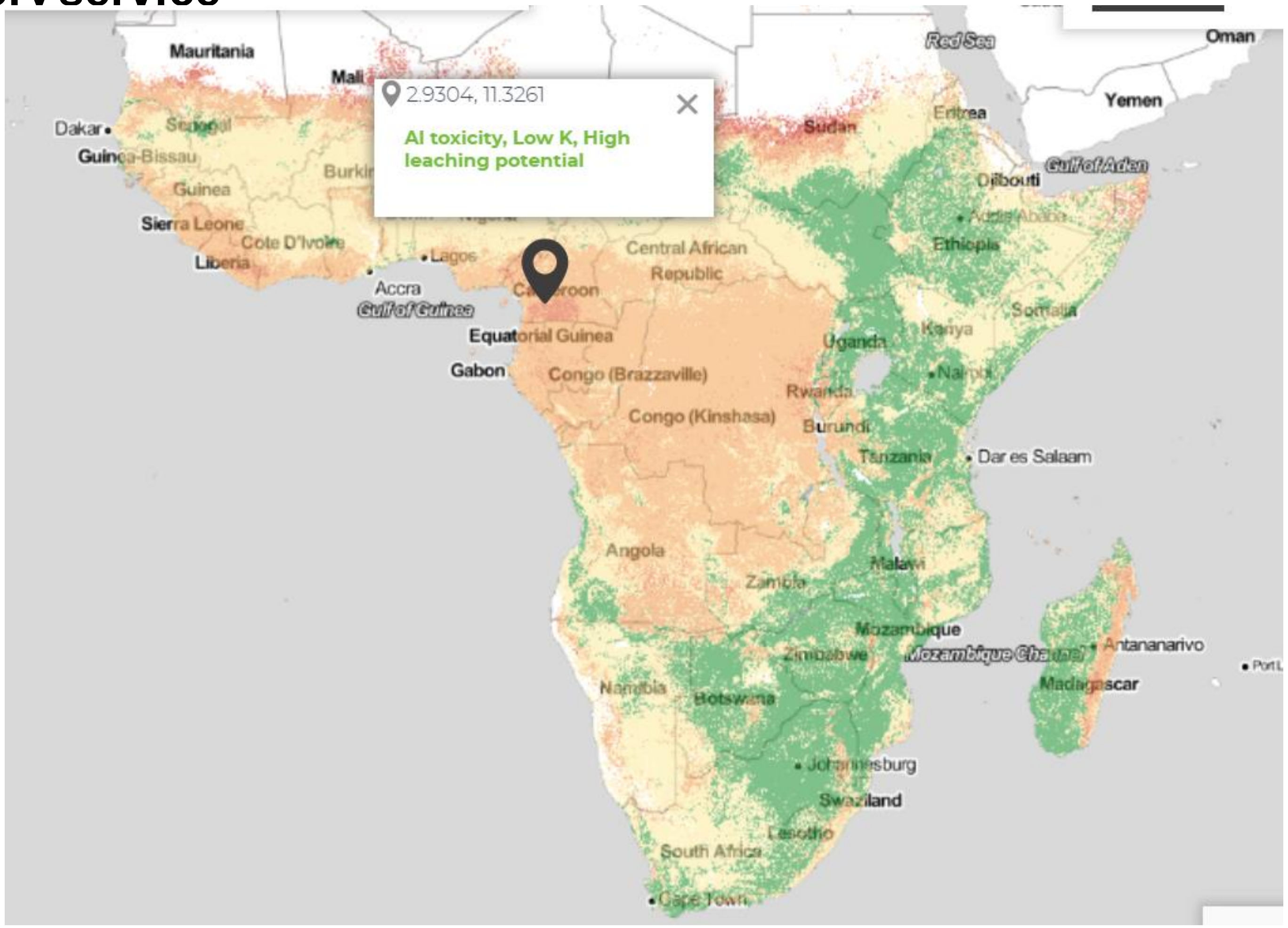
- Soil samples from over 100,000 locations
- Stack of covariates, incl. high resolution satellite data
- 5 regression modelling algorithms used in ensemble machine learning

22 soil properties (0-20 and 20-50 cm depths) at 30-m resolution = > 24 billion individual prediction locations

Open access soil property and nutrient maps for Africa at 30-m resolution

EXAMPLE: SOIL FERTILITY ADVISORY TOOL

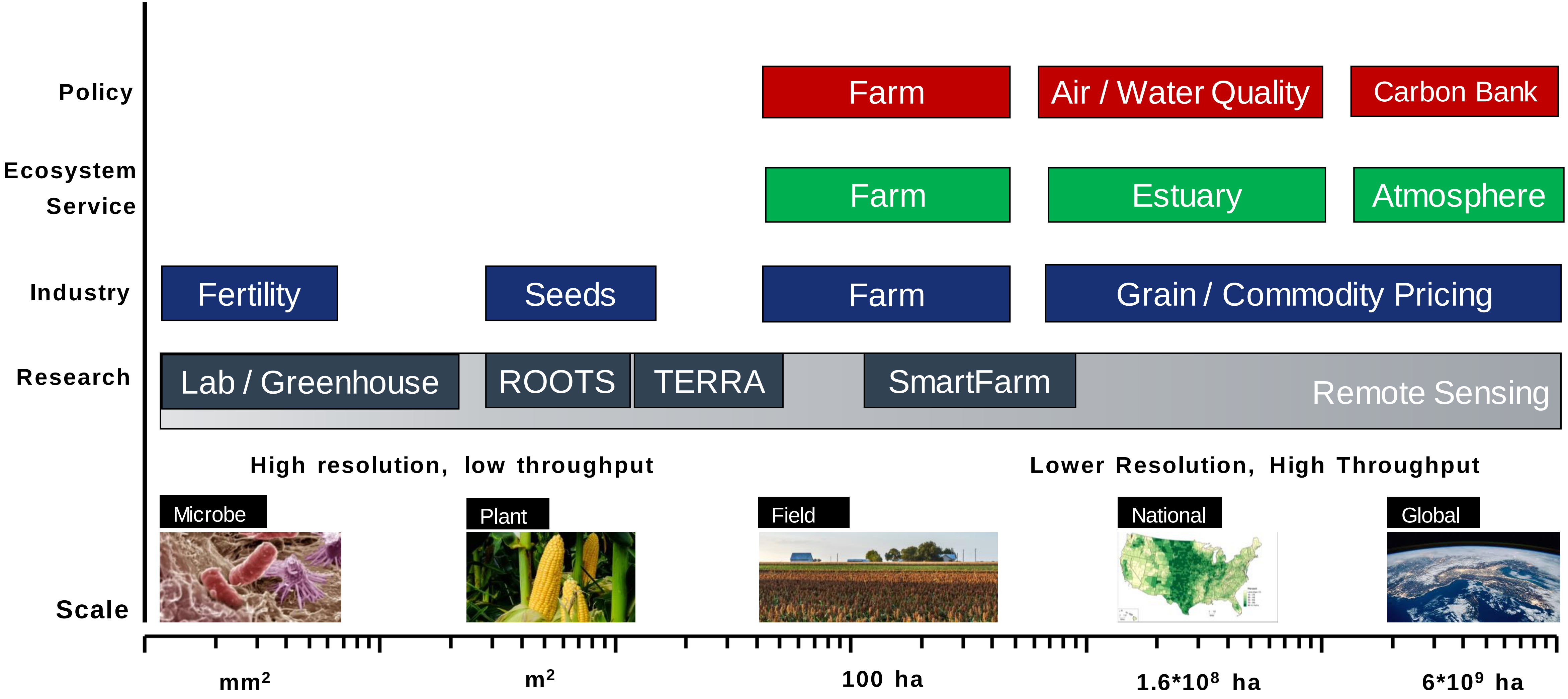
Building a spatial agronomy platform is fundamental to being able to provide a very low-cost, all-digital advisory service



Constraints to Productivity

Level
>5
4
3
2
1
0

SCALING RESEARCH AND TECHNOLOGY INFORMS POLICY AND CREATES MARKETS WITH CLIMATE IMPACT



CLIMATE-SMART SOIL TECHNOLOGY LANDSCAPE 2020

Transformative Investment in Climate-Smart Agriculture

FEBRUARY 2021

UNLOCKING THE POTENTIAL OF OUR SOILS

“Technology + Market + Policy”

Sponsors

Report Production

SMARTFARM PROGRAM FOR QUANTIFYING GHG FLUXES

1. Set a Baseline

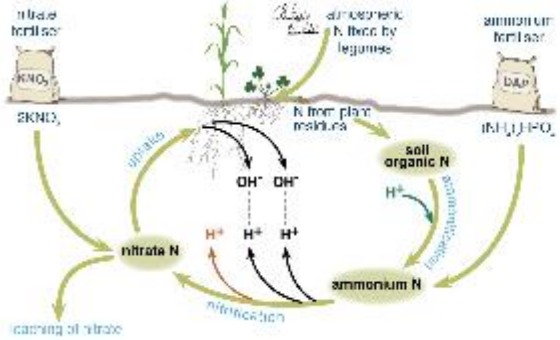
- Establish ground truth in real-world conditions
- Pilot market mechanisms
- Higher cost, higher resolution

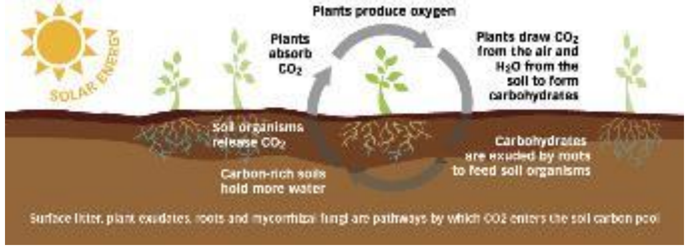
CHANGING WHAT'S POSSIBLE

A phased approach to quantify SOC and nitrogen fluxes in agricultural environments, and establish upstream carbon optimization incentives.

Phase I kicked off in April, 2020, and Phase II projects are getting underway in the spring of 2021.

2. Develop New Methods





- Directly measure N & C flux
- Increase reliability, resilience
- Reduce cost and footprint
- Incorporate IoT hardware

GREAT SCIENCE IS **COMPASSIONATE** SCIENCE

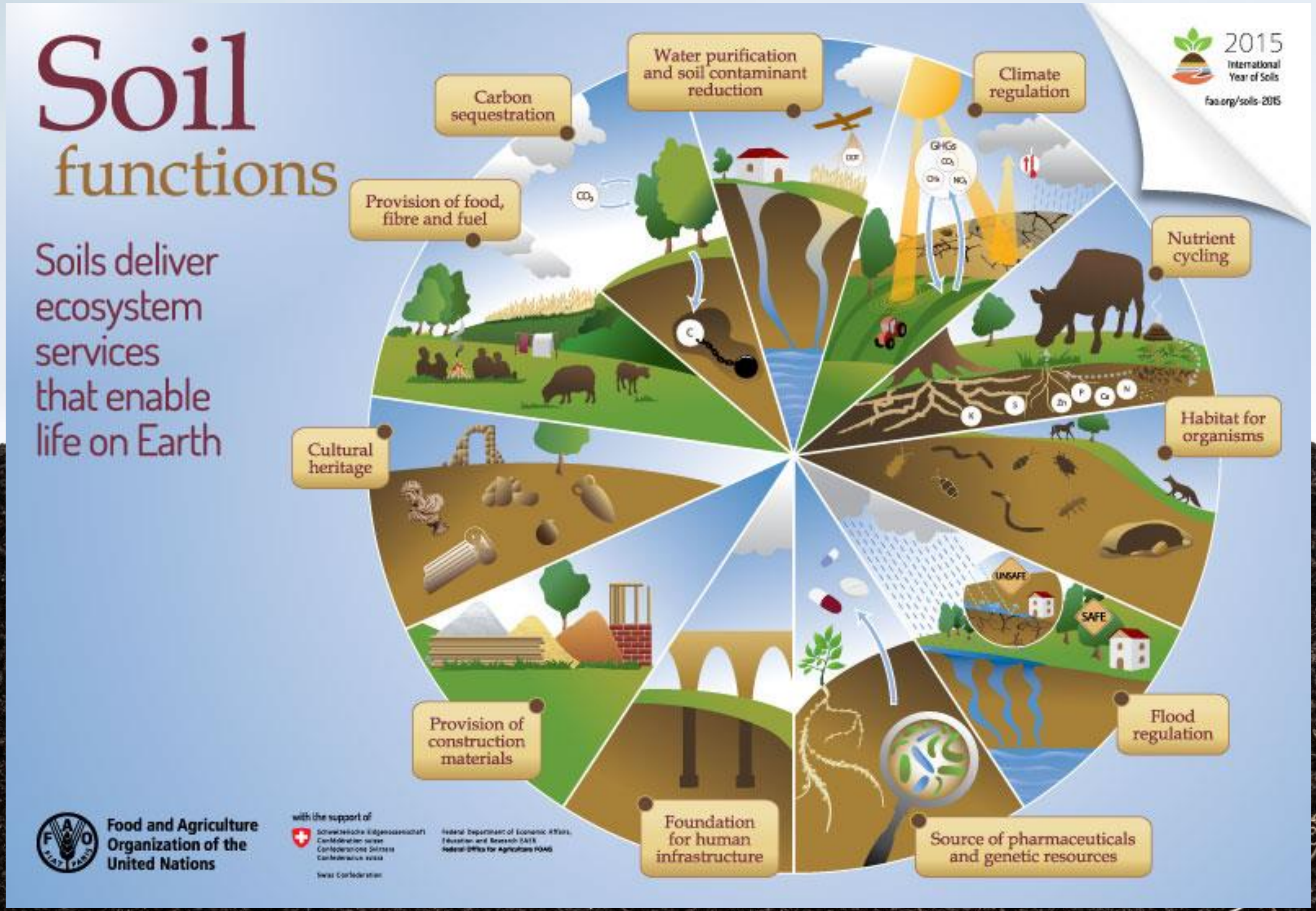
MARTIN LUTHER KING

THANK YOU!

Soil in Agricultural Systems

Ensuring we enhance ecosystems and human existence

Functions of Soil

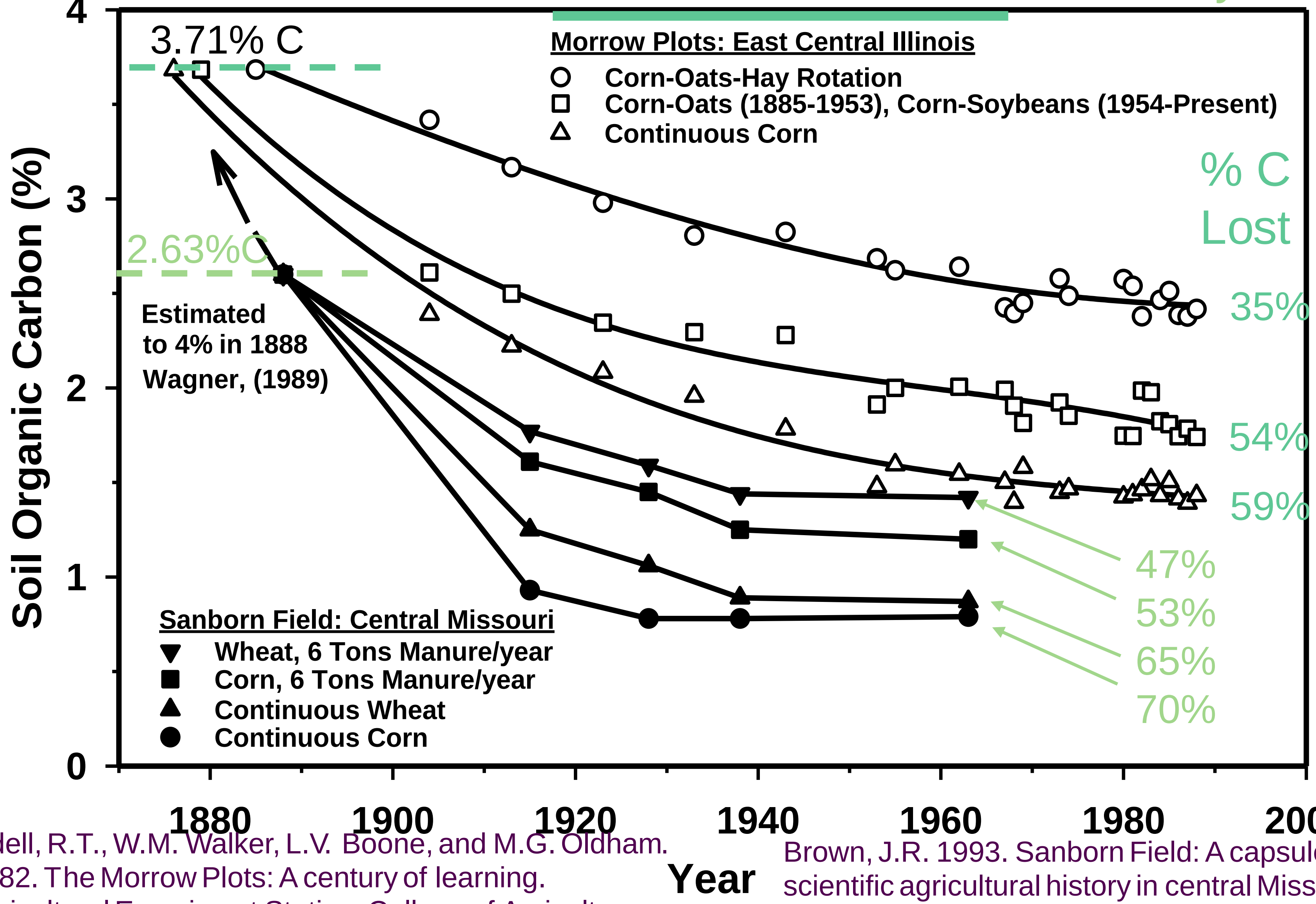


Functions of Soil- Agriculture

- Provide support for plants
- Serve as a water reservoir
- Nutrient source for plants
- Carbon cycling
- Decomposition of pesticides, antibiotics

Current State of Soils

Long Term Effects of Crop Rotations-110 years



Odell, R.T., W.M. Walker, L.V. Boone, and M.G. Oldham. 1982. The Morrow Plots: A century of learning. Agricultural Experiment Station, College of Agriculture, Univ. of Illinois Bull. 775, Urbana-Champaign, IL.

Brown, J.R. 1993. Sanborn Field: A capsule of scientific agricultural history in central Missouri. Missouri Agric. Experiment Station, Columbia, MO.

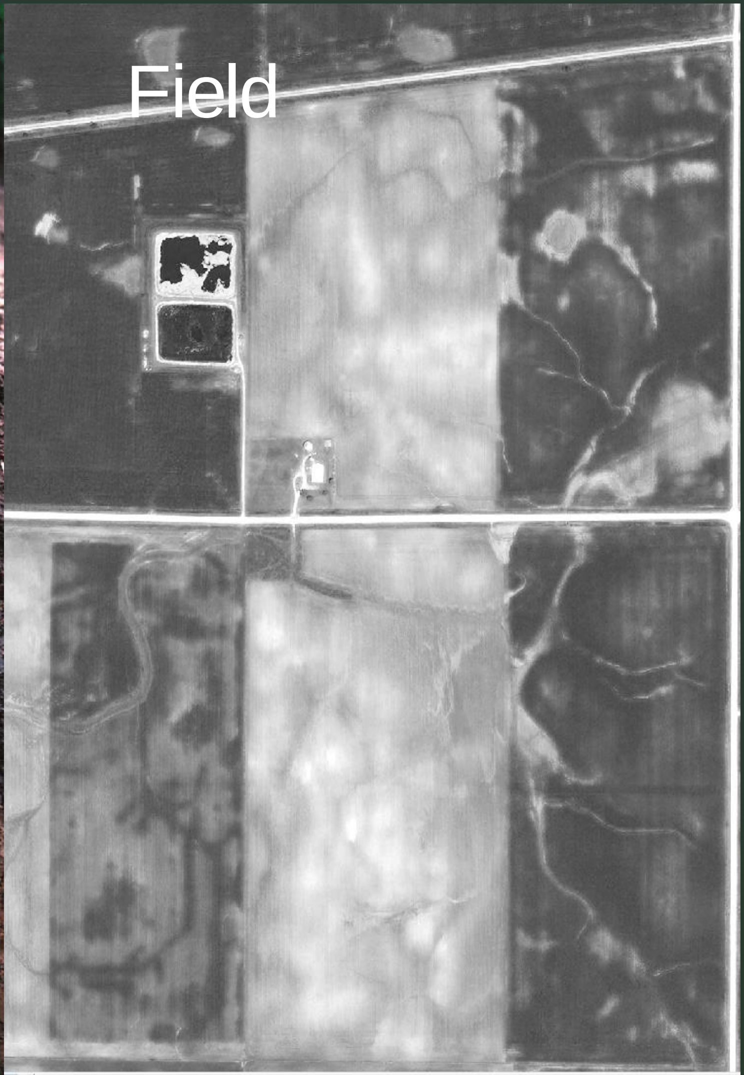
Agricultural Systems have Changed Our Soils

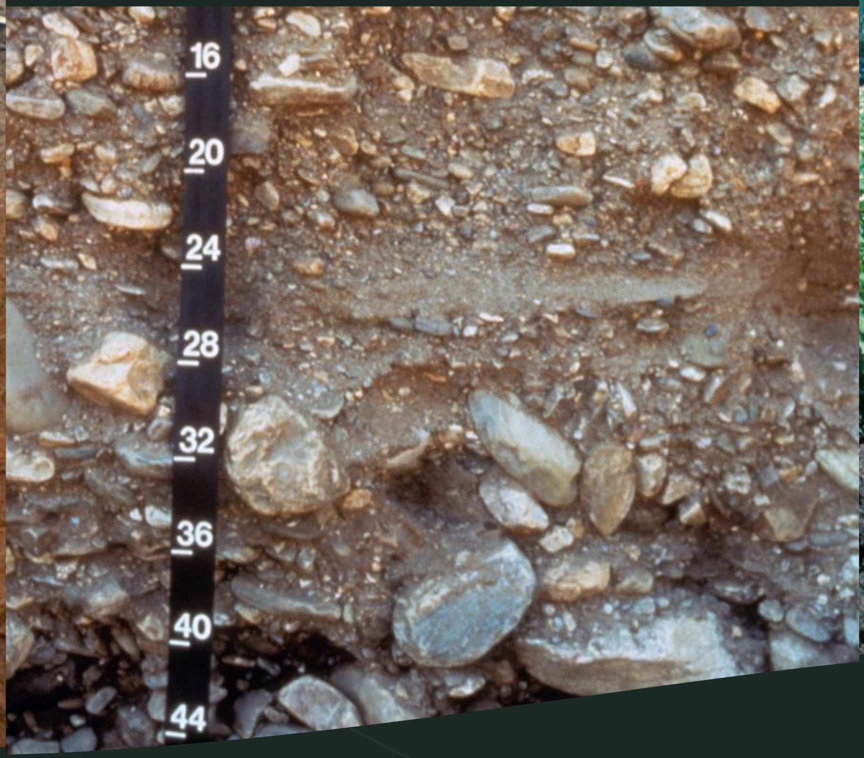
- Removed organic matter through tillage
- Cropping practices that limit return of carbon to the soil
- Reduced the functionality of soils and increased reliance on external inputs
- Increased erosion rates and increased soil degradation

Primary factor affecting agricultural systems is water

Our view of soil and agriculture is scale dependent

Scales of Soil in Agriculture





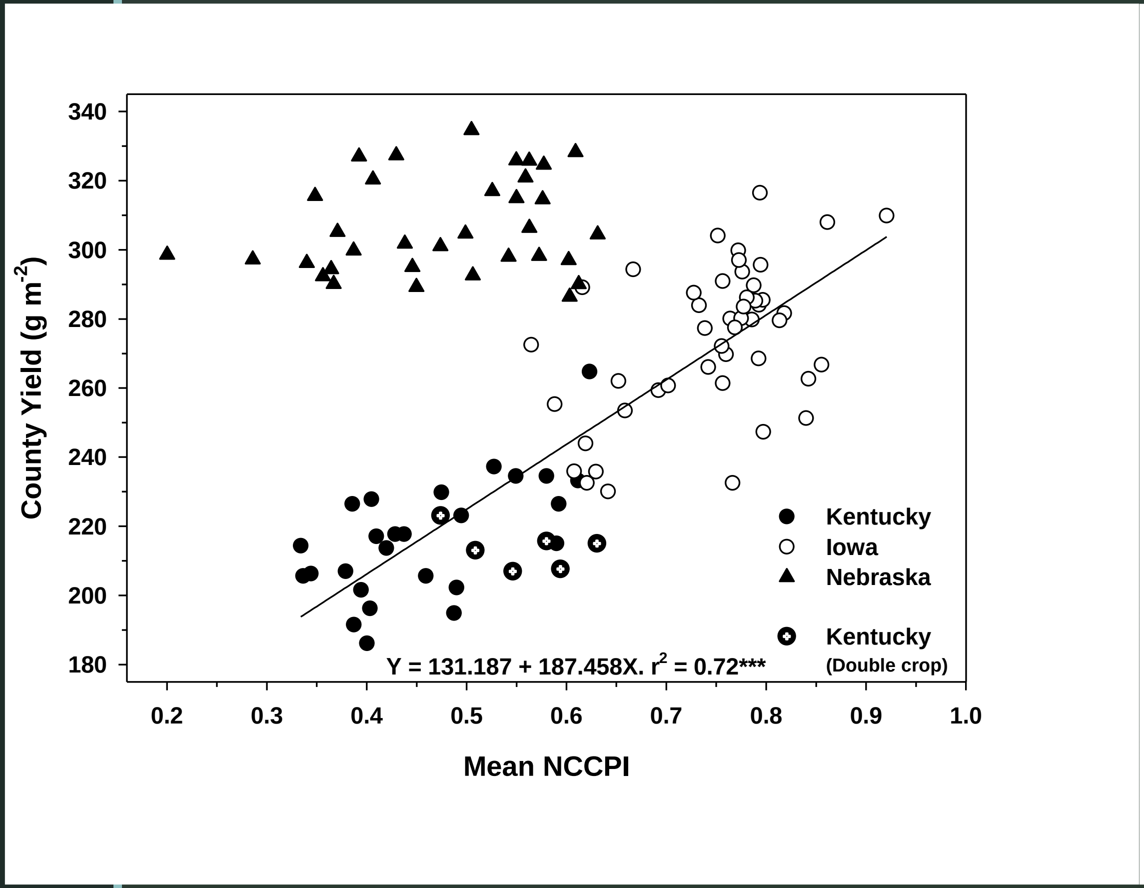
Soils are Diverse

Interdependence of Soil Functions

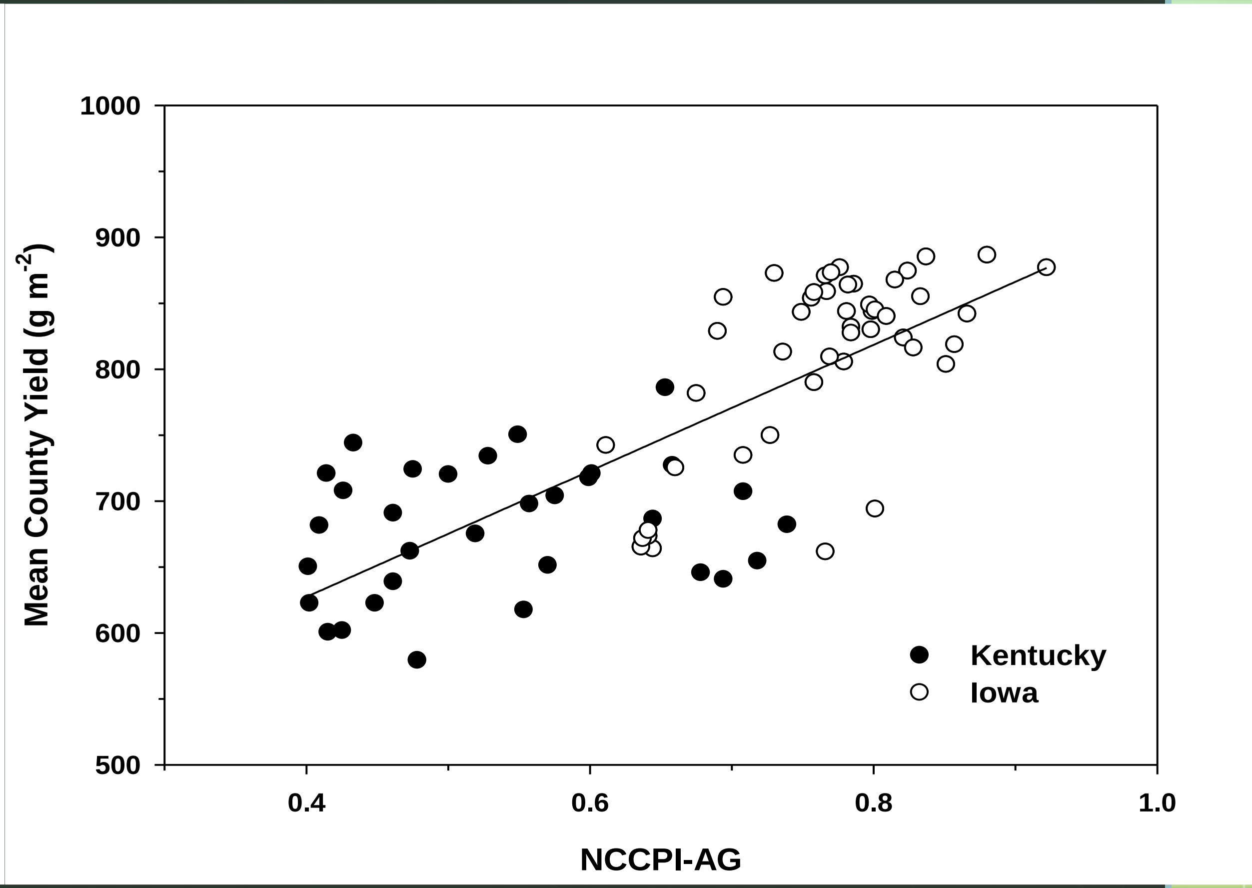
- Soil water is not separate from nutrient availability
- Support for plants is not separate from soil water availability

Good Soils = Good Yields

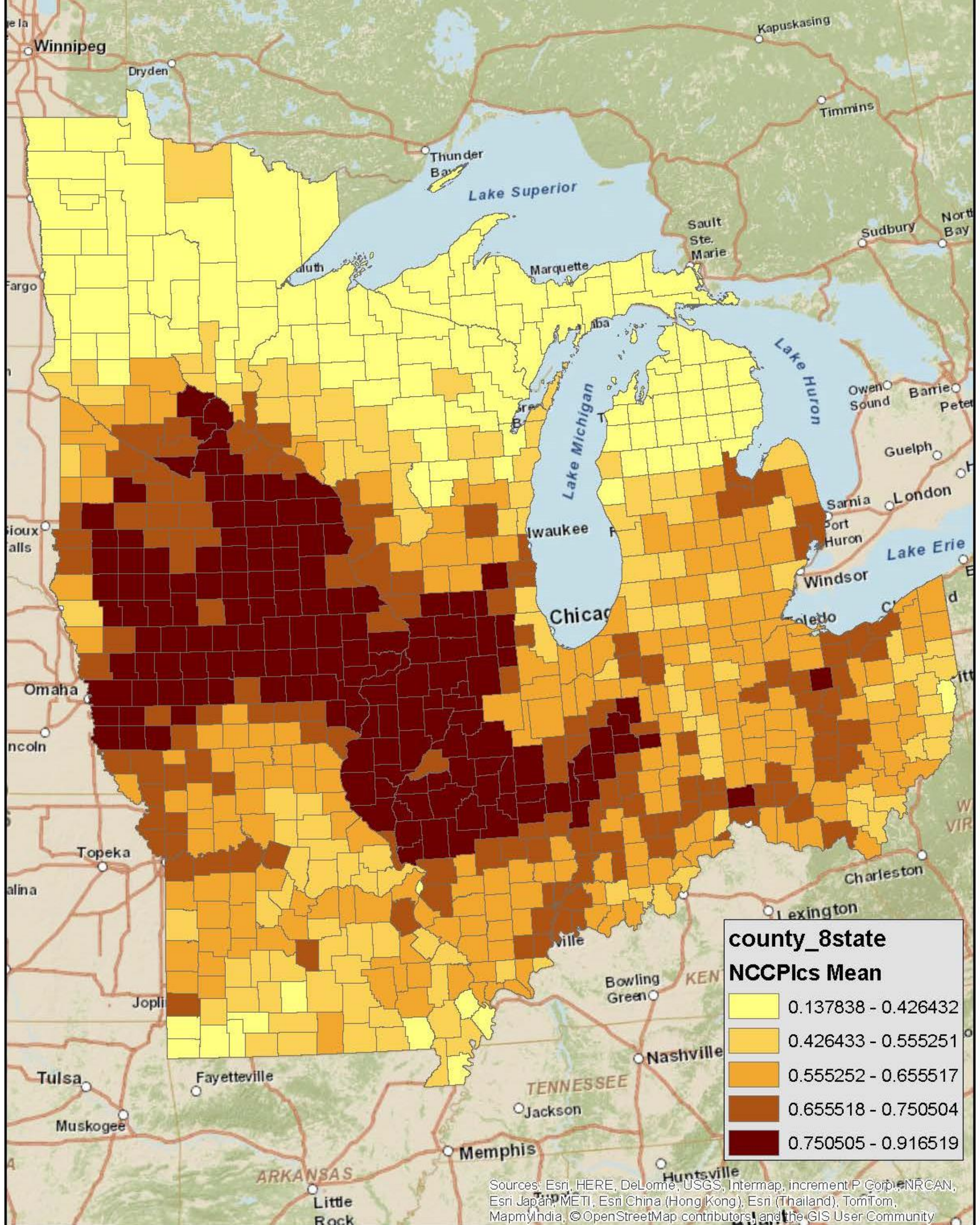
Soybean



Maize



Egli and Hatfield, Agronomy Journal, 2014a and 2014b



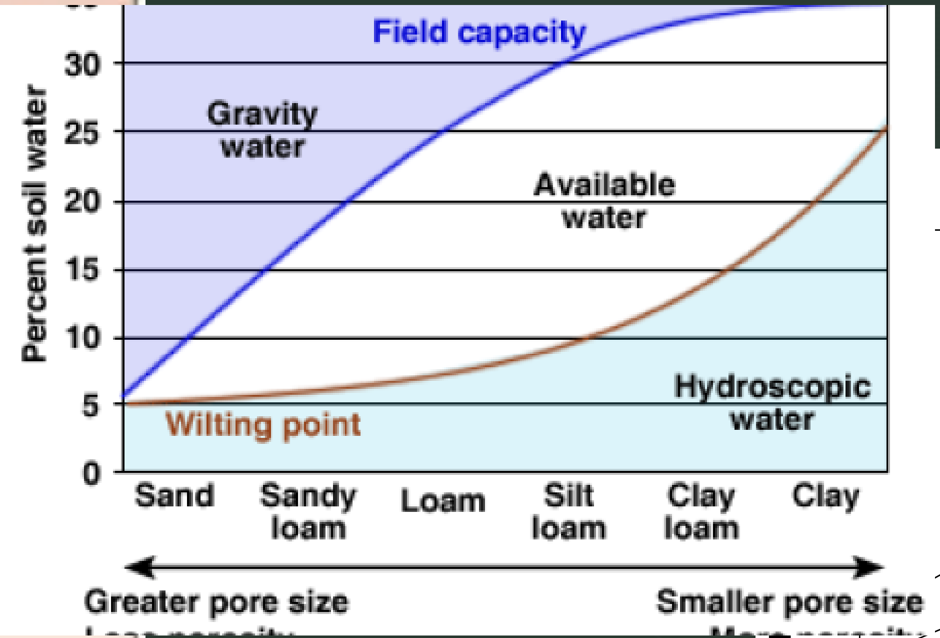
Variation in NCPPI across the Midwest

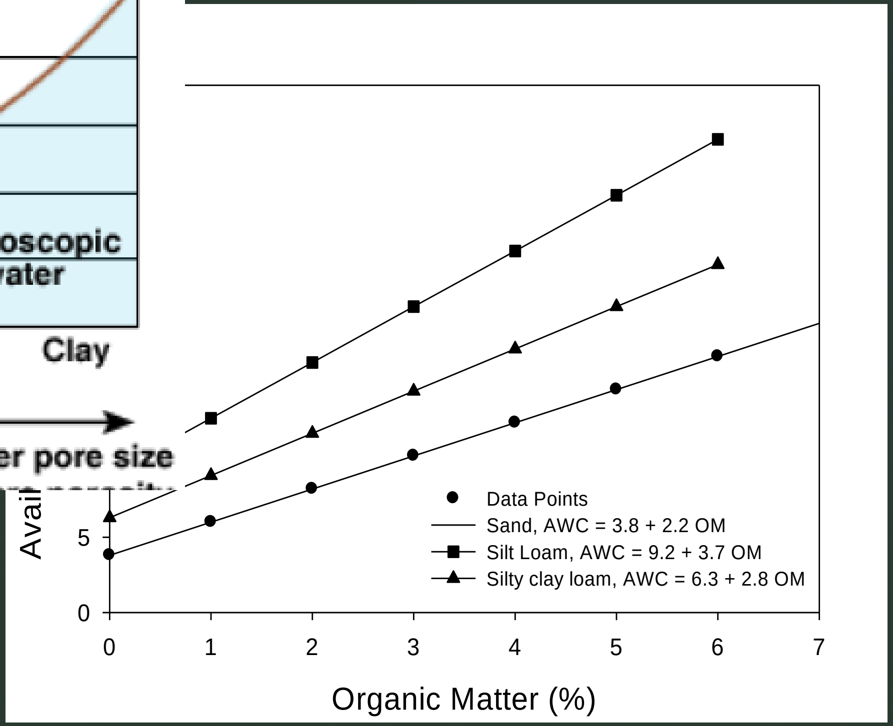
What do we need to know about soil for agricultural systems?

Enhance the functionality of soil

What we know about soils and water

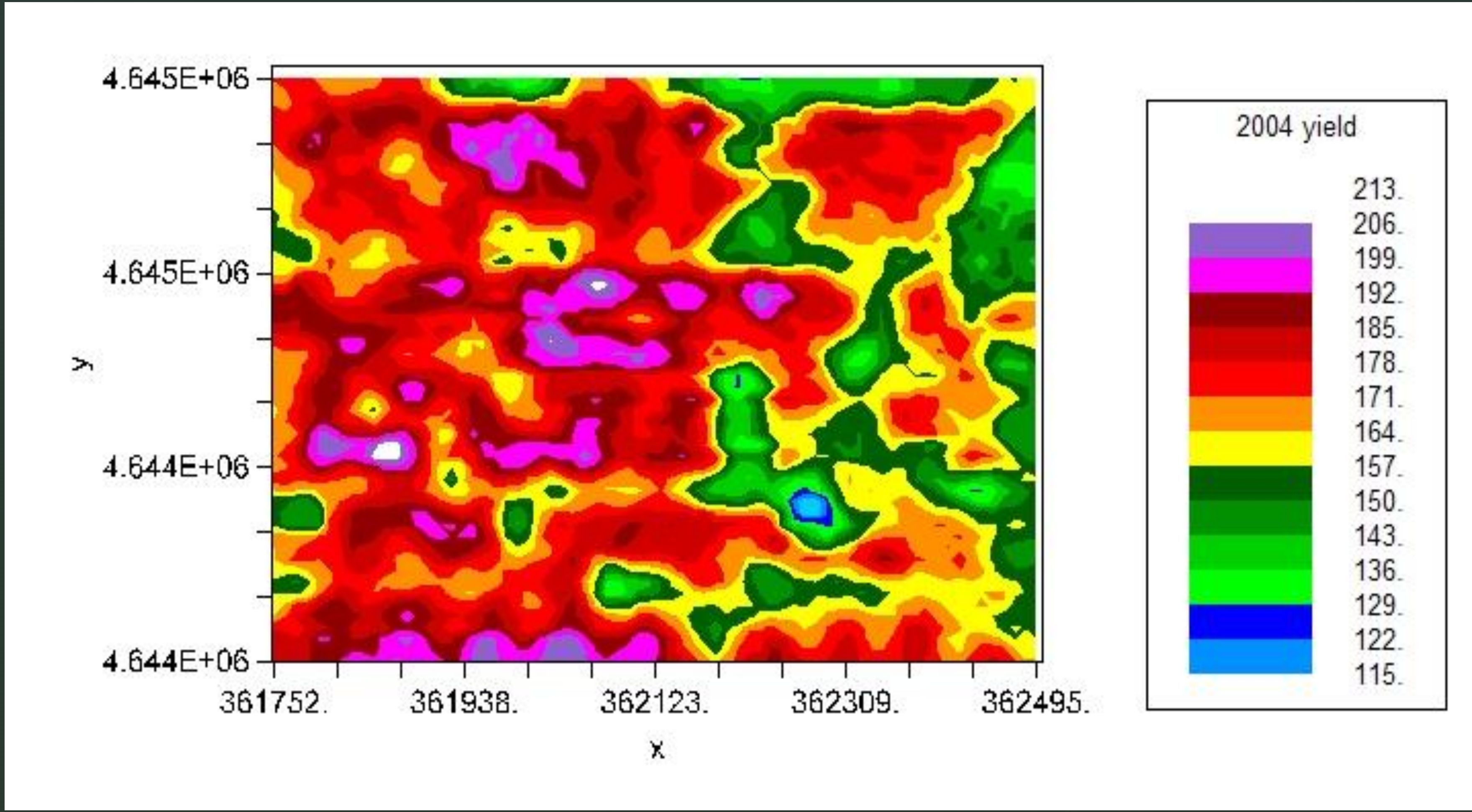
Available water capacity by soil texture	
Textural class	Available water ca[...] (inches/foot of de[...]
Coarse sand	0.25–0.75
Fine sand	0.75–1.00
Loamy sand	1.10–1.20
Sandy loam	1.25–1.40
Fine sandy loam	1.50–2.00
Silt loam	2.00–2.50
Silty clay loam	1.80–2.00
Silty clay	1.50–1.70
Clay	1.20–1.50



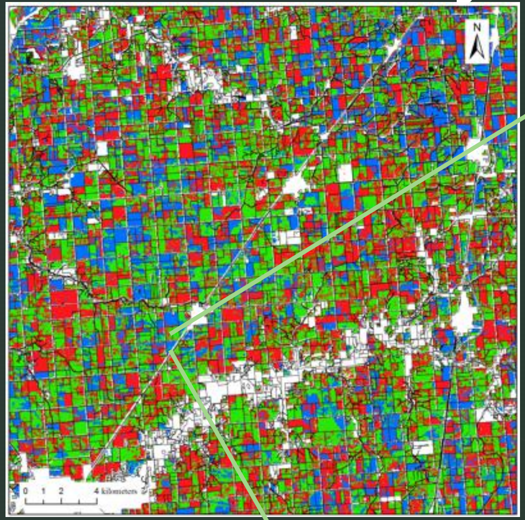


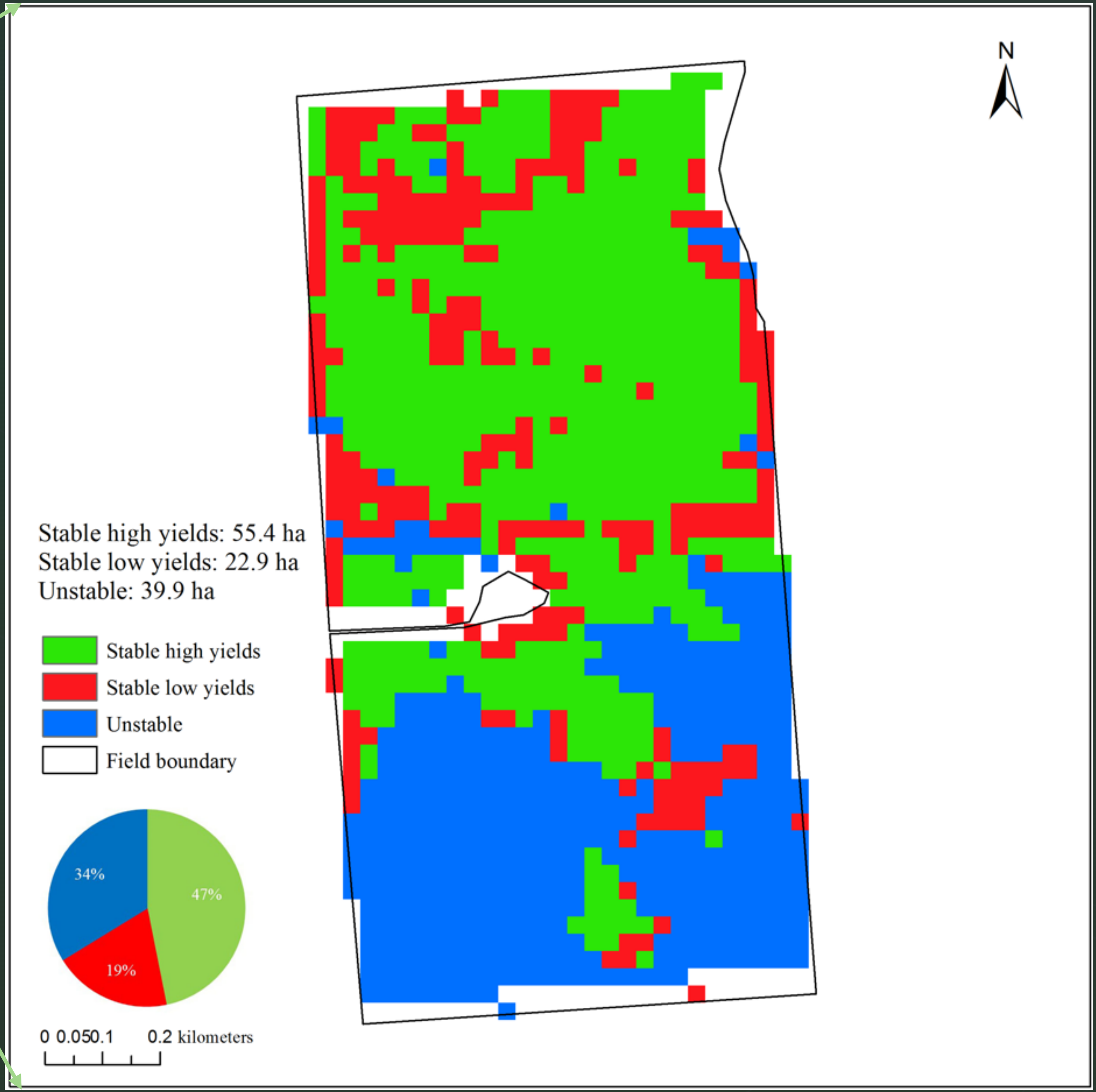
Hudson, 1994

Impact on productivity

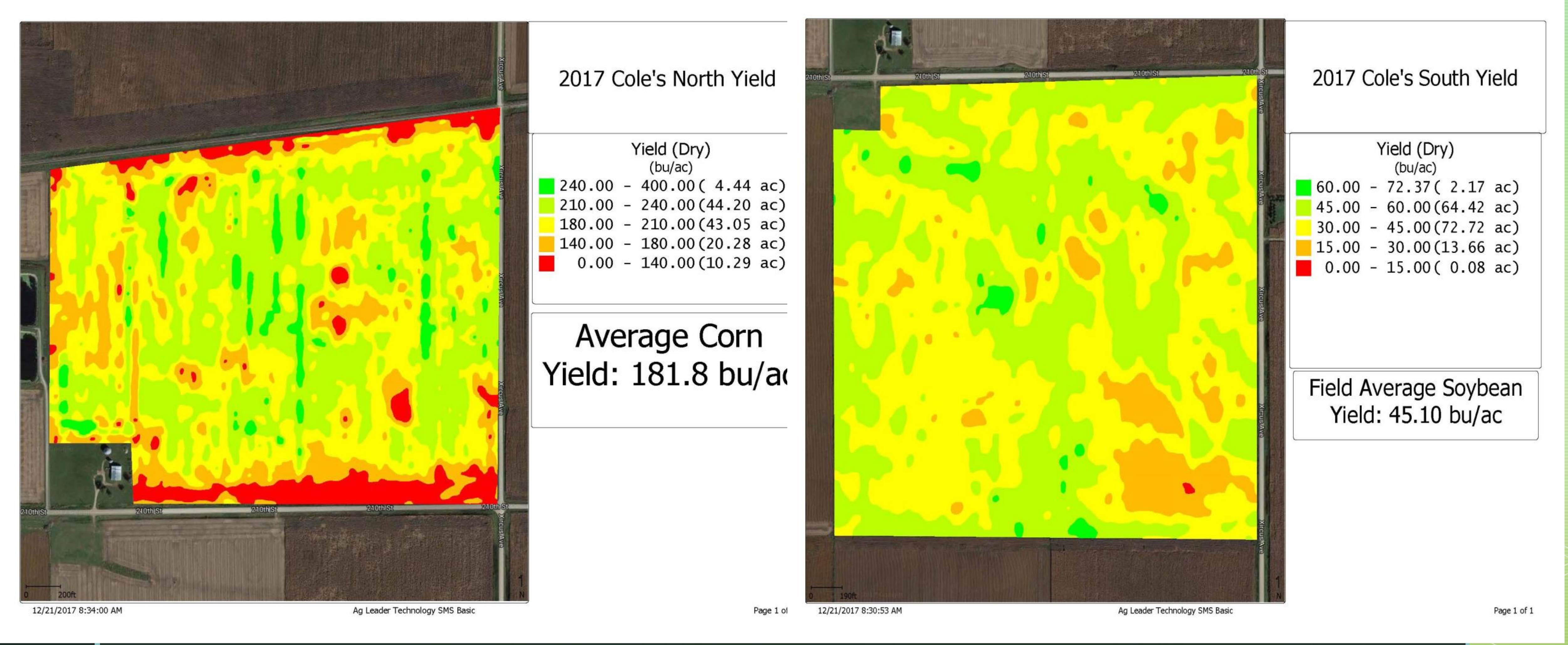


Yield stability- within field scale (70M acres)

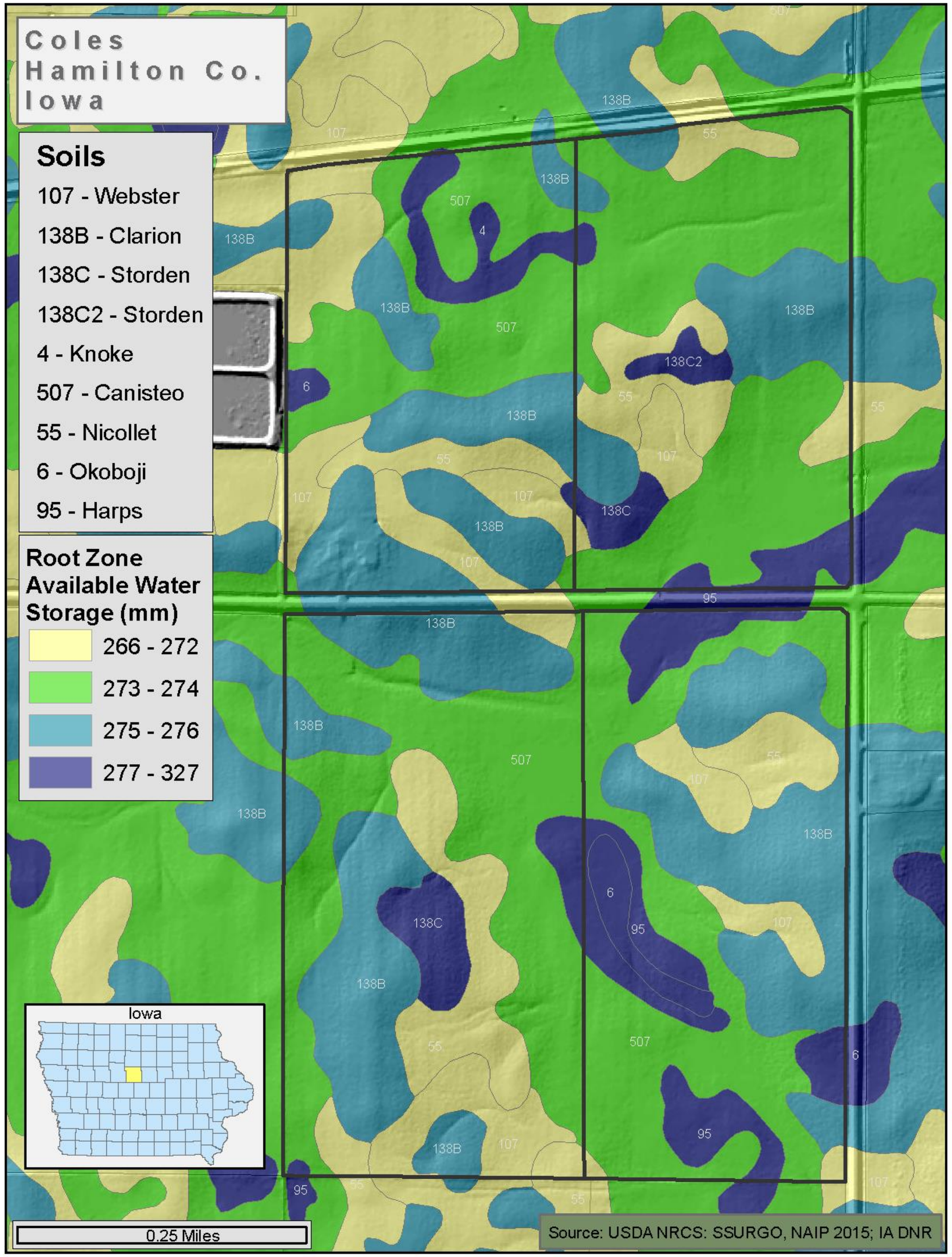




Field Scale Yield Variation

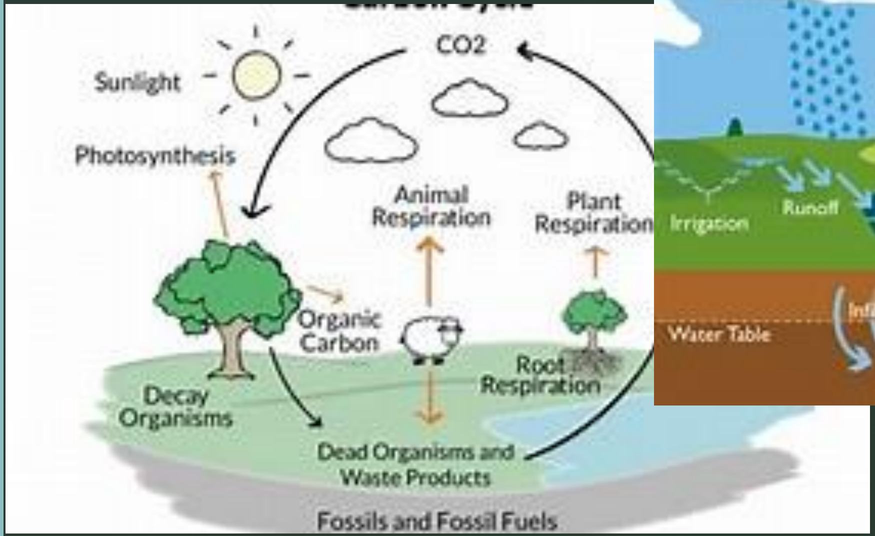


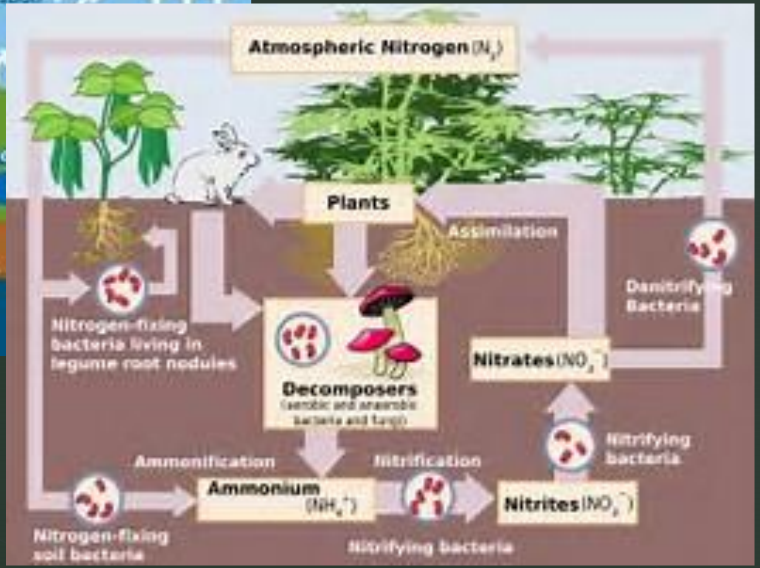
Variation of Water Holding Capacity within a production field



The central question is what can we do to change soil water availability and what do we need to know for information to evaluate the effect of these changes?

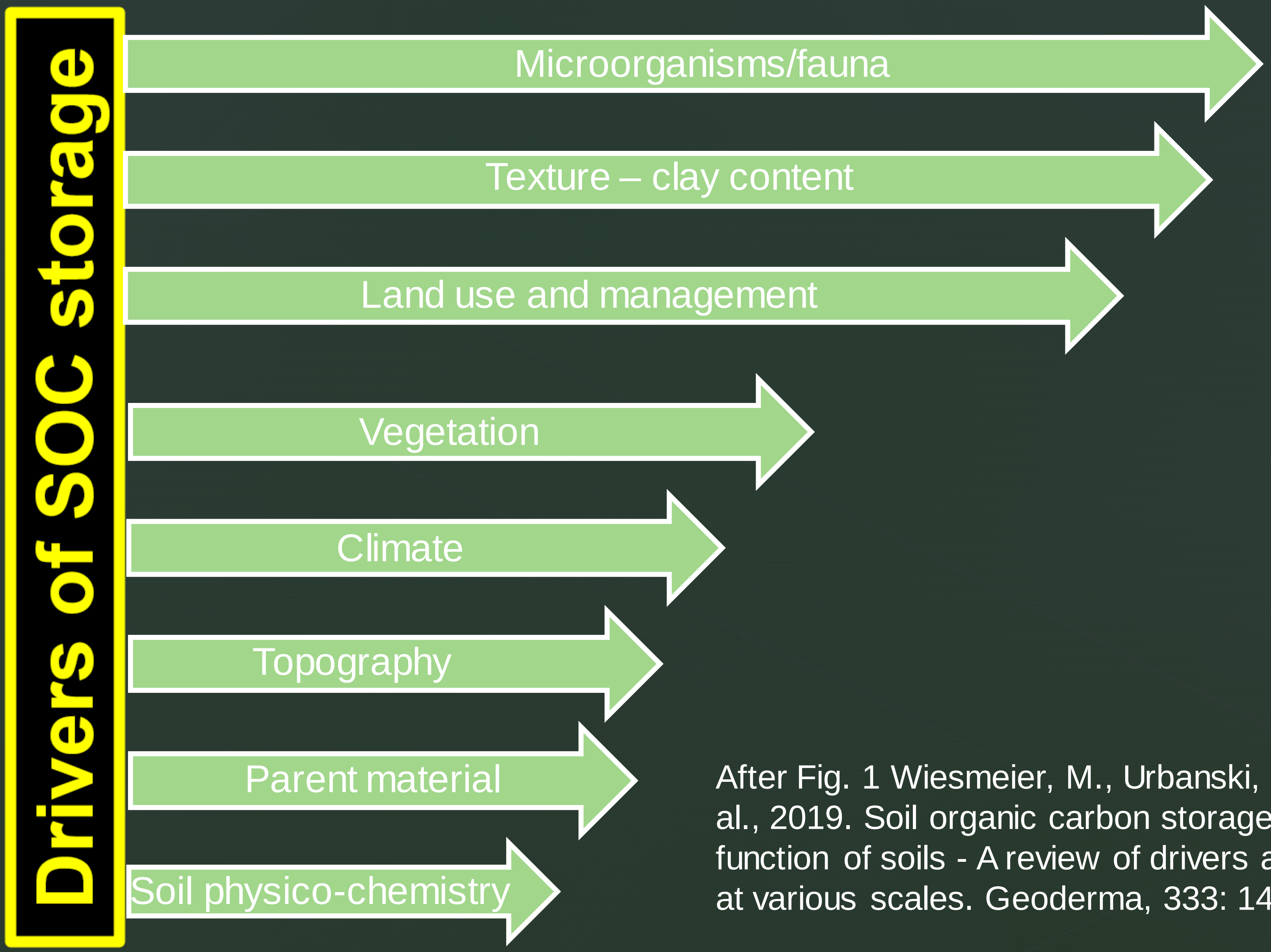
Reality of Agricultural Systems





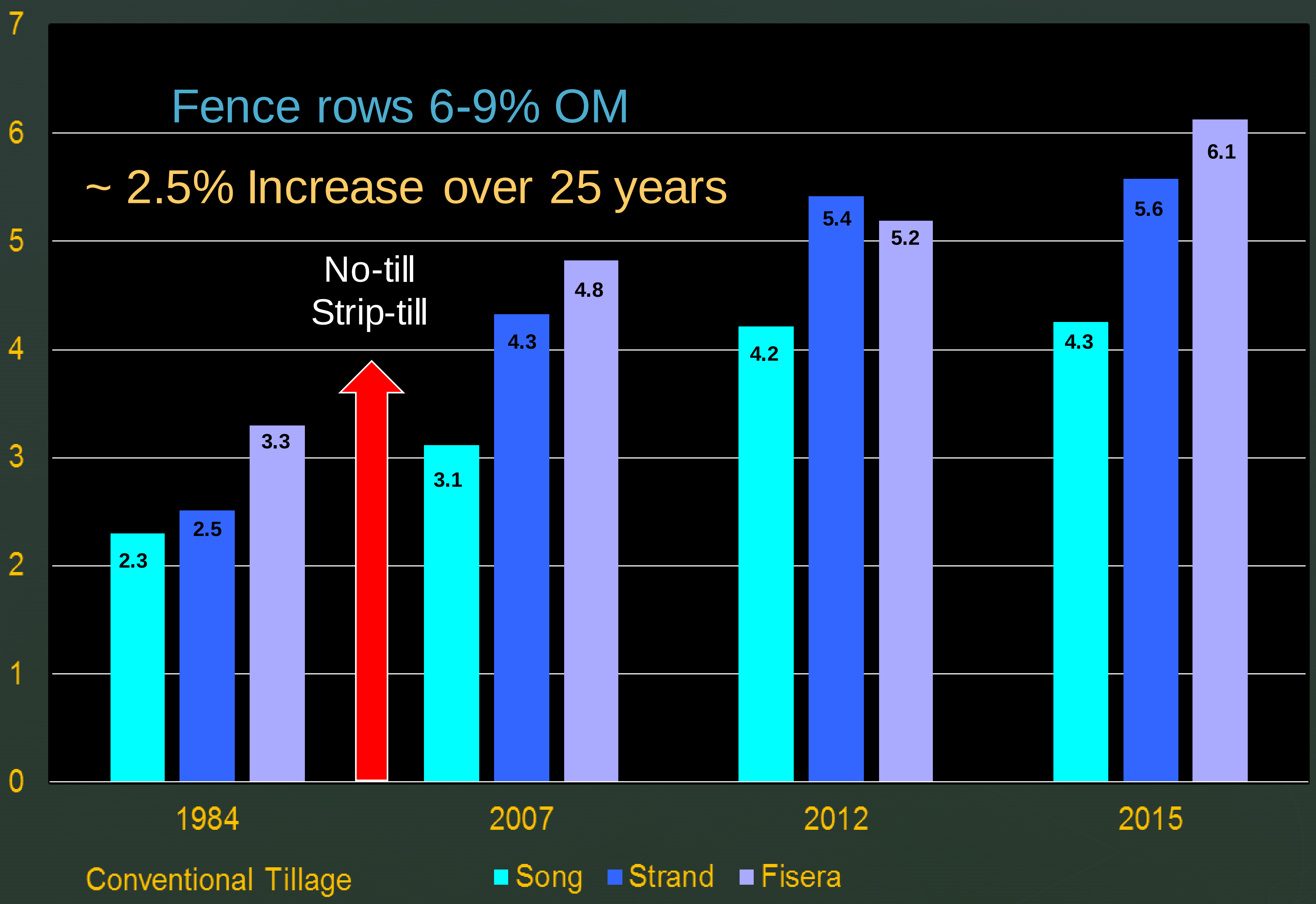
Agricultural systems are comprised of a number of processes and cycles

Relative ranking of SOC storage drivers



After Fig. 1 Wiesmeier, M., Urbanski, L., Hobley, et al., 2019. Soil organic carbon storage as a key function of soils - A review of drivers and indicators at various scales. Geoderma, 333: 149–162.

Organic Matter % Change Over Time



Evaluation of Changes in Soil

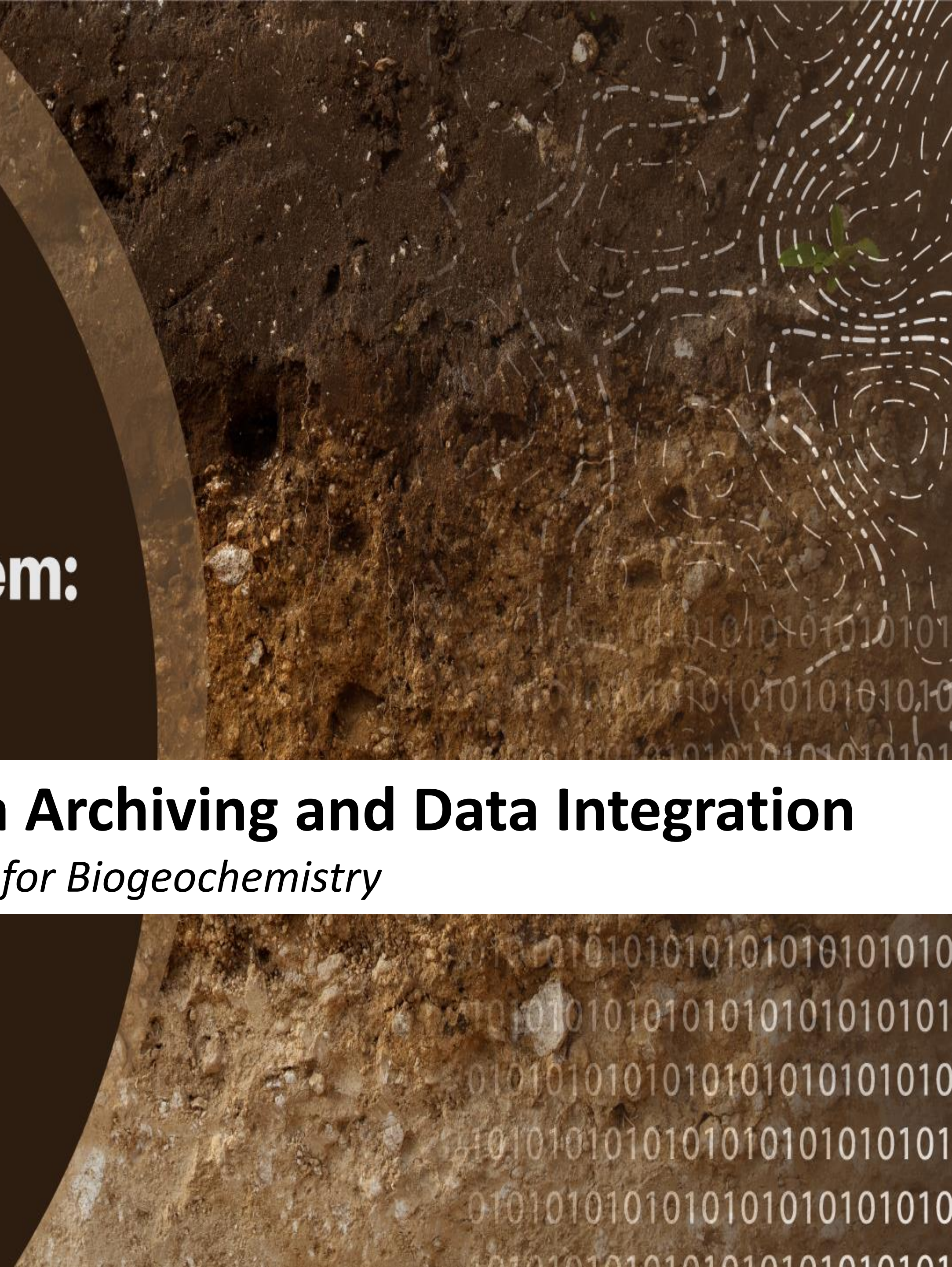
- Requires an understanding of interactions of processes within the soil volume
- Requires understanding of the history of soil management
- Need to understand what information is required about soil response to management

Why do we need to have soils information?

- Efficient production requires we understand the functionality of soils
- Functionality of soils are linked with climate and management in order to produce crops and livestock
- Our challenge should be to focus on how we can simultaneously increase functionality and production efficiency (inputs/outputs) through the use of information at different scales

The National Academies of SCIENCES ENGINEERING MEDICINE

Exploring a Dynamic Soil Information System: A Workshop



The Importance of Data Archiving and Data Integration

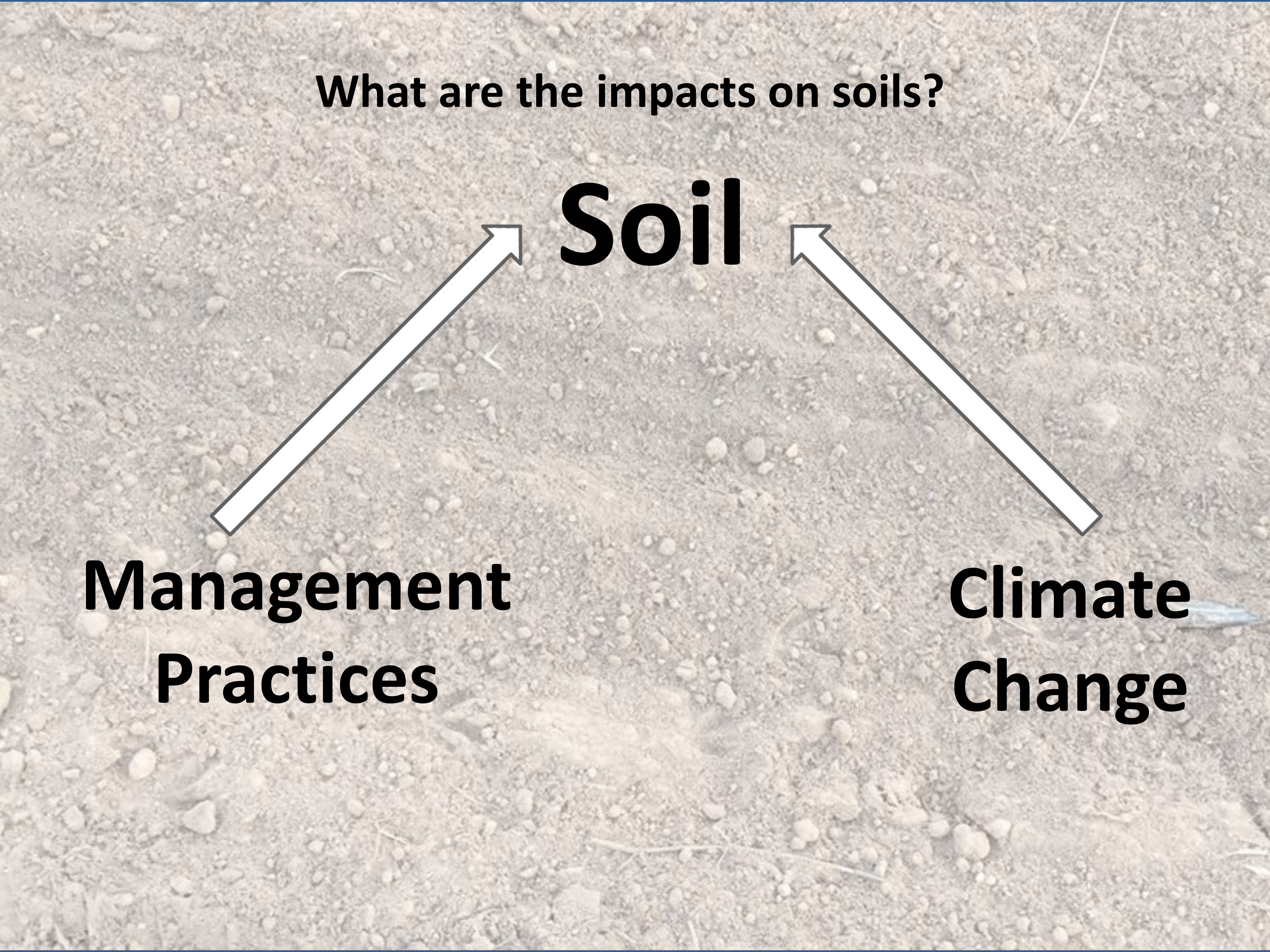
Alison Hoyt, Max Planck Institute for Biogeochemistry

How are land management and climate change impacting soils?

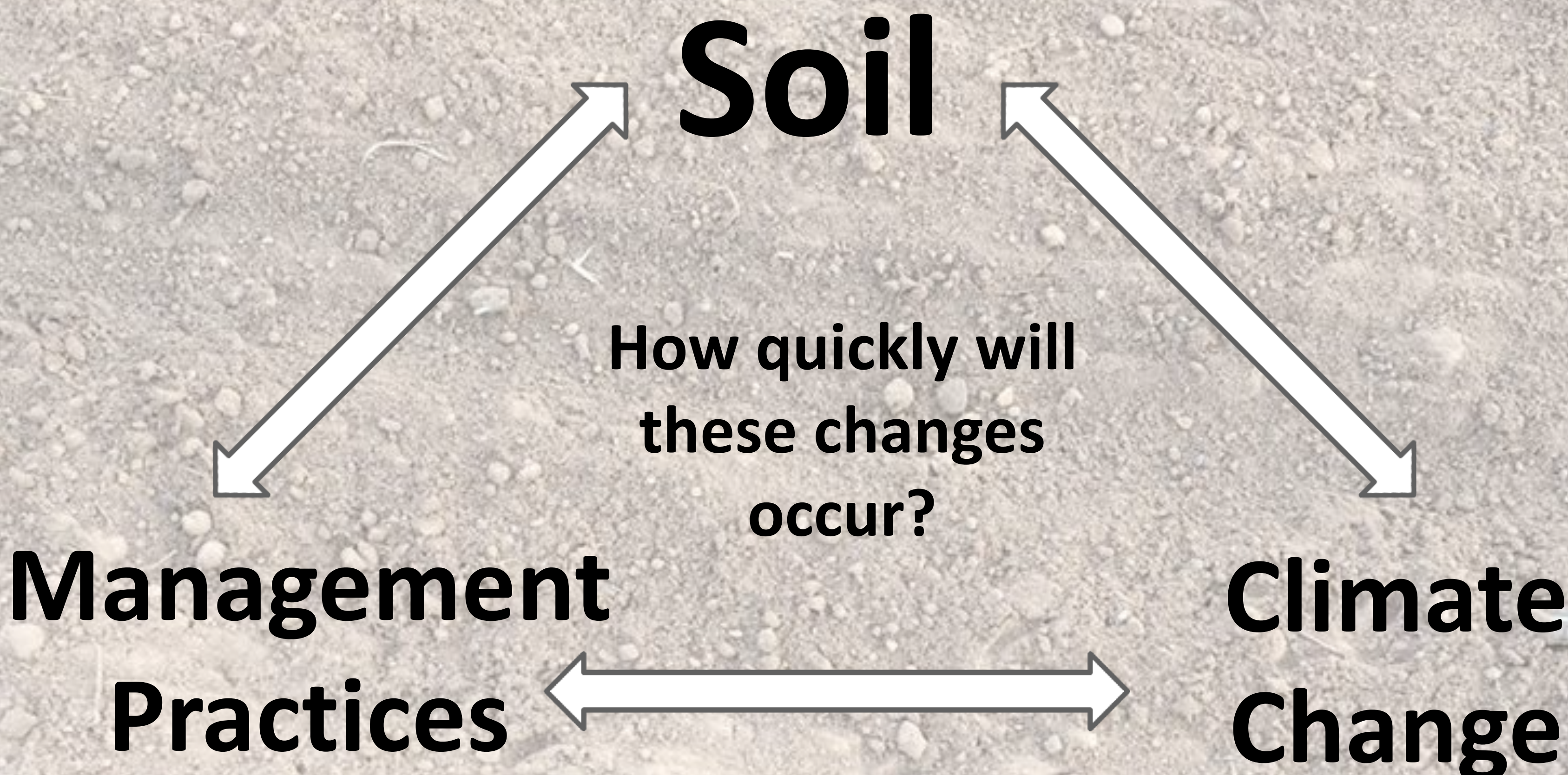
Impacts of Soil Erosion, Democratic Republic of Congo

How are land management and climate change impacting soils?

Permafrost Thaw, Siberia


What are the impacts on soils?
Soil
Management Practices
Climate Change

What are the impacts on soils? Feedbacks?



What is the potential of soils to mitigate climate change?

Soil C

1. Current stocks?
2. How might they change?
3. On what timescales?

How can we leverage soil data to answer these questions?

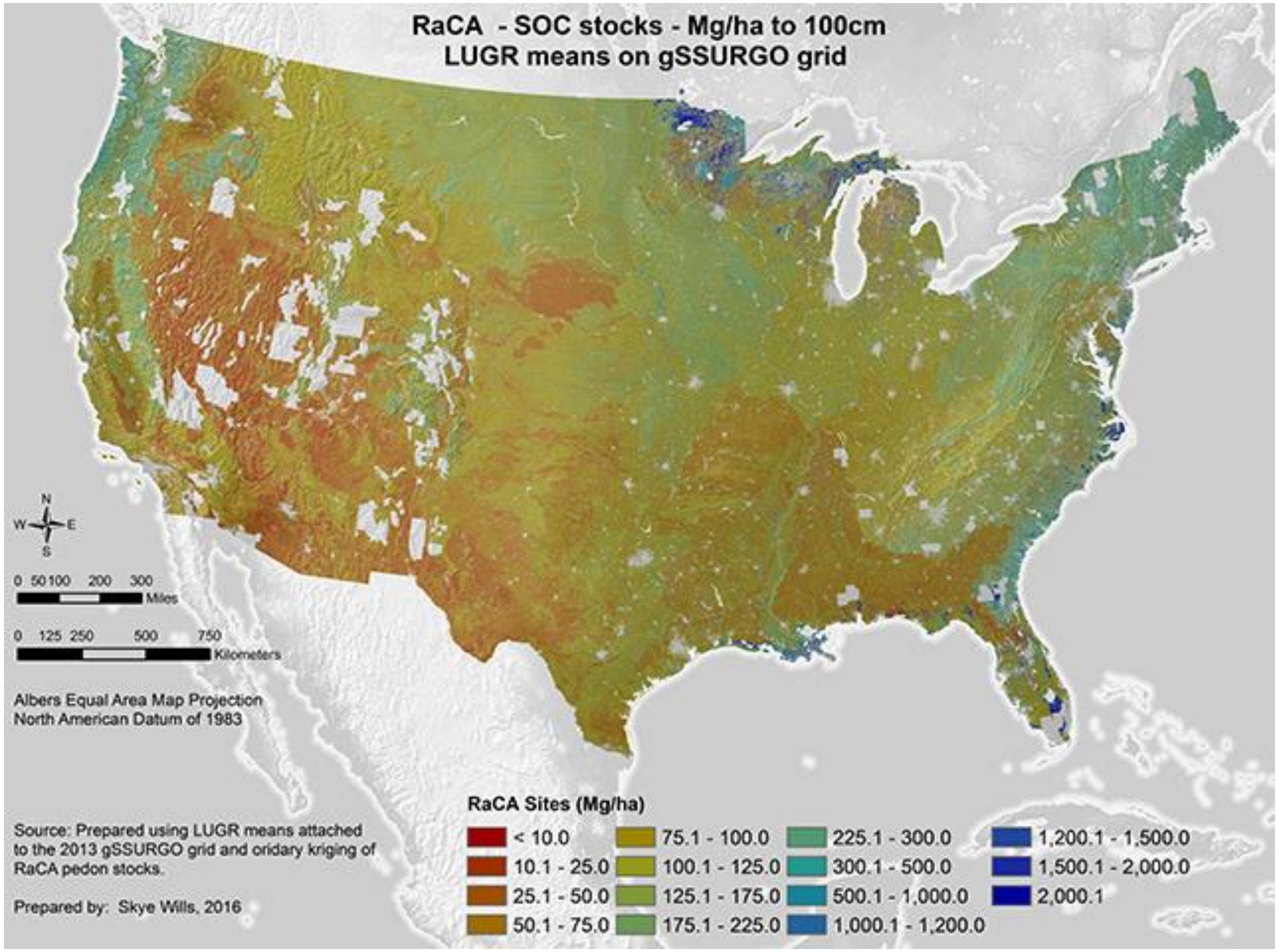
Part I: Continental scale sampling and data organization efforts

Part II: Grassroots efforts to organize data around central scientific questions

Part I:

Continental scale sampling & data organization efforts

Rapid Carbon Assessment (RaCA)



USDA Natural Resources Conservation Service
United States Department of Agriculture

NSF | neon
Operated by Battelle

EU Soil Observatory (EUSO) – launched Dec 2020
A dynamic and inclusive platform to provide
soil knowledge and data flows to safeguard soils

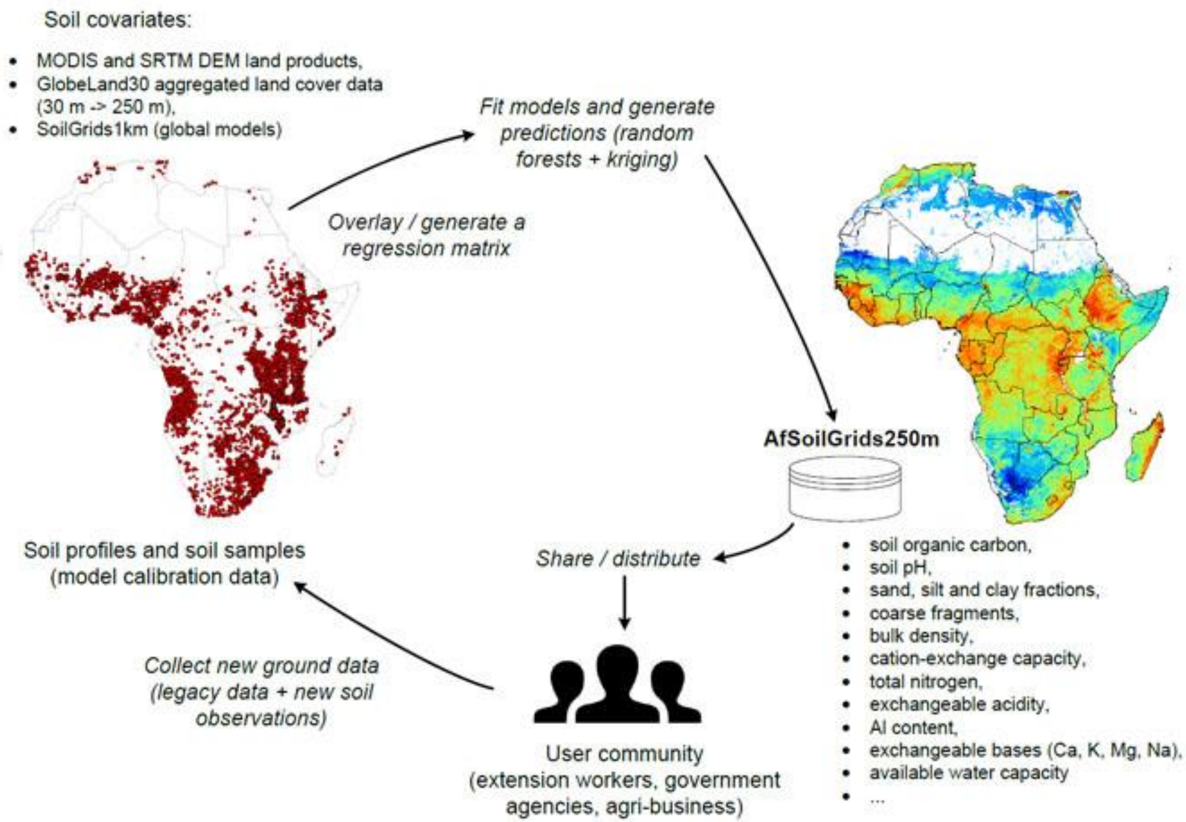
European Soil Data Centre (ESDAC)
Centre for datasets, services/applications, maps,
documents, events, projects and external links

European Commission

JOINT RESEARCH CENTRE

EUROPEAN SOIL DATA CENTRE (ESDAC)

African Soil Information System



Continental-scale Efforts

Pros:

-Systematic sampling and data organization

-Consistent standards; measurement by same lab; Careful sampling design

Continental-scale Efforts

Pros:

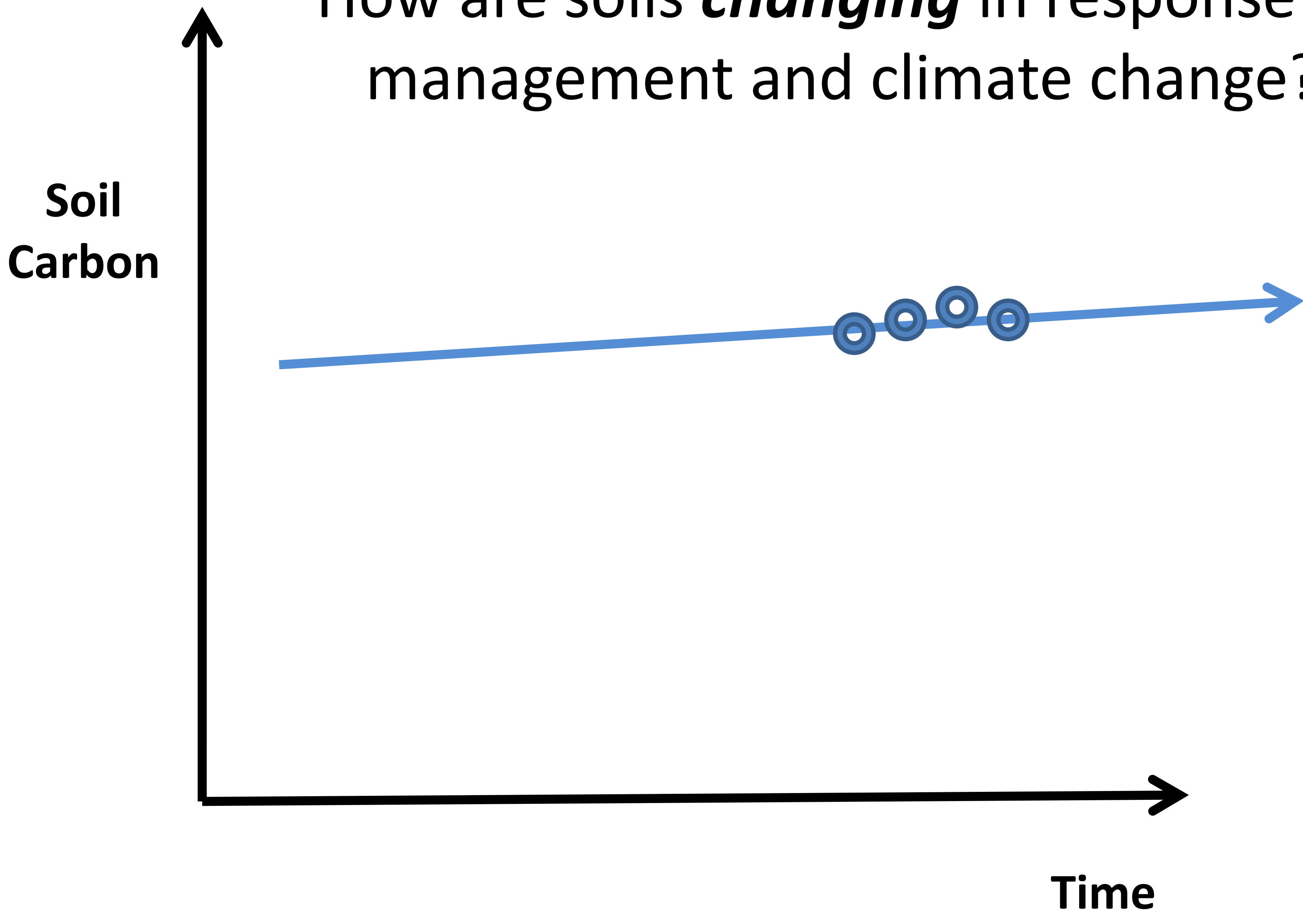
-Systematic sampling and data organization

-Consistent standards; measurement by same lab; Careful sampling design

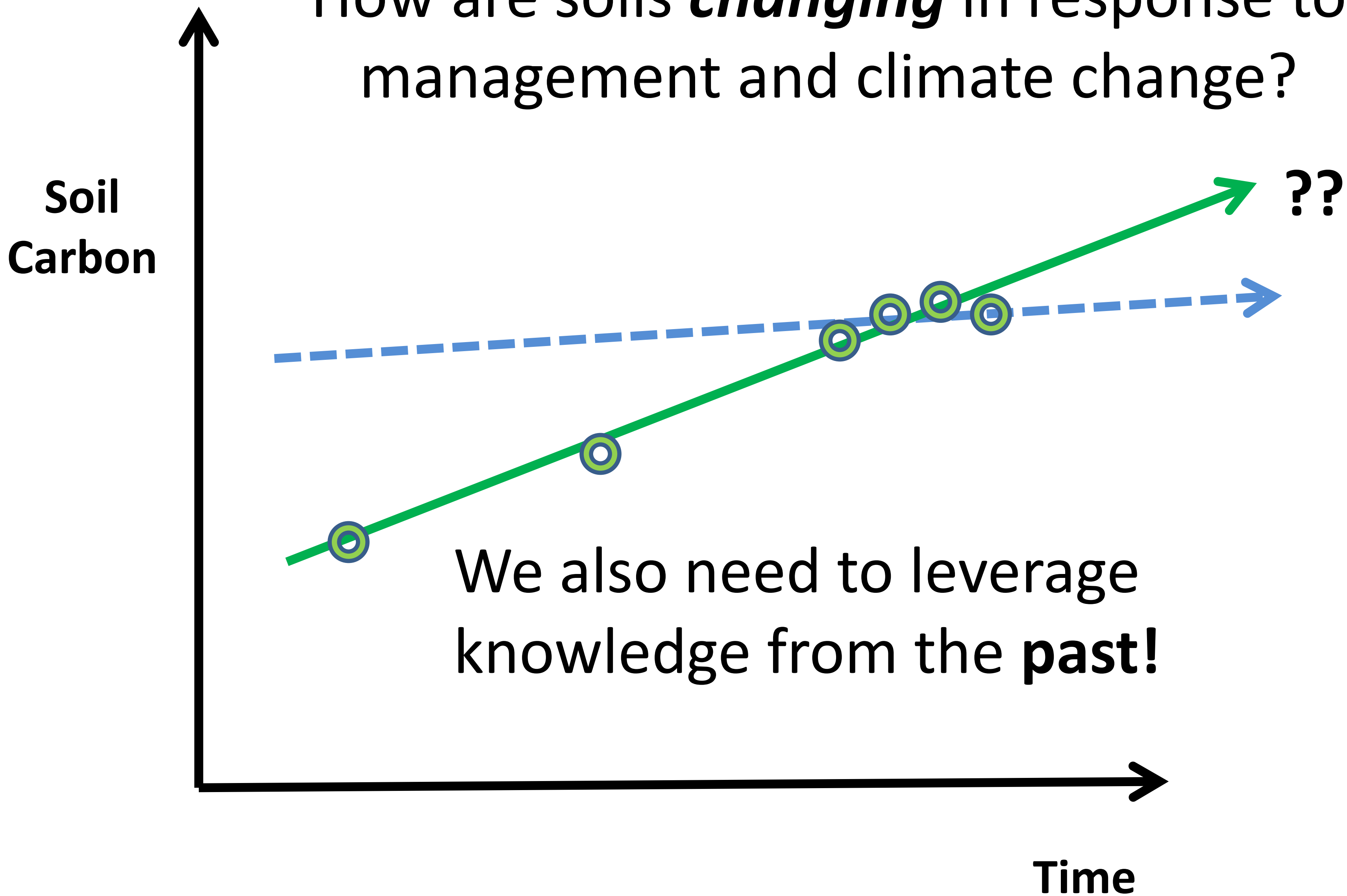
Cons:

-Can't go back in time! Measuring current soils is not always enough to answer key questions

How are soils ***changing*** in response to management and climate change?



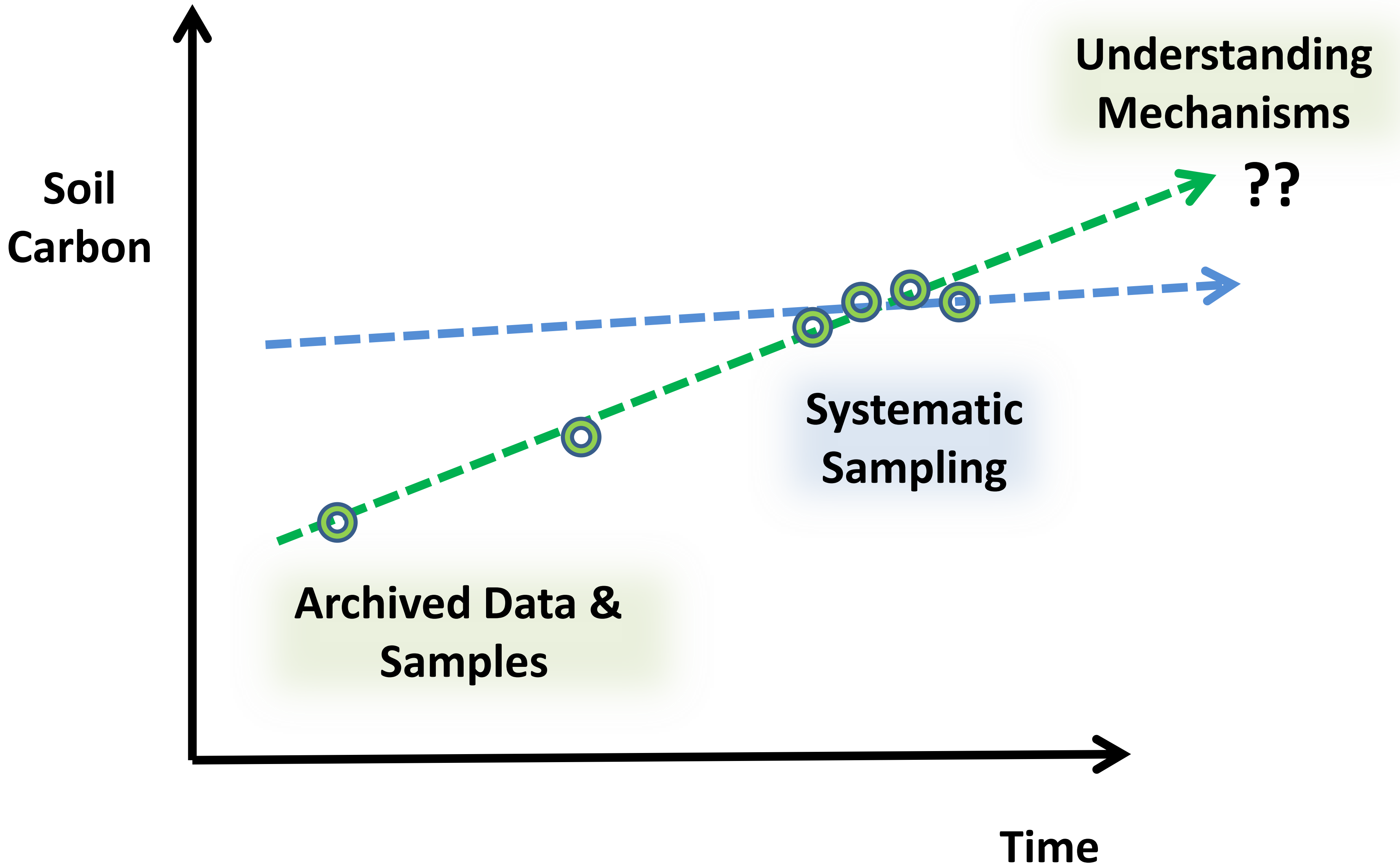
How are soils ***changing*** in response to management and climate change?



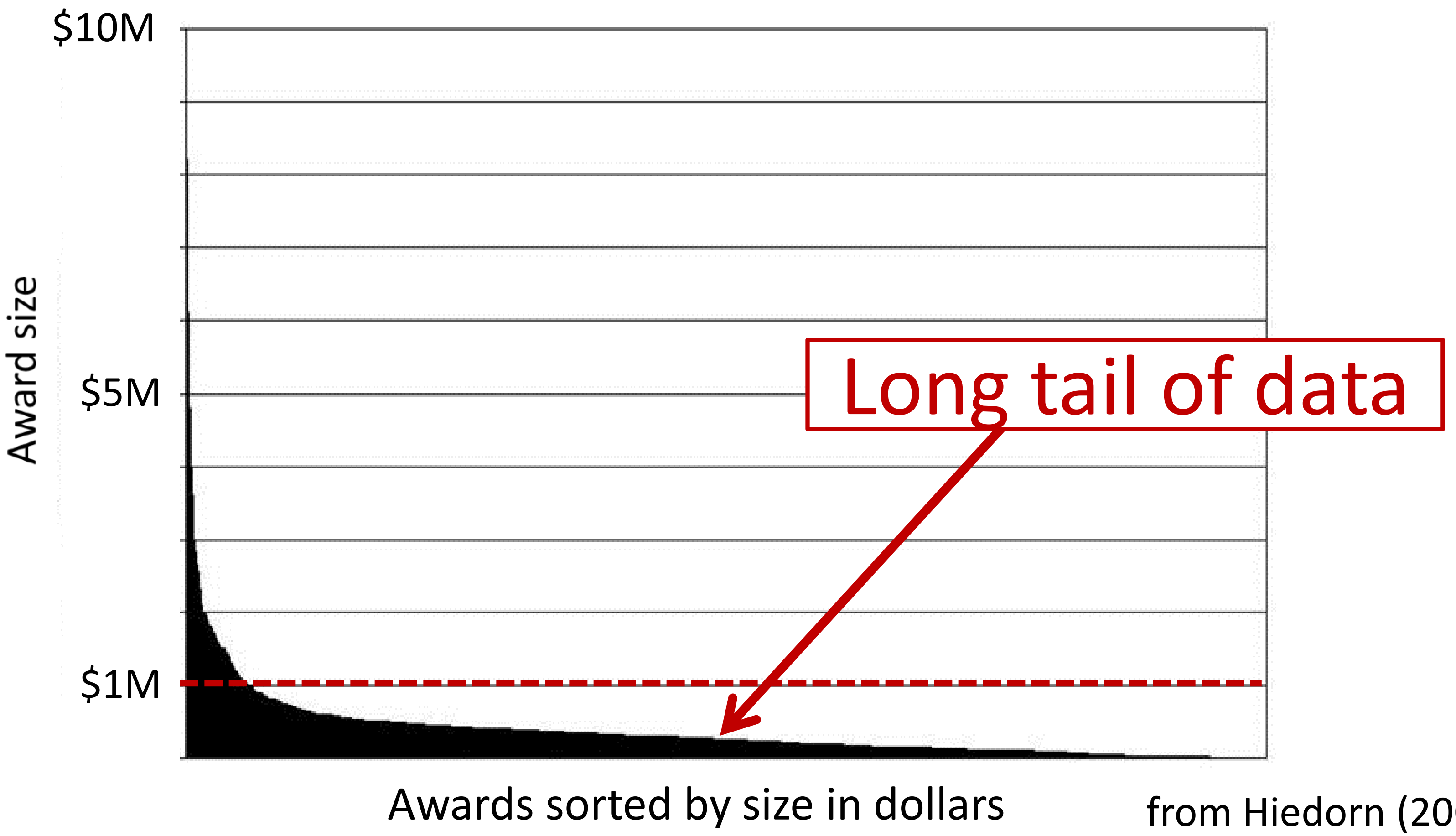
We also need to leverage knowledge from the **past!**

Part II:

Grassroots efforts to organize data around central scientific questions


Understanding
Mechanisms
??
Soil
Carbon
Systematic
Sampling
Archived Data &
Samples
Time

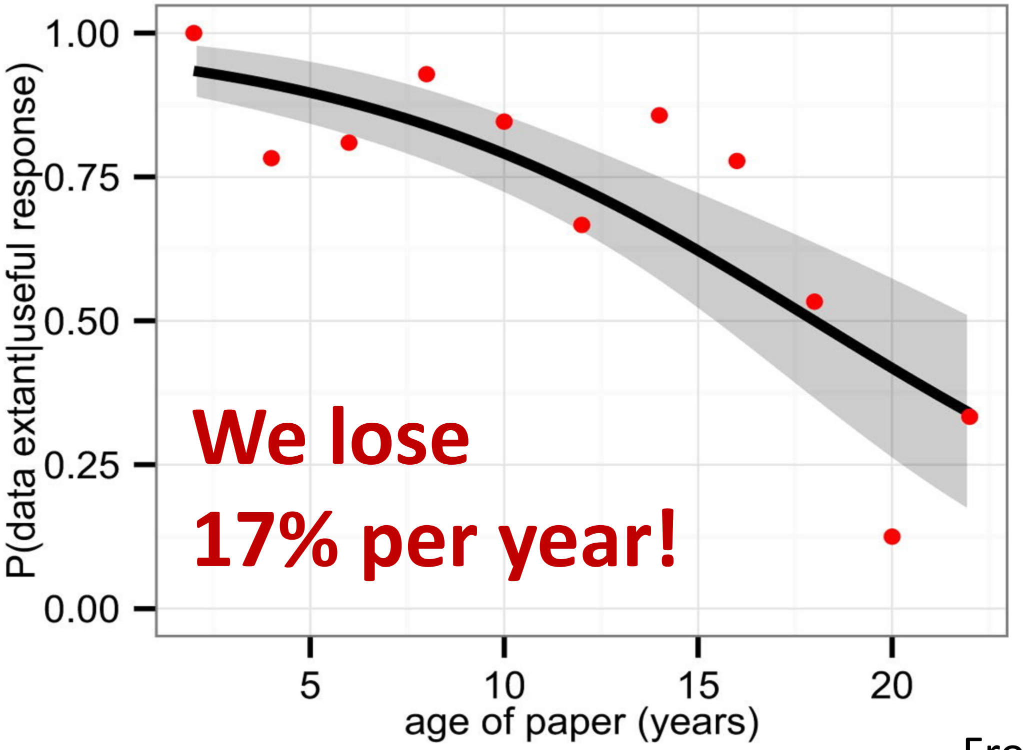
Repurposing past datasets –
How can we make the most of past investment?



from Hiedorn (2008)

Why archive data?

- Data is being lost at a precipitous rate
- ***To the Rescue!*** Many grassroots databases are emerging to compile these datasets & address core scientific questions



From Vines et al. (2014)

Case Study:

ISRAD

Int'l Soil Radiocarbon Database

Powell Center

USGS science for a changing world

USDA

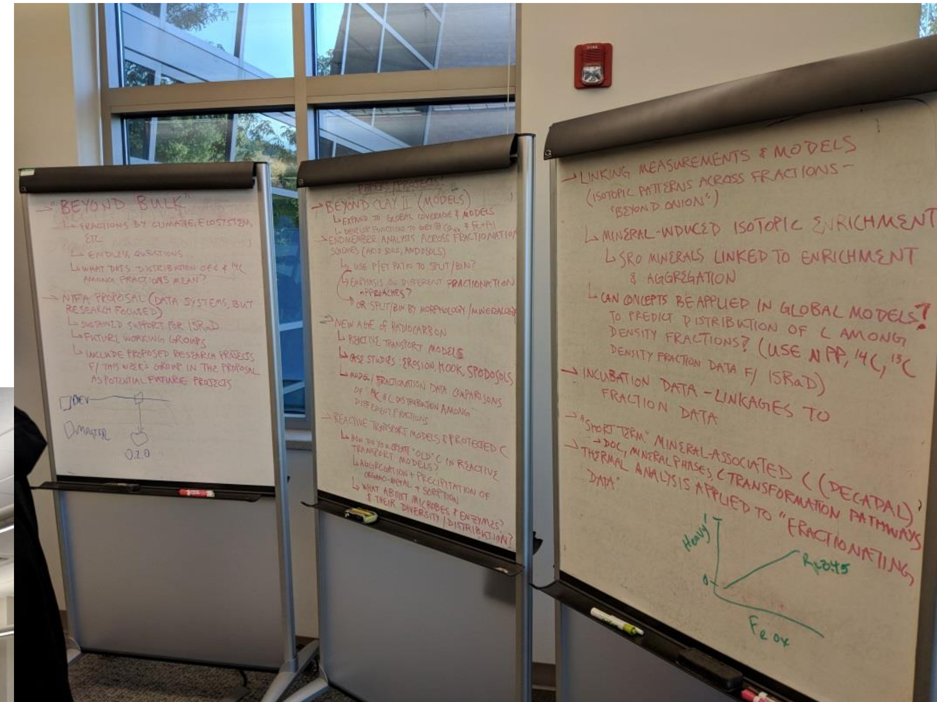
erc

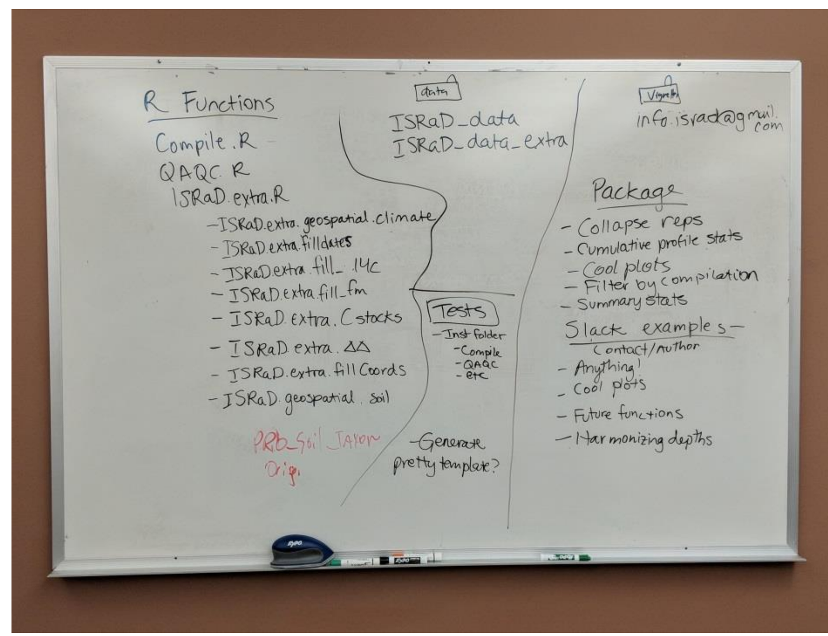
MPI-BGC Jena

BERKELEY LAB Lawrence Berkeley National Laboratory

Goal: Compile soil radiocarbon and related data

Dedicated Community + USGS Powell Center + ERC ^{14}Constraint Funding



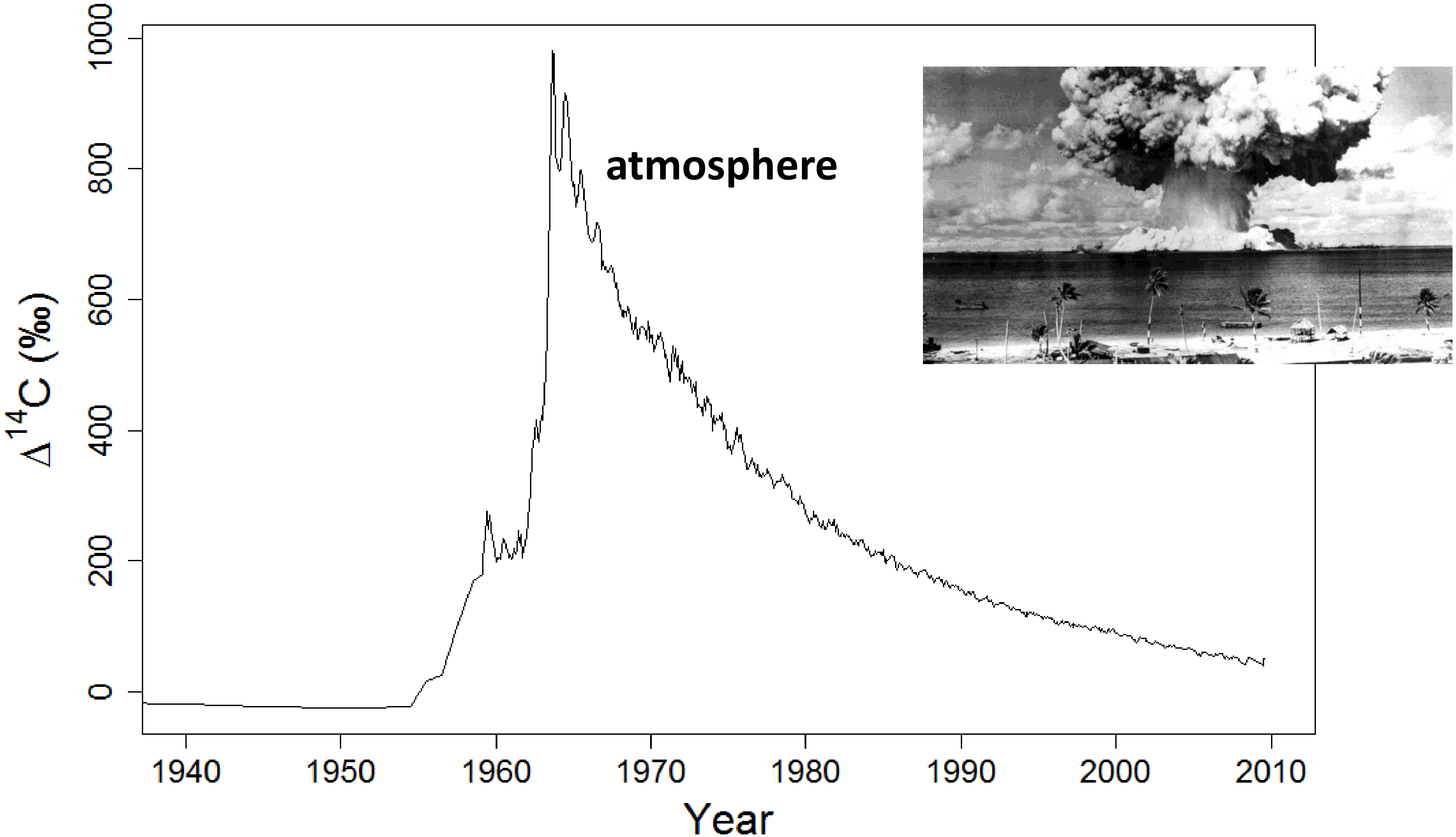


How will climate change impact soil C stocks?

On what timescales?

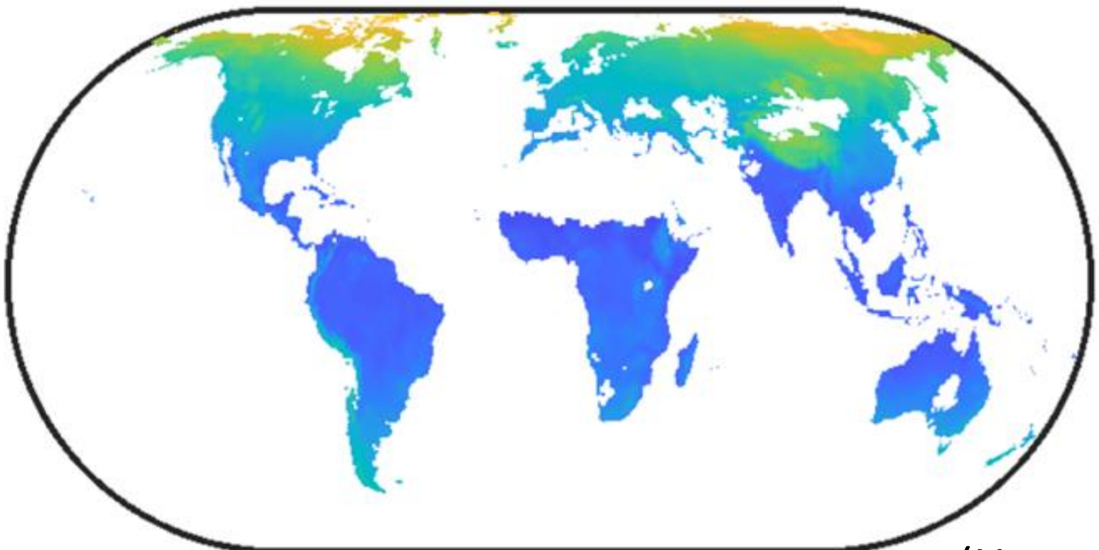
Radiocarbon provides a strong constraint on global rates of soil carbon cycling

“Bomb” ^{14}C – Global labelling!

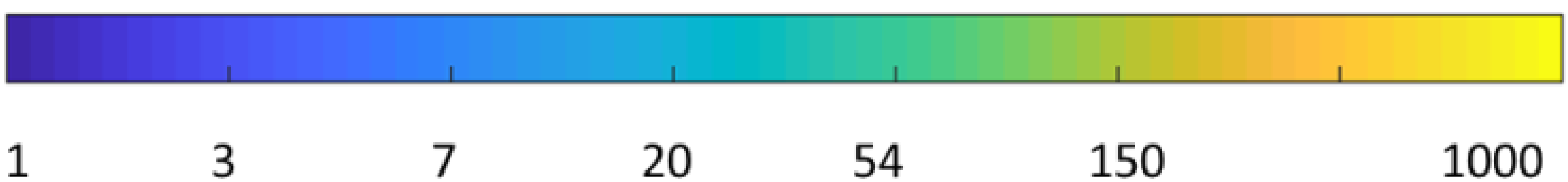


Transit Time → How **fast** does C cycle?

^{14}C of CO_2 respired from soil



(Hoyt et al, in prep)



Mean Transit Time

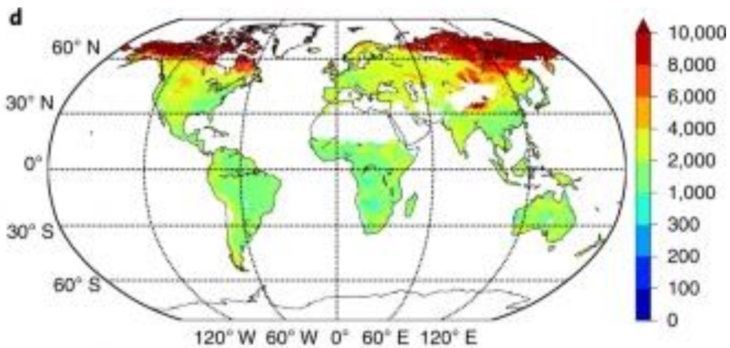
Mineral Soil 0-20cm

← Faster response to warming

→ Slower response to warming

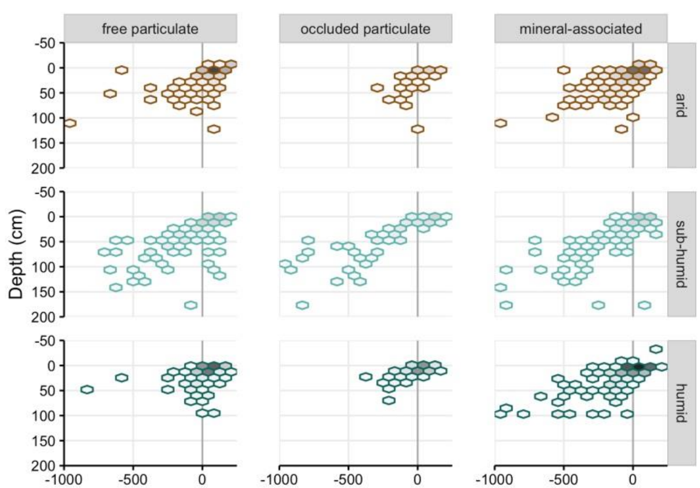
One Database: Many Questions

How old is soil C?



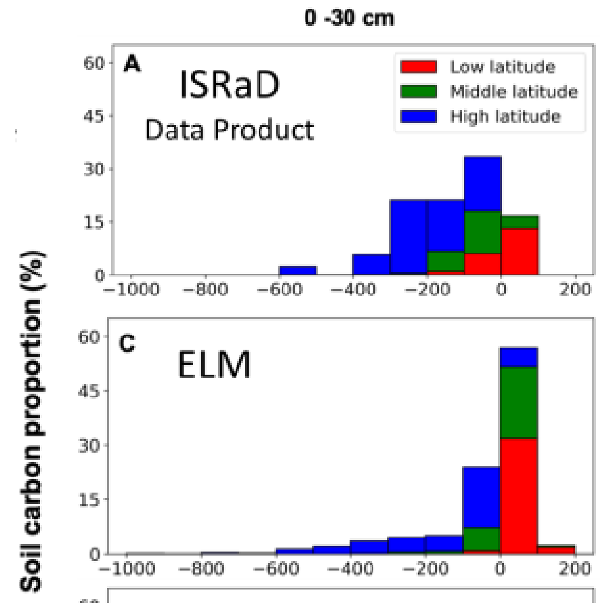
(Shi et al, 2020)

How is C distributed in soil fractions?



(Heckman, Hicks Pries, et al, in prep)

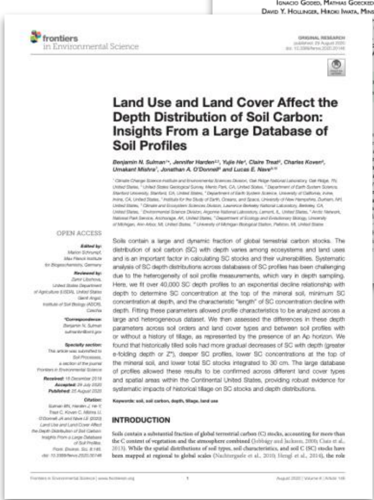
Can we benchmark Earth System Models with ^{14}C?



(Shi et al, 2020; Levine et al, in prep)

Many other success stories

These grassroots databases are answering big questions!



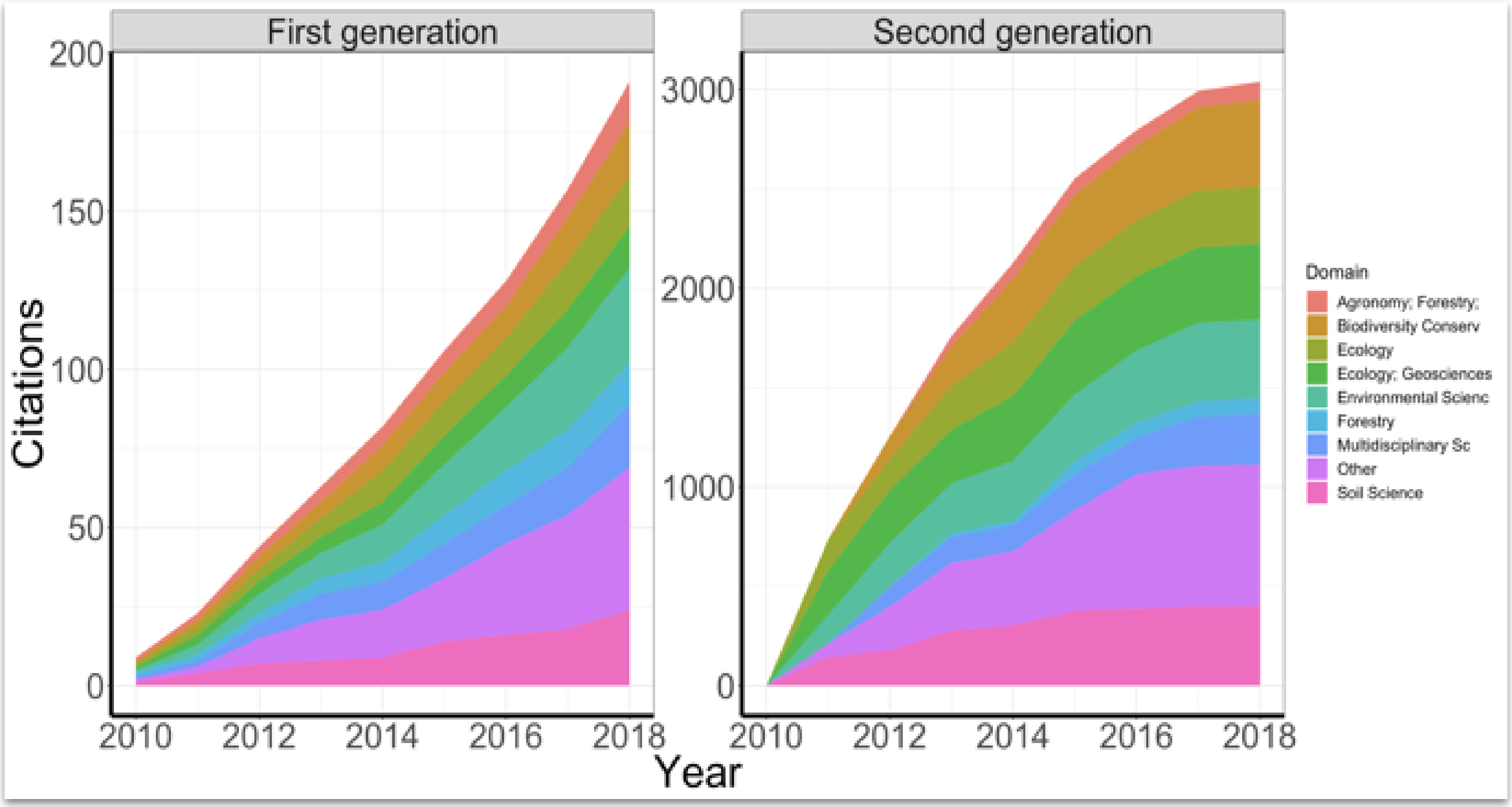
And many more including SoDaH, SOC-DRaHR, FRED, TRY, BAAD, COSORE, FungalRoot, ISCN, CC-RCN, C-PEAT ...

Measuring Impact:

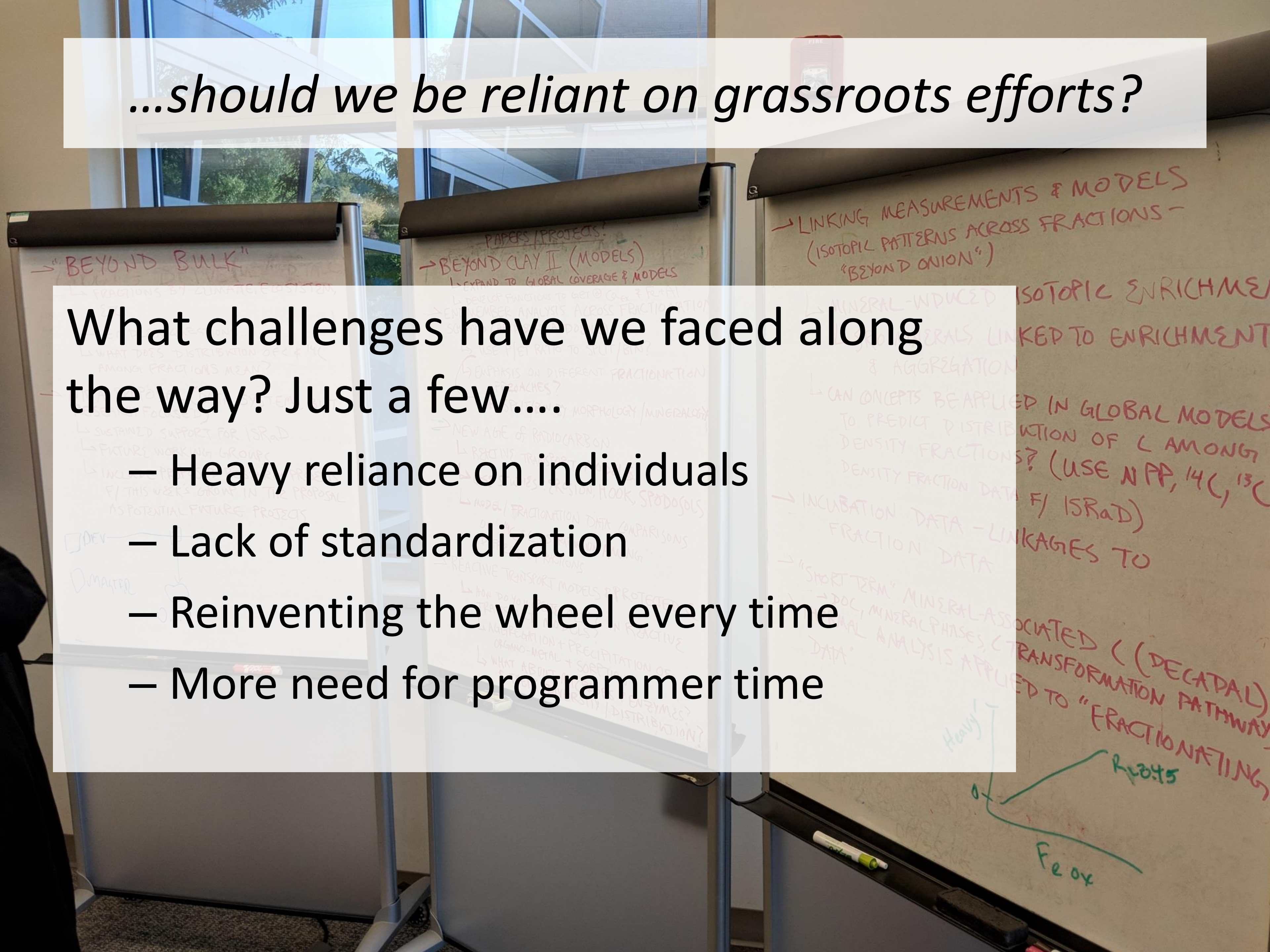
- Databases as foundations for synthesis efforts
- Central findings prompt further inquiry

SRDB: A Global Database of Soil Respiration Data

(Bond-Lamberty & Thomson (2010))



…should we be reliant on grassroots efforts?



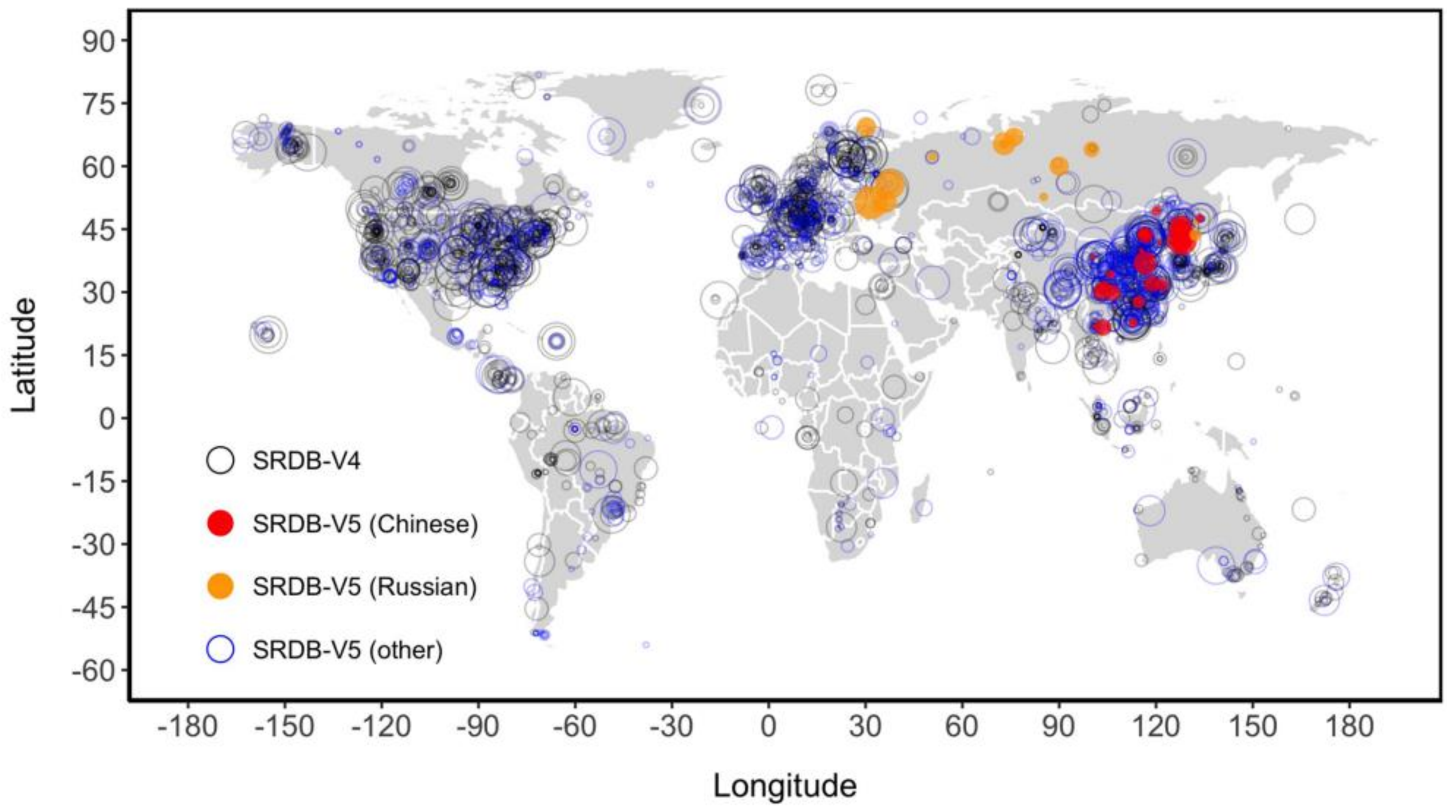
What challenges have we faced along the way? Just a few….

- Heavy reliance on individuals
- Lack of standardization
- Reinventing the wheel every time
- More need for programmer time

Key limitation: global data distribution

- Management impacts are ***regional and local***
- Climate change interactions are ***global*** – we must fill data gaps to draw conclusions

SRDB Data Distribution – similar to other networks!



Potential for new measurements… ***if*** we archive soil samples!

ICRAF World Agroforestry Archives
- Nairobi, Kenya

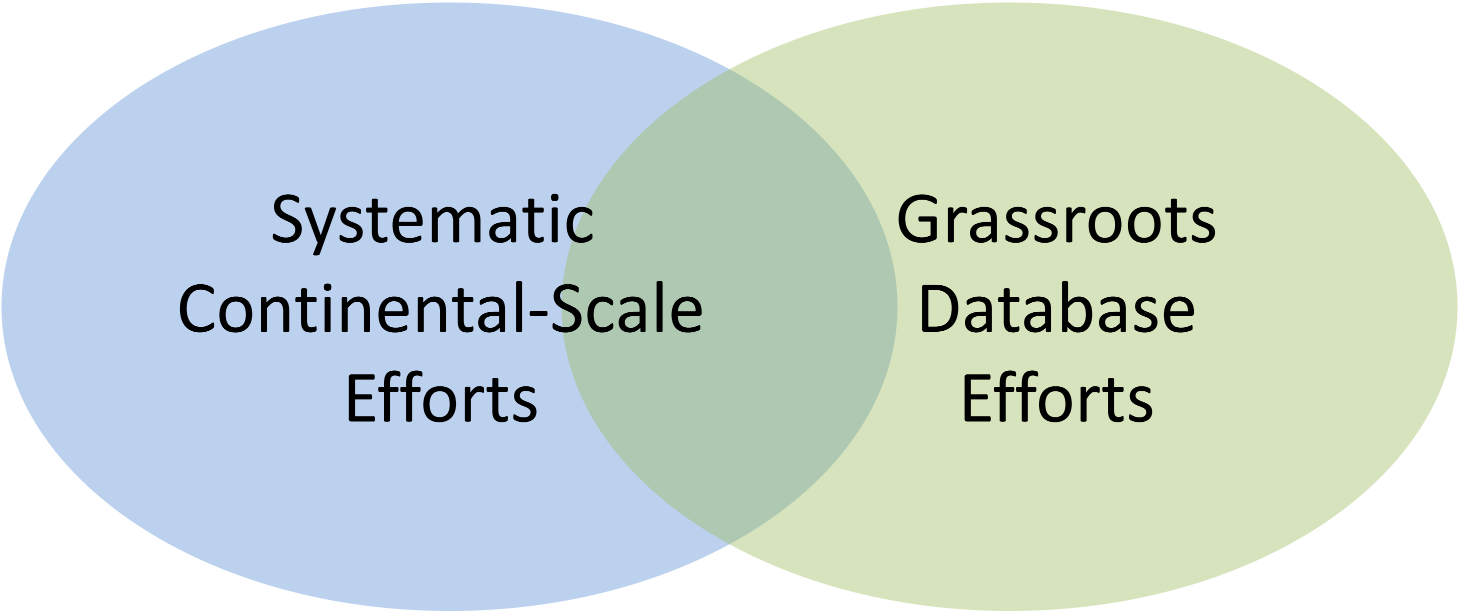
Precious samples
- Scientist Near You

Connectivity & Integration

- Better integration of people & data is needed!
- ISCN has served as a hub for many grassroots efforts, but new databases are constantly emerging, and many are not connected

ISCN

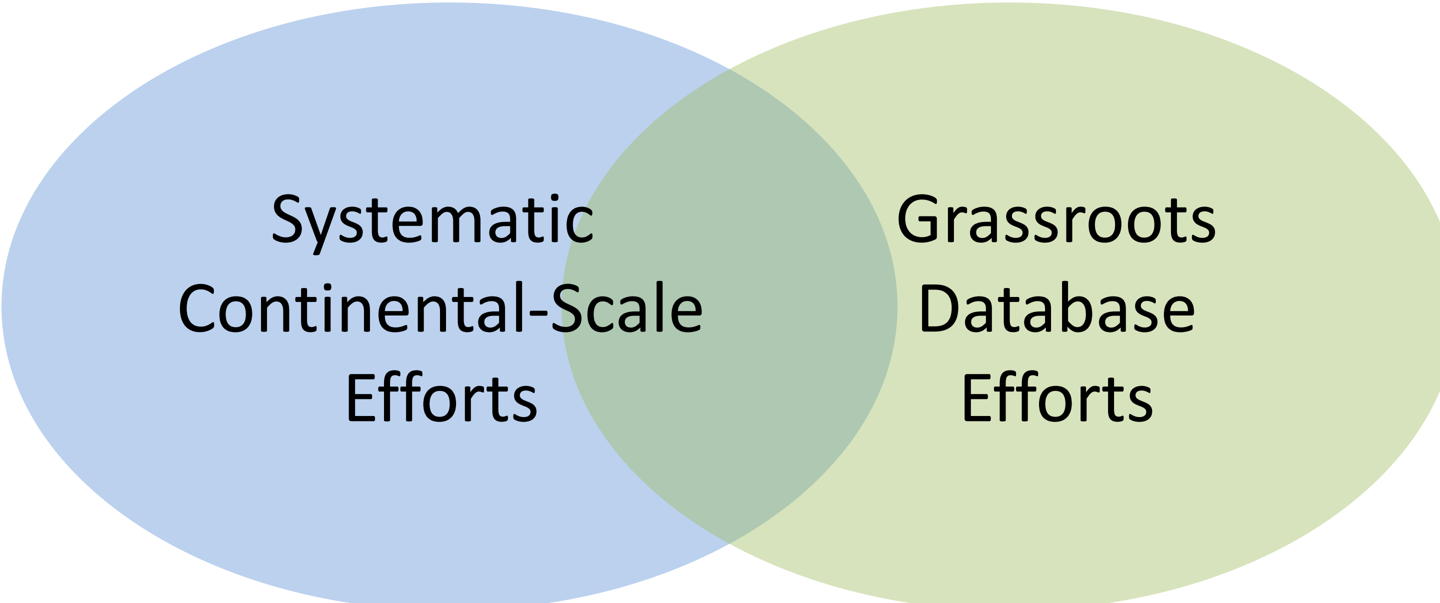
International Soil Carbon Network



Climate Change, Management & Soil C:

1. Current stocks?
2. How might they change?
3. On what timescales?

How can we support & improve on these efforts?



Support for cross-sector centers

Long-term funding

Dynamic part-time resources that are easily accessible

Hub for soil data & better integration

Systems for archiving soil samples

Mandates & support for data archiving

Support for new efforts using existing frameworks

USDA National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE

EXPLORING A DYNAMIC SOIL INFORMATION SYSTEM

Jim Dobrowolski National Program Leader
Water and Natural Resources

USDA NIFA

NATIONAL INSTITUTE OF FOOD AND AGRICULTURE

INVESTING IN SCIENCE | SECURING OUR FUTURE | WWW.NIFA.USDA.GOV

NIFA: The National Institute of Food and Agriculture

Small Agency with a Big Budget

- Up to $1.7 B
- Capacity—funds sent to land-grant institutions to support risky and long-term research, extension and outreach plus education
- Competitive—Discovery and applied research focused on agricultural production, quality and sustainability

The study of soils remains an important part of the NIFA portfolio

- With consistent representation over 15 yr. career
- More that 1,183 soil sustainability projects, focused on soil erosion, nutrient mgt. and microbial activity.

NIFA Awards Require Data Management

We often emphasize connections with existing inventories or networks that include but are not limited to:

- Training the next generation of scientists in soils science and management
- Development of minimum standards and methods for data collection and integration of data sets;
- Plans for long-term data management, data storage, and data sharing
- Linkages with publicly-accessible databases for collection information, tool development, sampling methods and data curation plans.

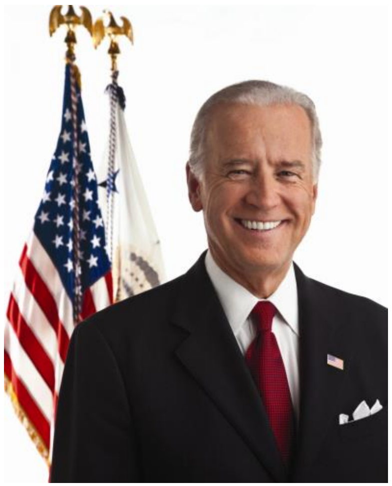
USDA National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE

NIFA Struggles to Send Folks to the Right Data Repository

Potential first stop: National Agriculture Library's Scientific Data Services

- Offering data management policy and planning, repository management, data and metadata curation and consultation, and preservation
- Although the "BETA" tag is gone, and the site is serviced by the Ag Data Commons, current domain and related informatics expertise is limited to biological sciences, geospatial and biophysical sciences, genomics, federal open data policy, and life cycle assessment
- You can submit or link your data to the Ag Data Commons to meet FAIR data requirements of journals when you submit manuscripts, or public access requirements of funders such as NIFA

Federal Call for Data Repository Specs



The White House Office of Science and Technology Policy

- Seeks public comments on a draft set of desirable characteristics of data repositories used to locate, manage, share, and use data resulting from Federally funded research

Here's where you can help! By participating fully in this workshop

- We can improve the current systems in place for widely monitoring soils—physical, chemical, biological
- We can better understand, document and manage the effects of land-use and cover changes on soils

The Dynamic Soil Information System

- Developing and implementing a dataset that encompasses the chemical, physical and biological attributes within the context of environmental and land–use conditions with a network of suppliers—is challenging
- Requires careful identification of known and innovative sampling methods with suitable metrics and attributes focused on the appropriate users
- NIFA has funded the collection of millions of soils-related data points—where are they now?

NSF Programs in Relation to Building a Dynamic Soil Information System

Dr. Matthew D. Kane
Program Director
Ecosystem Science Cluster
Division of Environmental Biology
National Science Foundation

NSF Champions Research and Education Across All STEM Fields

A Dynamic Soil Information System & NSF Big Ideas

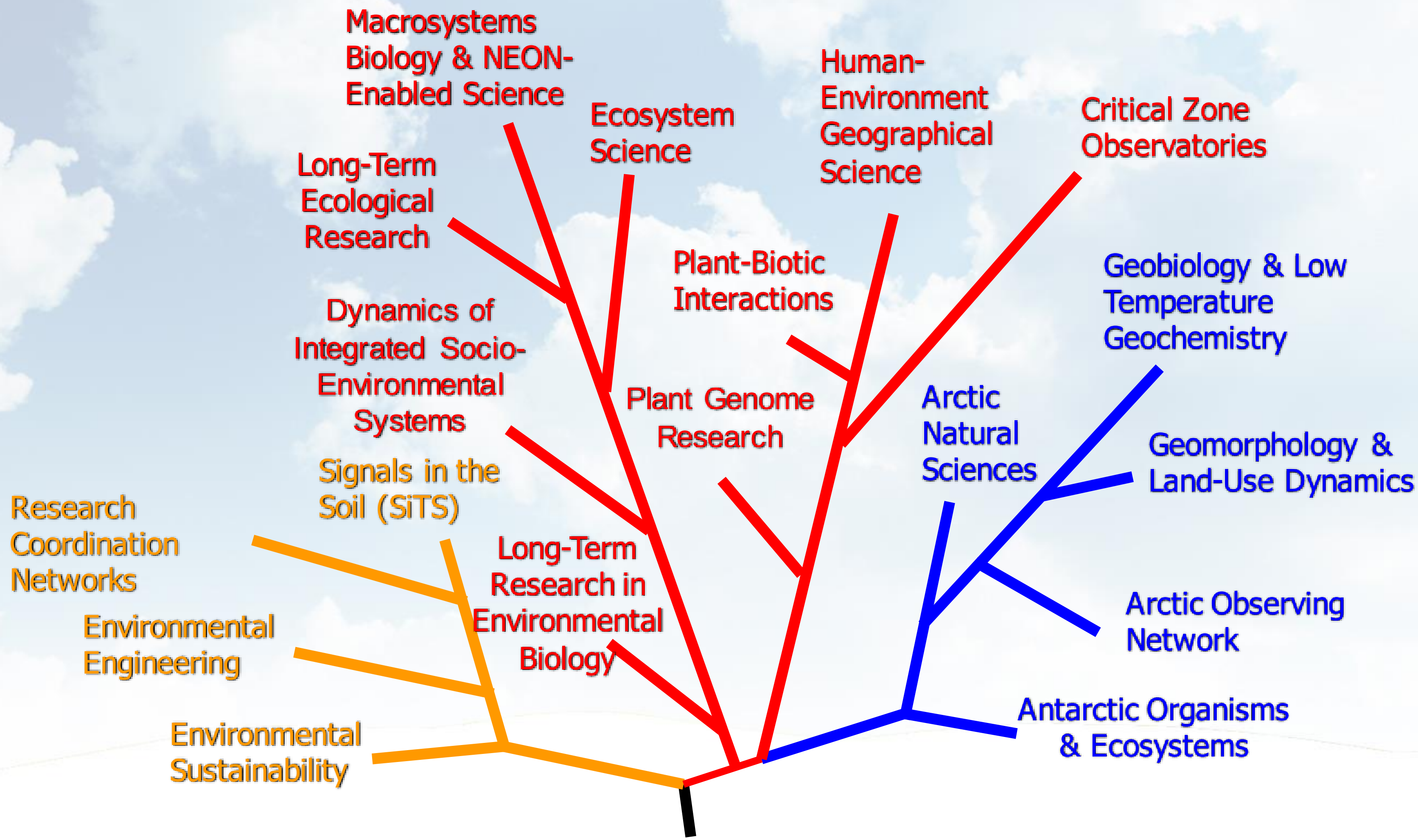
Harnessing Data for 21st Century Science & Engineering

Understanding the Rules of Life

Navigating the New Arctic

Growing Convergent Research

Relevance of NSF Programs to Building a Dynamic Soil Information System



National Ecological Observatory Network (NEON)

- Enable regional to continental scale research
- Enable individual and team science
- Democratize and standardize ecological research

- Geographically distributed field and lab infrastructure
- Fully networked research platforms
- Internet accessible, data, computational, analytical, and modeling capabilities

Open Environmental Data

neon™
National Ecological Observatory Network

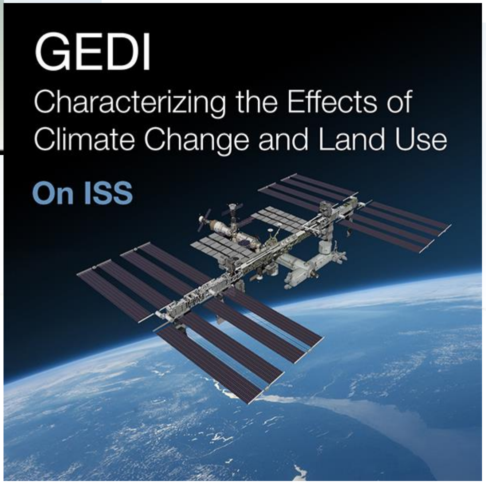
iDigBio
Integrated Digitized Biocollections

GBIF

NATIONAL SCIENCE FOUNDATION
LTER NETWORK
LONG TERM ECOLOGICAL RESEARCH

OOI
OCEAN OBSERVATORIES INITIATIVE

CZO | CRITICAL ZONE OBSERVATORIES
U.S. NSF NATIONAL PROGRAM



NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

NSF

National Science Foundation

Center for Advancement and Synthesis of Open Environmental Data and Sciences

Incubator for Team Science

Creative & Innovative Cyberinfrastructure

Inclusive Community Engagement

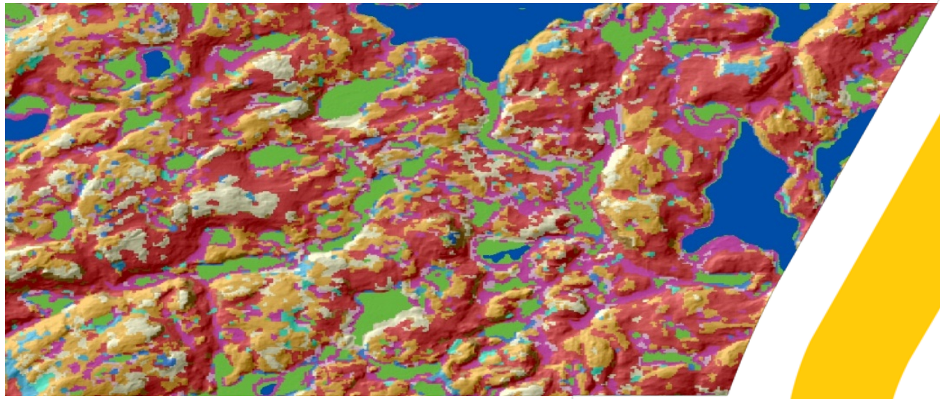
Data Science Training

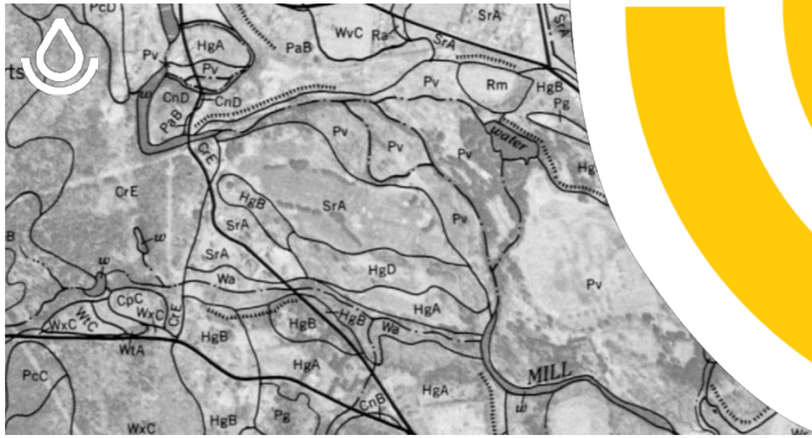
NSF 21-549

USDA

United States Department of Agriculture

NCSS
National Cooperative
Soil Survey





NRCS – Soil & Plant Science Division

Natural
Resources
Conservation
Service

NASEM – Dynamic Soil Information Systems Workshop – Mach 2-4, 2021

nrcs.usda.gov/

United States Department of Agriculture

Wouldn't it be great if you could get…

- **Soils information**
  - 10m grid (30 ft)
  - Properties to 120cm (4ft)
  - Estimate of accuracy
- **Interpretations for land use**
- **Real-time water/climate information**
  - Soil Moisture
  - Water table depth
  - Irrigation need
- **Forecasted effects of specific conservation practices**
  - Dynamic soil properties (soil health)
  - Water based resource concerns
  - Erosion
- **Determination of effective practices for desired land management goals (state and transition)**

… all in one place!

Natural Resources Conservation Service

nrcs.usda.gov/

USDA
United States Department of Agriculture

Dynamic Soil Survey

People & Information


Soil Maps


Ecological Sites

Dynamic Soil Survey


Climate and Hydrology Data


Dynamic Soil Properties

Natural Resources Conservation Service

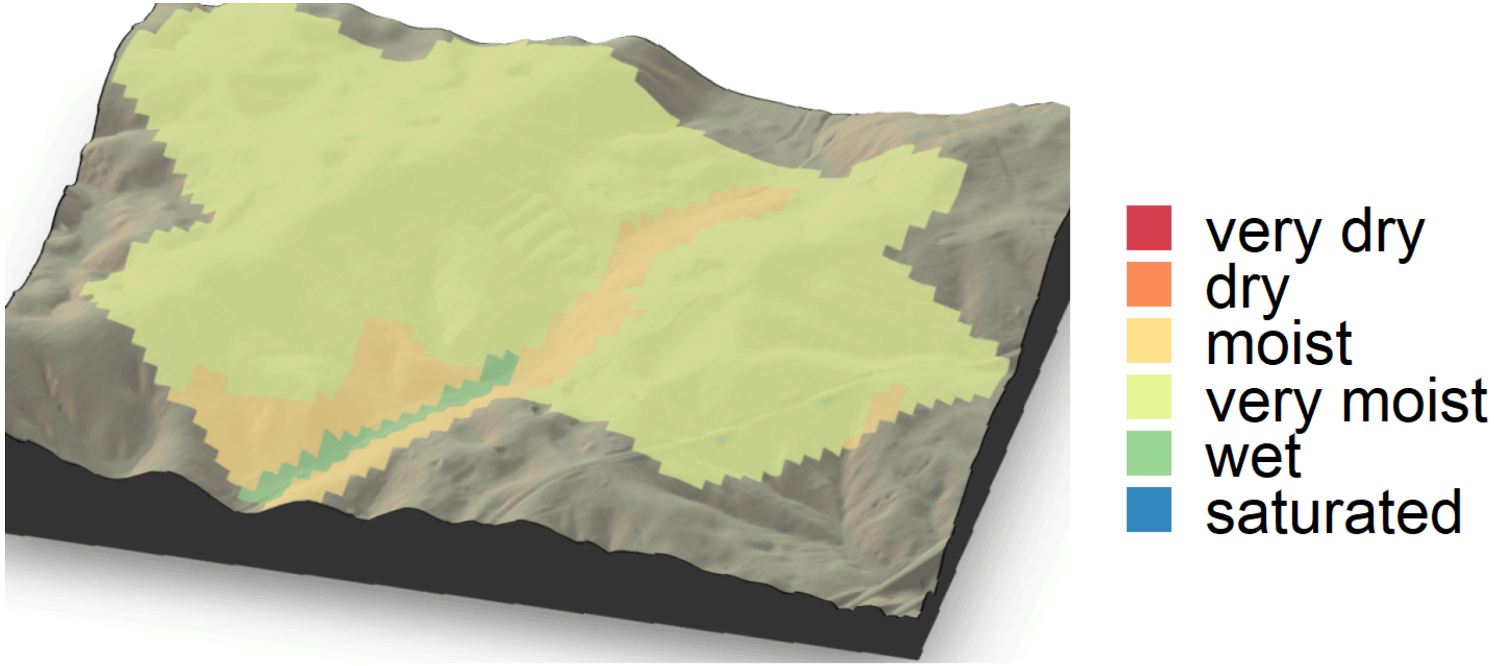
nrcs.usda.gov/

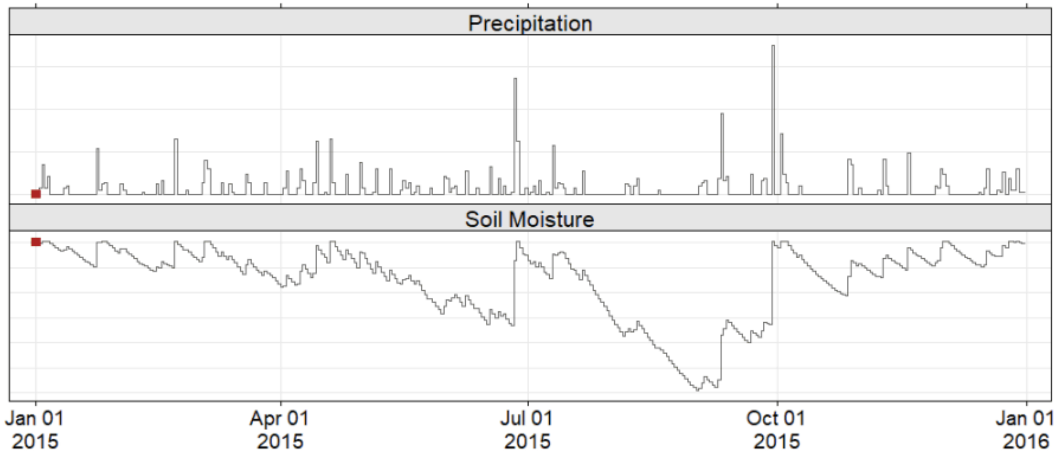
Dynamic Soil Survey

We need field data

We need scientists

We need your information





Dynamic Soil Survey: The Future

Dynamic Soil Survey

Resource Management

Soil Health

Initiatives

Conservation Planning

Equal Opportunity

- Nondiscrimination Statement
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- Office of the Assistant Secretary for Civil Rights
- 1400 Independence Avenue, SW
- Washington, D.C. 20250-9410
- (2) fax: (202) 690-7442

(3) email: program.intake@usda.gov

- USDA is an equal opportunity provider, employer, and lender

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Scientific Publication Statement

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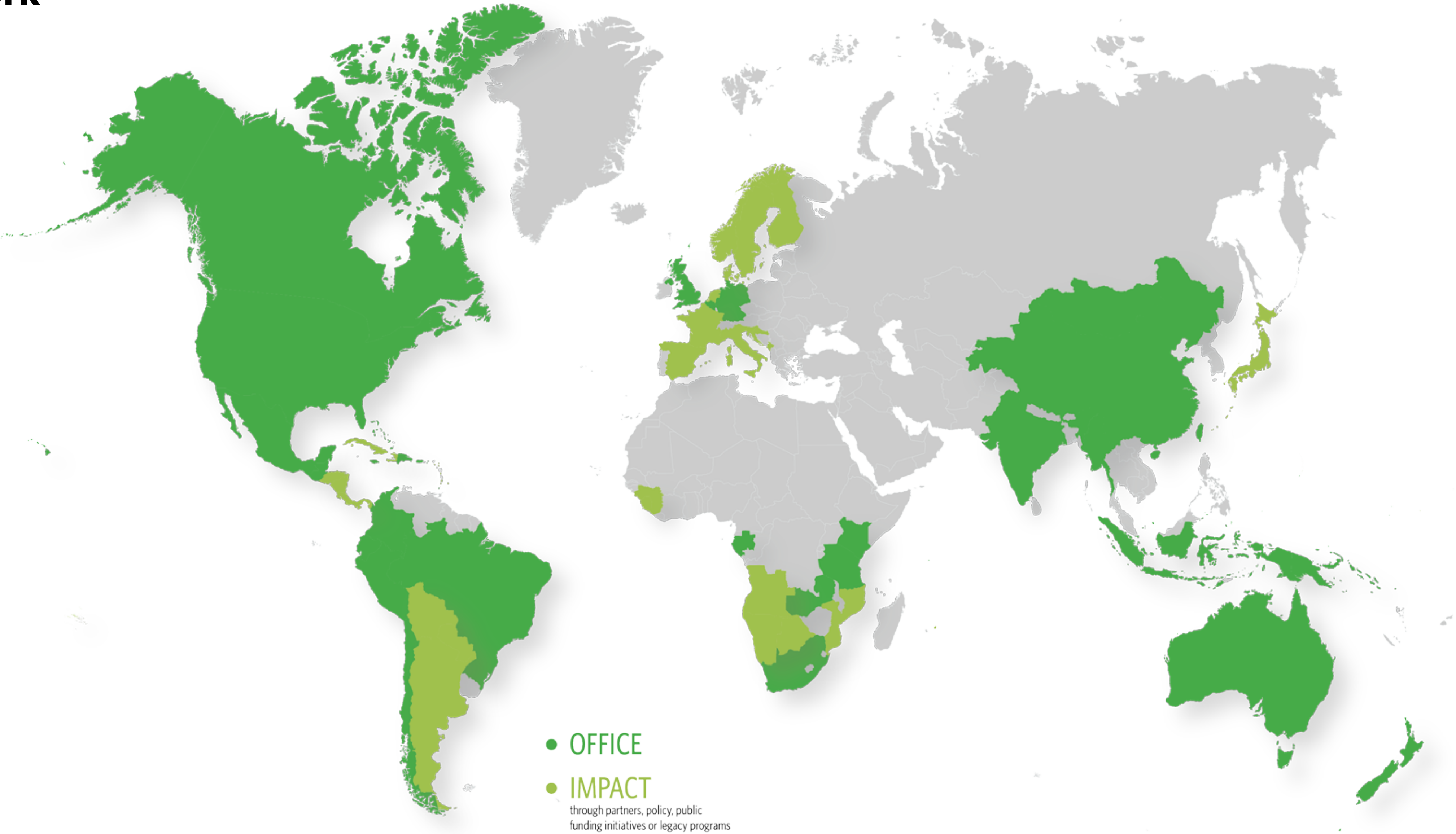
Where We Work



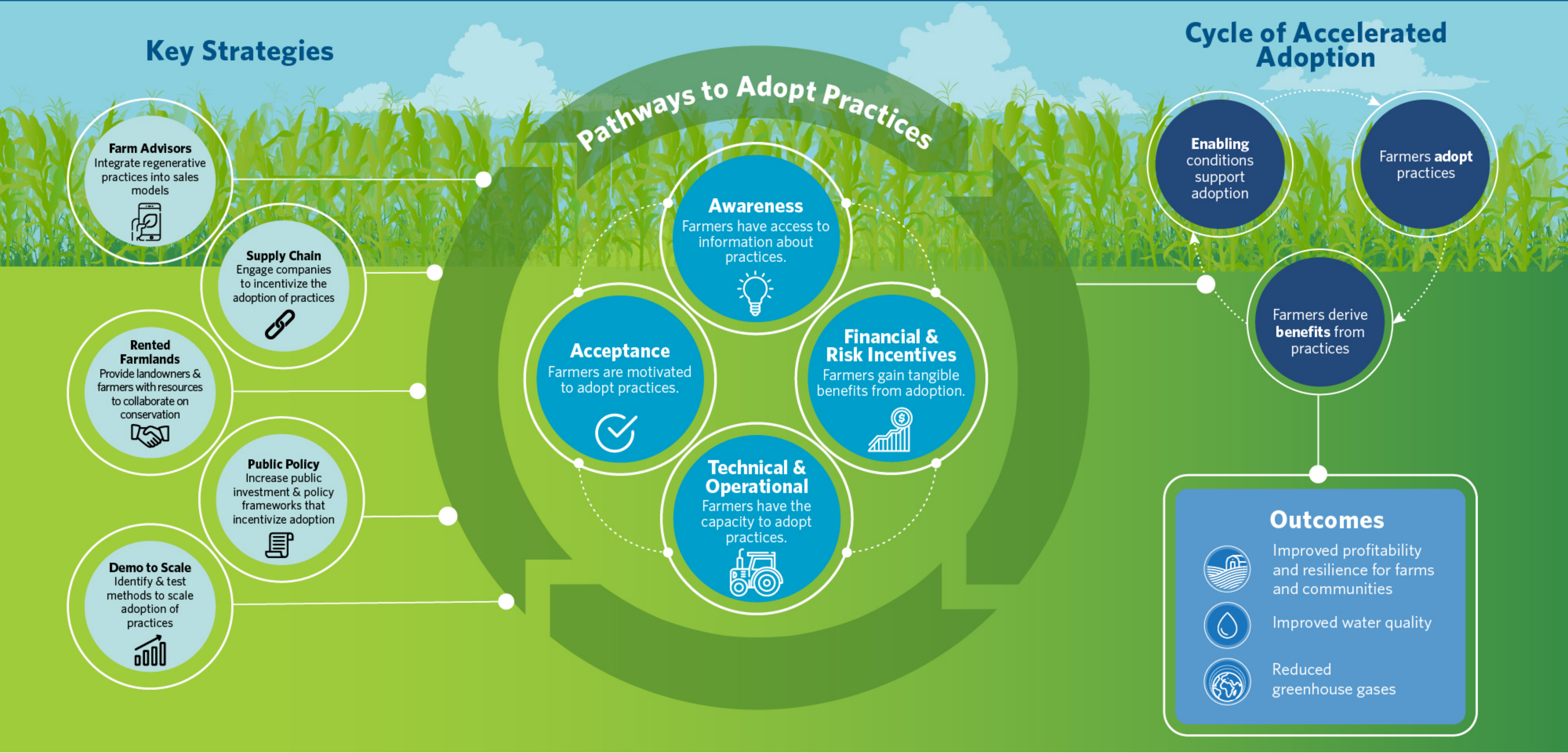
Stephen Wood, The Nature Conservancy

*re*Build Soil

Our Theory of Change to achieve a regenerative row crop system

U.S. farmers are vital to the creation of a regenerative agriculture system. But they can't do it alone. Key stakeholders across policy, business and science sectors have the opportunity to provide farmers with the resources and tools they need to adopt regenerative practices that will increase profitability, protect water quality, and mitigate climate change.

The Nature Conservancy



The National Academies of SCIENCES ENGINEERING MEDICINE

Exploring a Dynamic Soil Information System: A Workshop

A Virtual Workshop

Summary of Listening Sessions

Alison Marklein

March 2 2021

Our Year of Listening Sessions

GOAL
- Understand what exists in terms of a dynamic soil information systems

ACTION
- 18 Listening Sessions with:
  - US Agencies
  - International Agencies
  - Private Sector

RESULT
- Potential for increased inter-agency communication and collaboration
- Few dynamic soil data, identified needs and gaps
- Funding for monitoring is needed for long-term dynamic understanding

Our Year of Listening Sessions

US AGENCIES

- NRCS
- NOAA
- NEON
- US Forest Service
- Soil Health Partnership
- University of Minnesota
- NCEAS

INTERNATIONAL AGENCIES

- FAO: Global Soil Partnership
- ISRIC
- CSIRO
- ISRaD
- Prairie Soil Carbon Project (Canada)
- Chinese Academy of Sciences
- JRC European Soil Data Centre
- iSDA
- Rothamsted

PRIVATE SECTOR

- Gates Foundation
- METER Group
- dataONE
- Cyverse
- Viresco

Questions for Listening Sessions

- What is your vision, and what do you want to do with soil data?
- What is working well with your current database or data collecting effort?
- What are the roadblocks?
- How are data curated, transferred, analyzed, and shared?
- What are the drivers of change?
- What do you want to be able to do?
- How is your data being used? Who uses it?
- What infrastructure is needed to capture and store the data?
- At what spatial and temporal scales are different variables measured?

US-based and global data products

- NRCS: NASIS database (internal), gNATSO, SSURGE
- NOAA: National Integrated drought info system, National coordinated soil moisture monitoring network.
- Soil Health Partnership
- NEON: 15 active soil data products
- US Forest Service: FIA
- dataONE
- gLOSIS
- IsRAD
- Global Soil Partnership
- ISRIC

What we learned: Challenges

- Continuous funding - monitoring
- Understaffed for soil science and/or data analytics
- Data privacy and security
- Data naming conventions, harmonization
- Common methodology including sampling and analysis procedures
- Error associated with methodology, analysis, facilities
- Capturing spatial and temporal data at varying scales
- Destructive samples

Example: European Joint Research Centre

Summary of Soil Committee Conversations

Organization: European Commission, Joint Research Center

Presenter/s:
Luca Montanarella, Panos Panagos

Organizational objectives/goals:
The goal of the JRC is to provide scientific evidences and data for policies on soil:

- Soil Data Information from 27 countries
- Soil Data for Agriculture, Environment, Climate Change, Biodiversity, Human Health Policy

Description of data products / inventory:

- JRC soil information system harmonize and free
- LUCAS (Land Use Cover Area frame Survey)
- survey in collaboration Eurostat

Specific data collected:

Data collected	Spatial Resolution	Temporal resolution	Regularly updated?
Data from National soil Information system Data: soil physical/chemical Properties (e.g. Texture, SOC, heavy metals) Soil biodiversity (DNA extraction/genomics since 2015)	(2 km x 2 km basis for Lucas) but sampling is done 14 km x 14 km grid	Dynamic system (every three year) for Land Use and Land Cover change	Yes, as new data come in the dataset gets updated.

Example: European Joint Research Centre

Summary of Soil Committee Conversations

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Organizational objectives/goals:
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- Soil Data Information from 27 countries
- Soil Data for Agriculture, Environment, Climate Change, Biodiversity, Human Health Policy

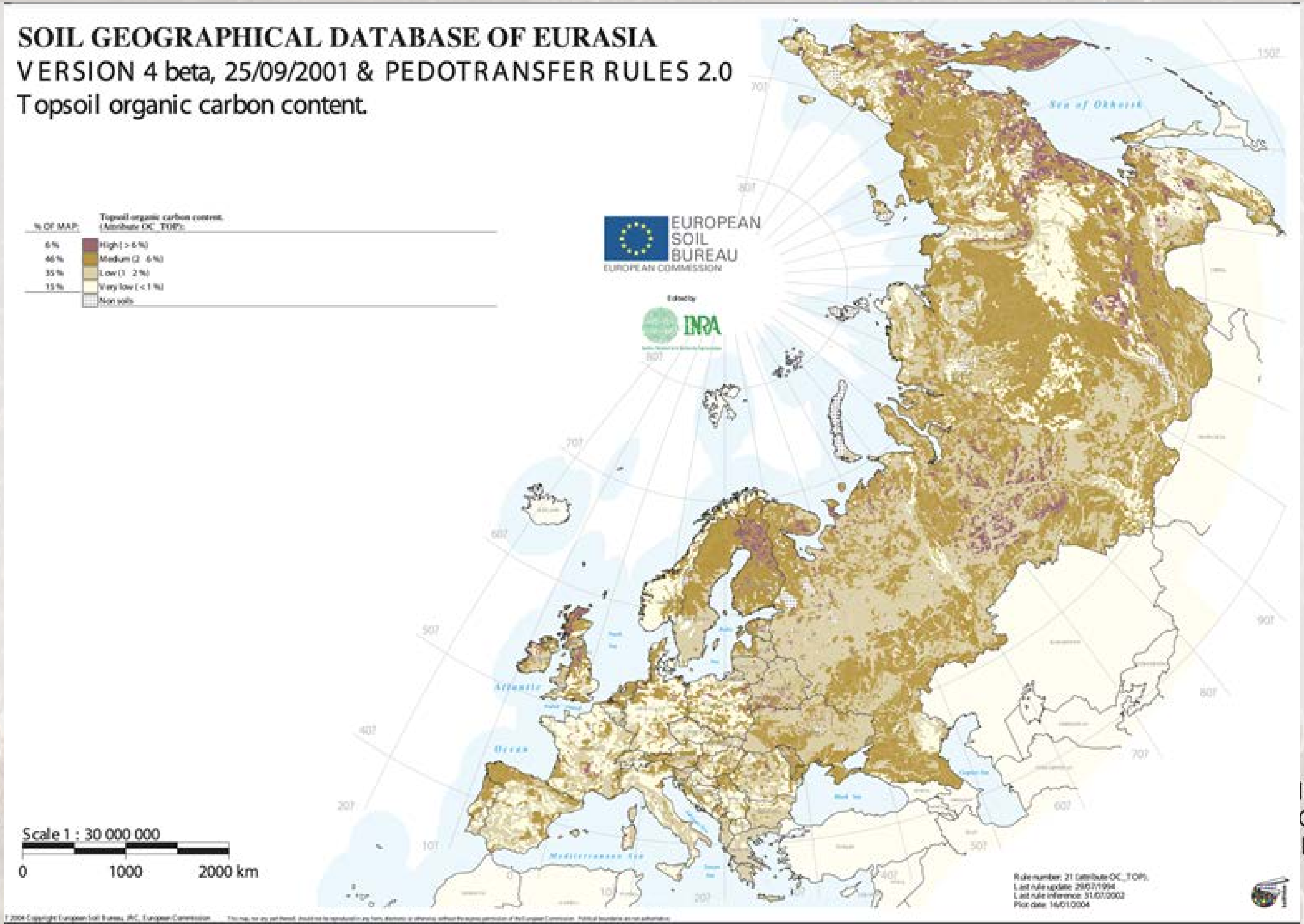
Data challenges:

- Laboratory issues in the past, now soil data only from one lab
- Spectral and remote sensing still have large uncertainties
- Diversity in interest from EU member states (some don't have monitoring systems)
- Uncertainties in scaling
- Delay in reporting results from analysis (5 years late)

Data successes:

- Harmonized Soil Database for Europe
- Data used by different stakeholders: scientists, modelers, policy makers, farmers
- Strong collaborations between groups and agencies operating in this space (EU,

Example: European Joint Research Centre



Exploring a Dynamic Soil Information System: A Workshop

IENCES
GINEERING
DICINE

Example: European Joint Research Centre

- Goals: Agriculture, environment, human health, climate change, biodiversity, ecosystem services
- 27 member states with common info relevant to EU policy
- Part of EU Budget, approved by Parliament
- Resampled every 3 years (2009, 2012, 2015 available online)
- All samples analyzed in same lab (takes 18 months for analysis)
- Physical properties (texture, BD, moisture, depth of topsoil)
- Chemical (C, N, P, micronutrients, pH, soil contamination properties)
- Biological properties (DNA sequencing)
- Some info on land use including crop type, management
- 300,000 samples to 20cm depth, irregular grid for policy-relevant locations (~14km2)
- Main challenge: data privacy (private lands; heavy metal data not private)

Example: NOAA

Summary of Soil Committee Conversations

Organization: NOAA,

Presenter/s: Marina Skumanich

Organizational objectives/goals:

- National Coordinated soil moisture monitoring network
- Goal: multiplatform soil moisture, gridded products, merging in situ, remote sensing, numerical model output
- partnering agencies at federal and state level, 150+ end users

Description of data products / inventory:

- 21 mesonets including NRCS, SCAN& SNOTEL, NOAA< USCRN, various states
- NASA SMPA L3 product
- NLDAS-2: NOAA model
- Volumetric water -> percentiles
- Spatial interpolation -> 4km grid using SSURGO soil and PRISM precipitation

Specific data collected (new row for every factor):

Data collected	Spatial Resolution?	Temporal resolution ?	Regularly updated?
Volumetric water	4km	Near real time	yes

Example: NOAA

Summary of Soil Committee Conversations

Organization: NOAA,

Presenter/s: Marina Skumanich

Organizational objectives/goals:

- National Coordinated soil moisture monitoring network
- Goal: multiplatform soil moisture, gridded products, merging in situ, remote sensing, numerical model output
- partnering agencies at federal and state level, 150+ end users

Data challenges:

- User needs: how best to represent soil moisture? Percentiles, anomalies, USDM category, VWC, MM. How to communicate uncertainty?
- Underlying data maps not currently available because of mesonet funding, but goal is to make it accessible. Map data is available but not underlying mesonet data
- Recognize the uncertainty in sensors, validity
- Data integration:
    - Spatial distribution issues / representativeness
    - Depth, record period, and data gaps
    - Sensor performance, metadata, data formed variability

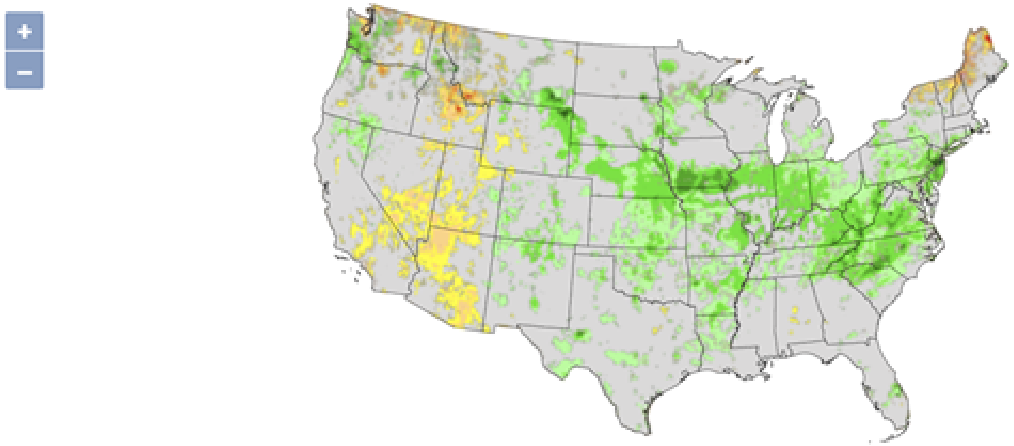
Data successes:

- They've established proof of concept and operational for >1 year

Example: NOAA

Current Soil Moisture Conditions

5 cm Soil Moisture Percentile   0–100 cm Soil Moisture Percentile



This Blended Soil Moisture Product (5cm All Blend), developed by researchers at Ohio State University and the University of Illinois, is a high-resolution gridded soil moisture map derived from *in situ*, model-generated, and satellite data. The 5 cm All Blend is computed using a simple average to combine 5 cm interpolated *in situ* volumetric water content (VWC) percentiles, NLDAS Noah 0-10 cm VWC percentiles, and Soil Moisture Active Passive (SMAP) L3 enhanced VWC percentiles (~5 cm). To match the NLDAS output time step, the All Blend is generated daily with a 5-day delay. Learn more.

5 cm Soil Moisture Percentiles

< 2 | 2 – 5 | 5 – 10 | 10 – 20 | 20 – 30

70 – 80 | 80 – 90 | 90 – 95 | 95 – 98 | > 98

***Currently, data is only available for the contiguous U.S.**

Source(s): NationalSoilMoisture.com   Last Updated - 03/02/21

Example: NOAA

- Goals: multi-platform soil moisture gridded products, managing in situ, remote sensing, and numerical model output
- Networks: state agencies (mesonets) and federal
- 150+ end users
- Developing cyber infrastructure
- Next steps include interpolating soil moisture data (space, time, depth), blending data sources, validation and QC
- Goal is to make underlying data accessible, but currently unavailable due to limited mesonet funding
- Recognize we all do better if we coordinate with each other
- Projections is future goal

Soil physical properties

	texture	bulk density	soil moisture	aggregate stability	depth of topsoil	soil temperature	Available water capacity
European commission	X	X	X		X		
NEON	X	X	X			X	
CSIRO	X	X	X	X	X		
U. Minnesota	X	X	X	X			
Rothamsted	X	X	X	X	X		
Viresco	X	X	X		X		
Soil Health Partnership	X			X			X
IsRAD	X	X		X	X		

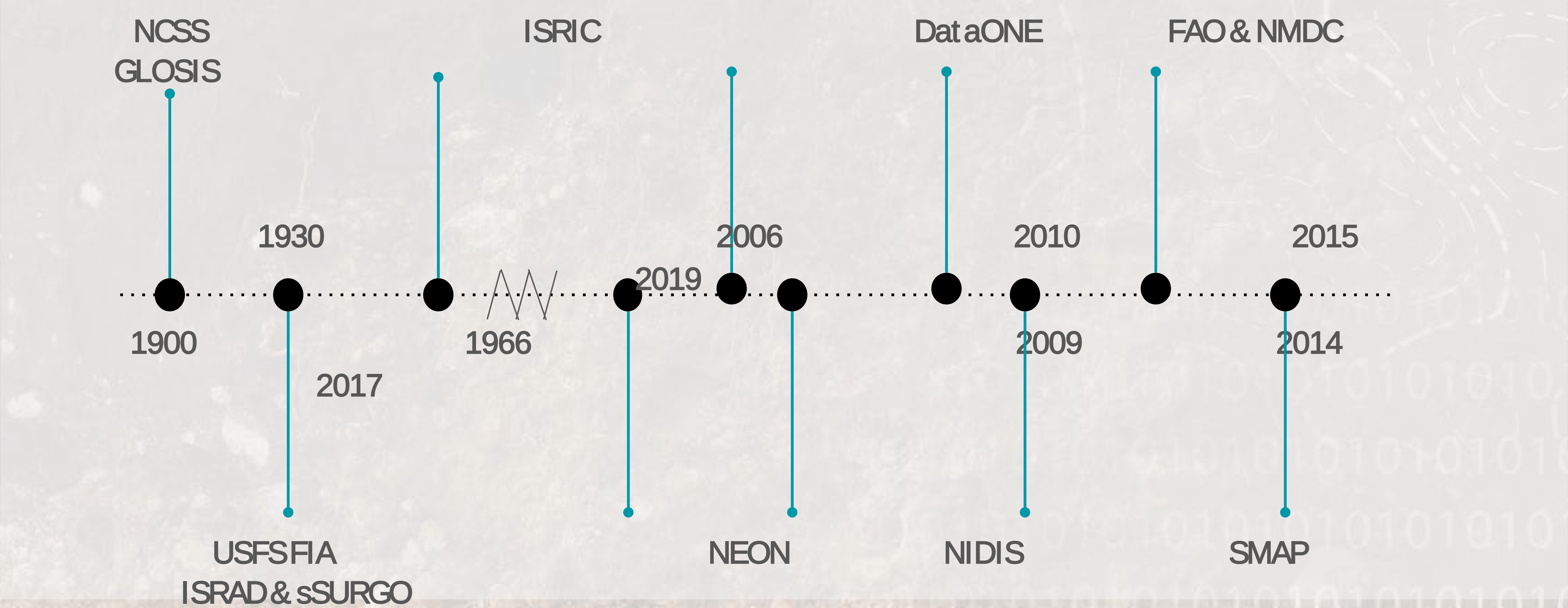
Soil chemical properties

	C	N	P	micronutrients	pH	metals	N transformations	C isotopes	N isotopes
European commission	X	X	X	X	X	X			
NEON	X	X	X	X	X	X	X	X	X
CSIRO	X	X	X	X	X	X			
U. Minnesota	X	X	X	X	X				
Rothamsted	X	X	X	X	X				
Viresco	X	X							
Soil Health Partnership	X	X	X	X	X				
IsRAD	X	X	X	X	X	X		X	X

Soil biological properties

	microbiome omics	PLFA	root traits	C respiration	soil health indicator	pathogens	microbiome phenotyping
European commission	X						
NEON	X	X	X				
CSIRO	X	X	X	X	X	X	
U. Minnesota	X			X		X	X
Rothamsted					X		
Viresco							
Soil Health Partnership				X	X		
IsRAD	X	X	X	X			

Timeline of Soil Data Products



Recommendations

- Funding monitoring for long-term understanding
- More repeated measurements
- More communication between agencies
- Increased clarity on nomenclature, etc.
- More metadata on sampling methodology and processing
- Data at scale relevant to farmers
- Archived soils for future analysis

Thank you to our presenters

- David Lindbo, U.S. Department of Agriculture–Natural Resources Conservation Service
- Ronald Vargas and colleagues, FAO's Global Soil Partnership
- Marina Skumanich, NOAA's National Integrated Drought Information System
- Maria Bowman, Soil Health Partnership
- Rik van den Bosch and colleagues, ISRIC
- Andrew Bissett, Mark Farrell, and V. Gupta, CSIRO
- Linda Kinkel, University of Minnesota
- Brian McConkey and Ben Ellert, Prairie Soil Carbon Project
- Mark Schildhauer, National Center for Ecological Analysis and Synthesis
- Cory Lawrence, Susan Trumbore, Alison Hoyt, and colleagues, ISRaD
- Luca Montanarella and Panos Panagos, JRC European Soil Data Centre
- Zhongjun Jia, Xian-Zhang Pan, and Ganlin Zhang, Chinese Academy of Sciences
- Lee Stanish and Samantha Weintraub, NEON
- Christian Witt and colleagues, Gates Foundation
- Colin Campbell, METER Group
- Andy Macdonald and Richard Ostler, Rothamsted Research
- Parker Antin, Cyverse

USDA
United States Department of Agriculture

National Soil Survey Center

Natural Resources Conservation Service

NCSS Soil Information Systems

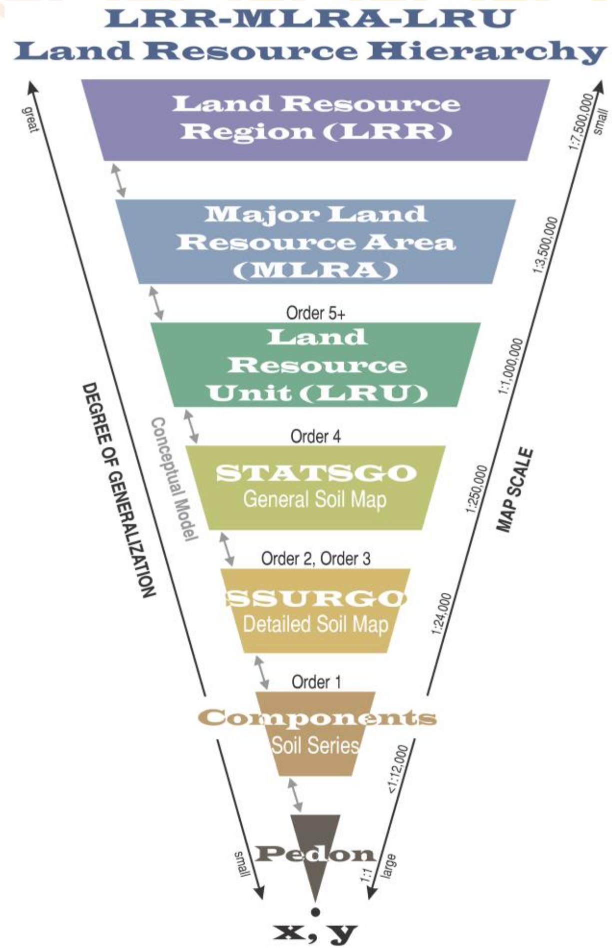
March 2, 2021 Drew Kinney

Natural Resources Conservation Service

nrcs.usda.gov/

Soil information Systems – Vector Data

National Soil Information System (NASIS)



1. LRR = Land Resource Region

1:7,500,000 minimum size delineation 560,000 ha. (1,400,000 ac.)
28 LRR's

2. MLRA = Major Land Resource Area

1:5,000,000; minimum size delineation 250,000 ha. (620,000 ac.)
278 MLRA's

3. LRU = Land Resource Unit (not available as of 2021)

1:1,000,000; minimum size delineation 10,000 ha. (25,000 ac.)
800 LRU's with 5306 polygons

4. STATSGO = State Geographic Database

1:250,000; minimum size delineation 625 ha. (1545 ac.)
9562 STATSGO2 Map Units; 81,770 polygons

5. SSURGO = Soil Survey Geographic Database

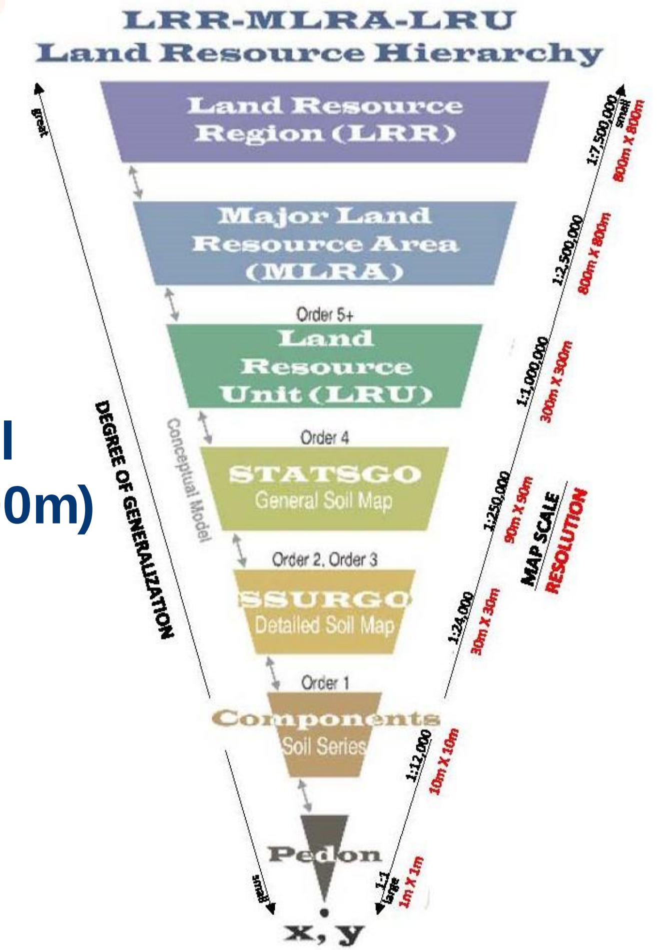
1:24,000; minimum size delineation 1 ha (2.5 ac.)
36,568,209 million polygons

SEE NATIONAL SOIL SURVEY HANDBOOK PART 649.4 CARTOGRAPHIC STANDARDS FOR DEFINITIONS OF EACH OF THE FIVE SOIL SYSTEMS LISTED ABOVE.

Soil information Systems – Raster Data

National Soil Information System (NASIS)

1. Soil Grids (800m CONUS)
2. Global Soil Map products (90m)
3. Soil Properties Stack (about a dozen Soil Property rasters for CONUS, 30m and 100m)
   * available in 2021
4. gNATSGO (10m State, 30m CONUS)
5. gSSURGO (10m State, 30m CONUS)
6. Raster Soil Surveys (10m)



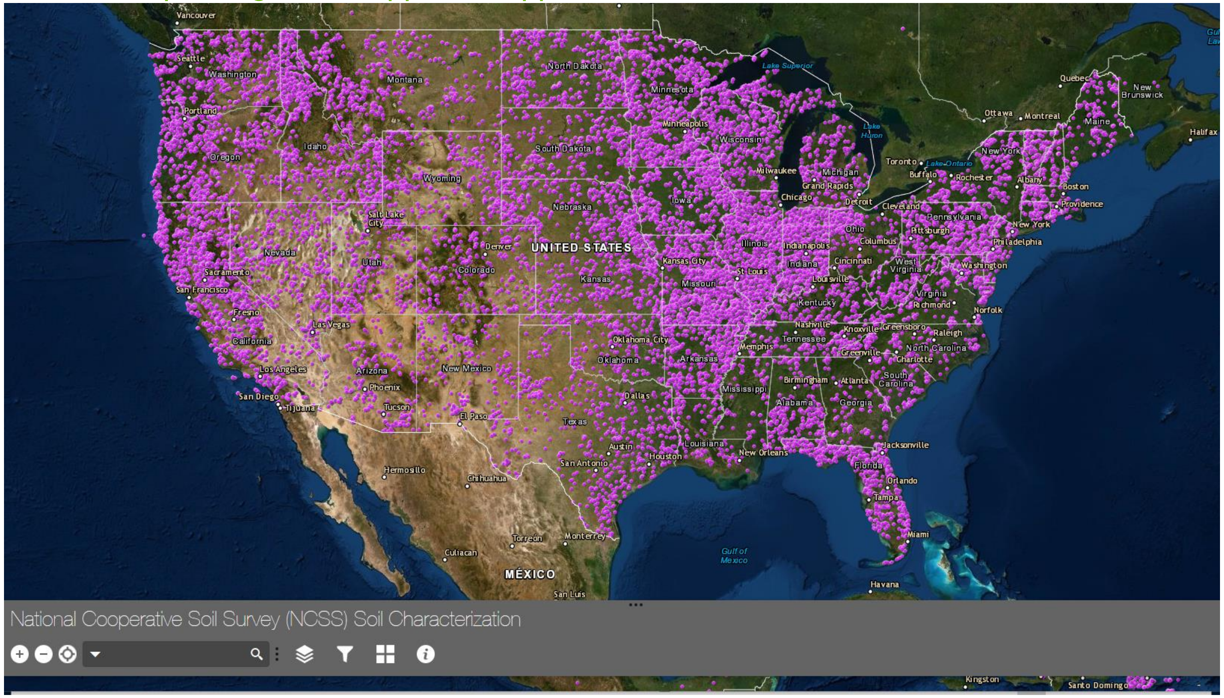
Soil information Systems – Point Data

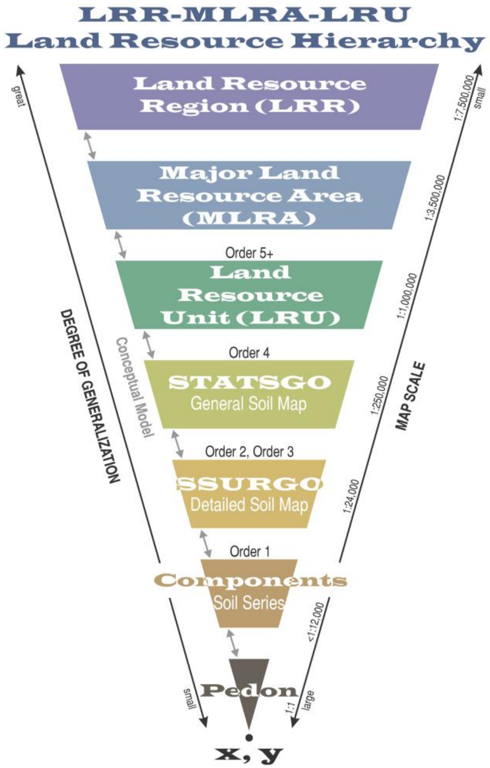
National Soil Information System (NASIS)

1. **Soil Characterization Database** (65,943 pedons with lab data)
   - includes Official Series (OSD) Database. 24,779 Soil Series

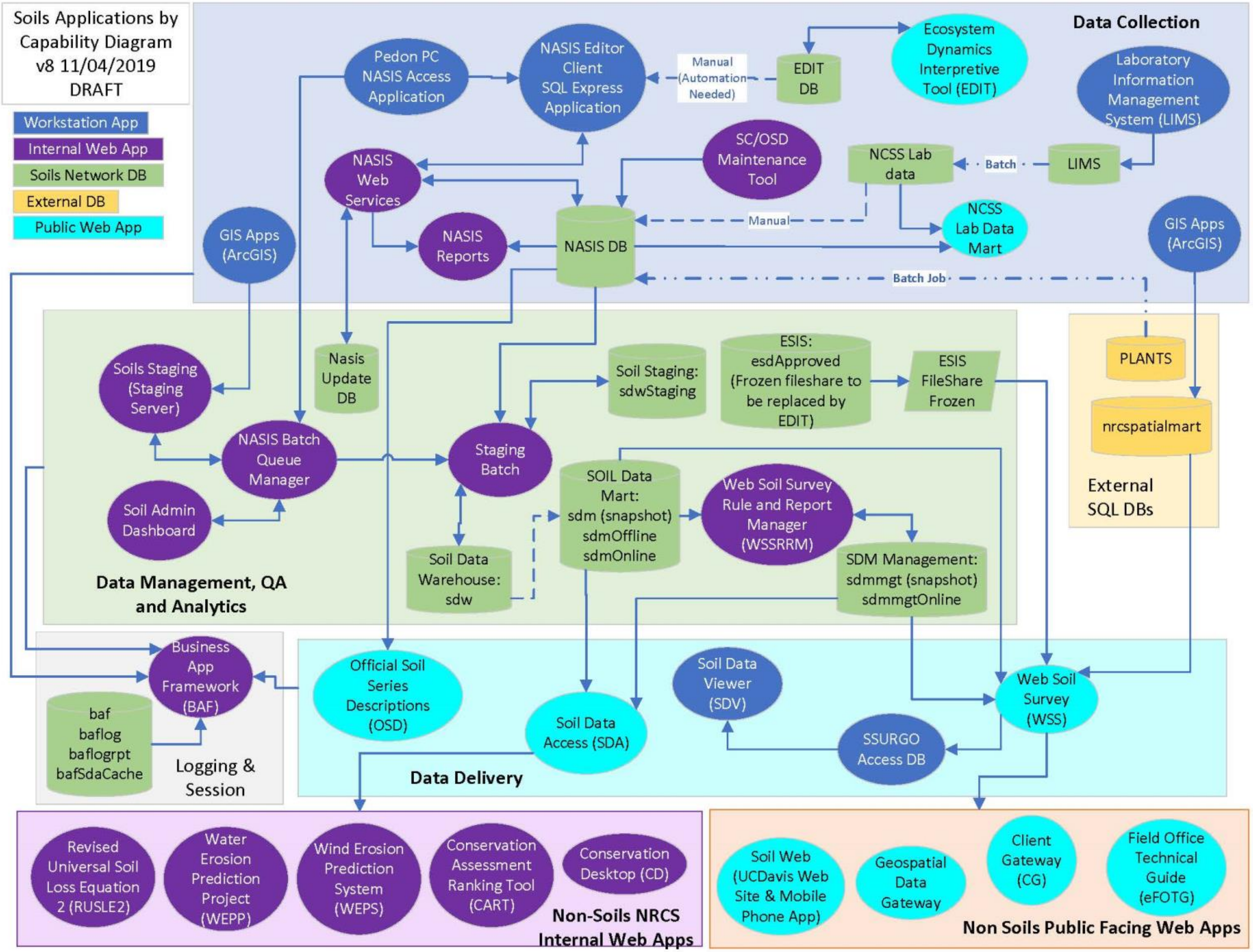
2. **Pedon database** (456,403 field observations)

https://nrcs.maps.arcgis.com/apps/webappviewer/index.html?id=956154f98fc94edeaa2dbad99b

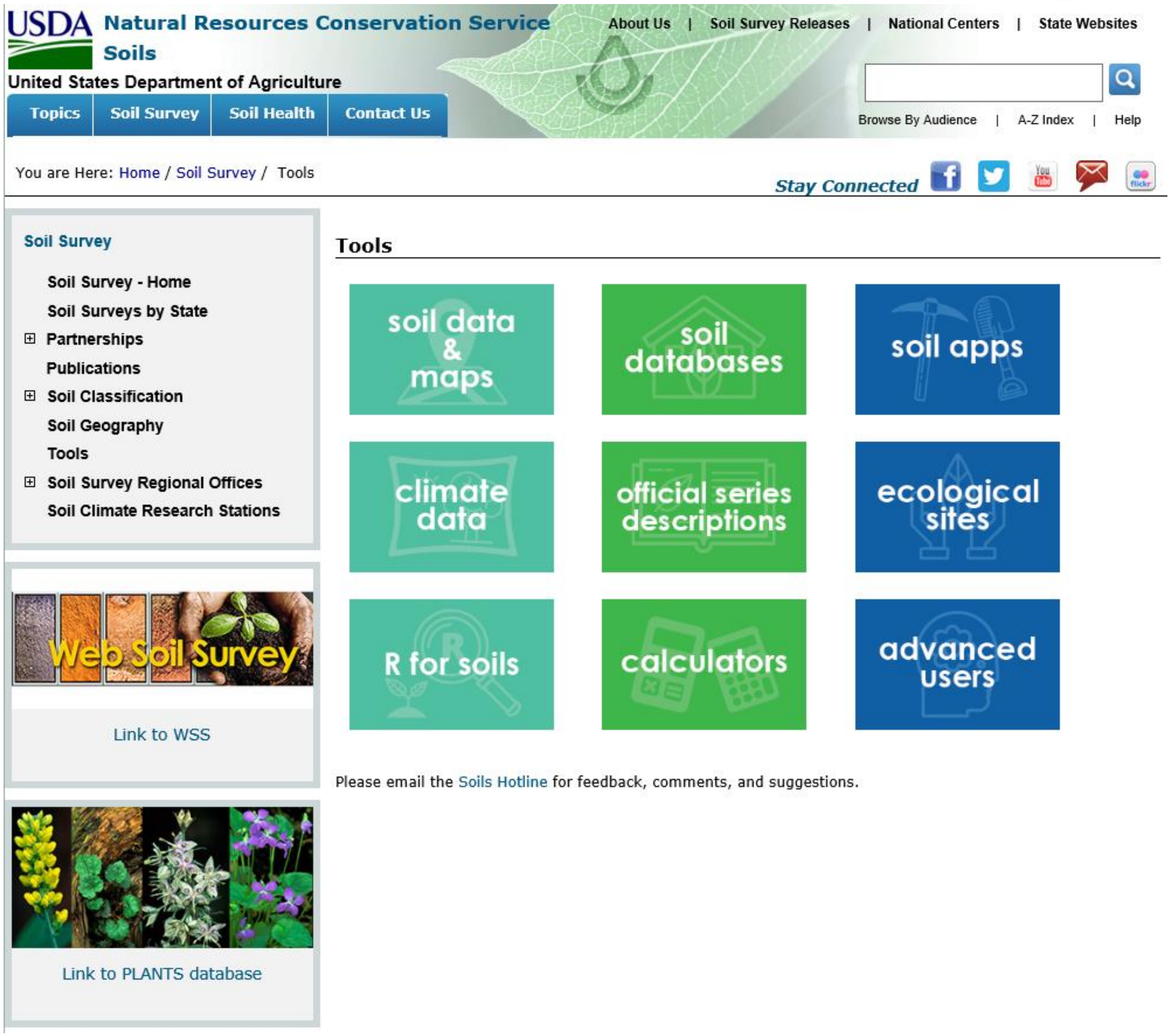




NASIS Schema



https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/tools/

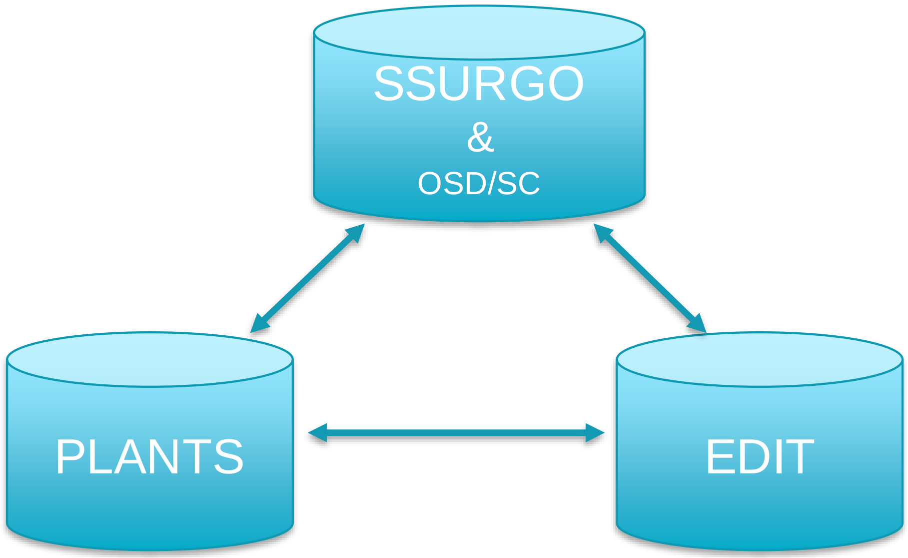


Heiden Series– Fine, smectitic, thermic Udic Haplustert

Soil information Systems (Other Databases)

National Soil Information System (NASIS)

1. Pant List of Accepted Nomenclature, Taxonomy and Symbols (PLANTS) database
2. Ecosystem Dynamic Interpretive Tool (EDIT) Database



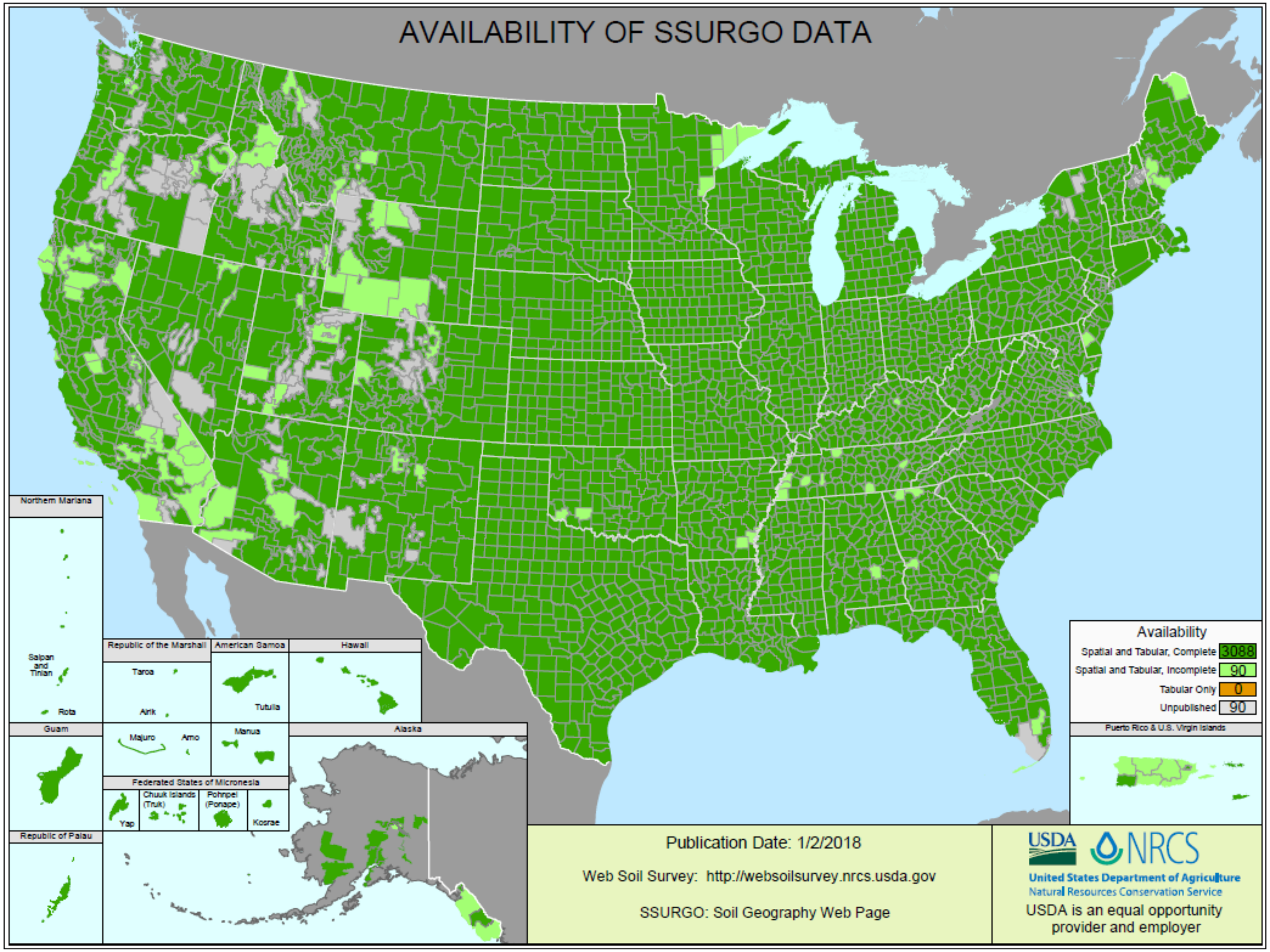
Soil information Systems – Delivery

National Soil Information System (NASIS)

Kenefick Series – Ultic Hapludalf

1. Web Soil Survey (WSS)
2. Soil Data Access (SDA)
3. Soil Characterization (LDM, OSD)
4. Soil Web

SSURGO Coverage 1935-2019



Amarillo Series–
Aridic Paleustalf

Plant List of Accepted Nomenclature Taxonomy and Symbols- PLANTS

Welcome to the PLANTS Database | USDA PLANTS

Search
Name Search
Scientific Name Go
- State Search
- Advanced Search
- Search Help

PLANTS Topics
- Alternative Crops
- Characteristics
- Classification
- Cover Crops
- Culturally Significant
- Distribution Update
- Documentation
- Fact Sheets & Plant Guides
- Introduced, Invasive, and Noxious Plants
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- Wetland Indicator Status

Image Gallery
- 50,000+ Plant Images

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- State PLANTS Checklist
- Advanced Search Download
- Symbols for Unknown Plants
- NRCS State GSAT Lists
- NRCS State Plants Lists

Related Tools
- Crop Nutrient Tool
- Ecological Site Information System
- PLANTS Identification Keys
- Plant Materials Web Site
- Plant Materials Publications
- USDA Plant Hardiness Map

You are here: Home / Plant Profile

GENERAL | IMAGES | SYNONYMS | CLASSIFICATION | LEGAL STATUS | WETLAND | RELATED LINKS

***Potentilla rivalis* Nutt.**
brook cinquefoil

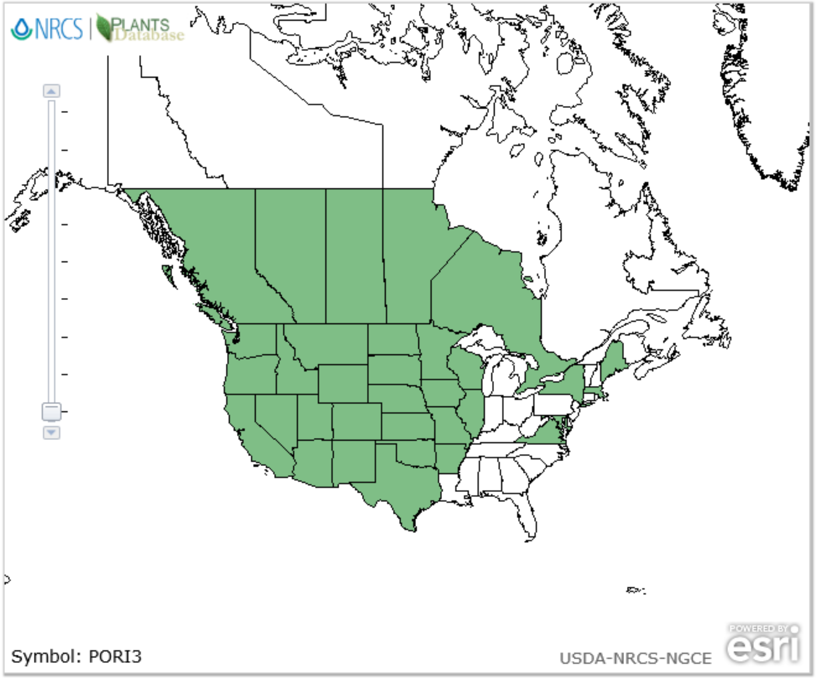
Show All

General Information

Symbol:	PORI3
Group:	Dicot
Family:	Rosaceae
Duration:	Annual Biennial
Growth Habit:	Forb/herb
Native Status:	CAN N L48 N

Data Source and Documentation

About our new maps



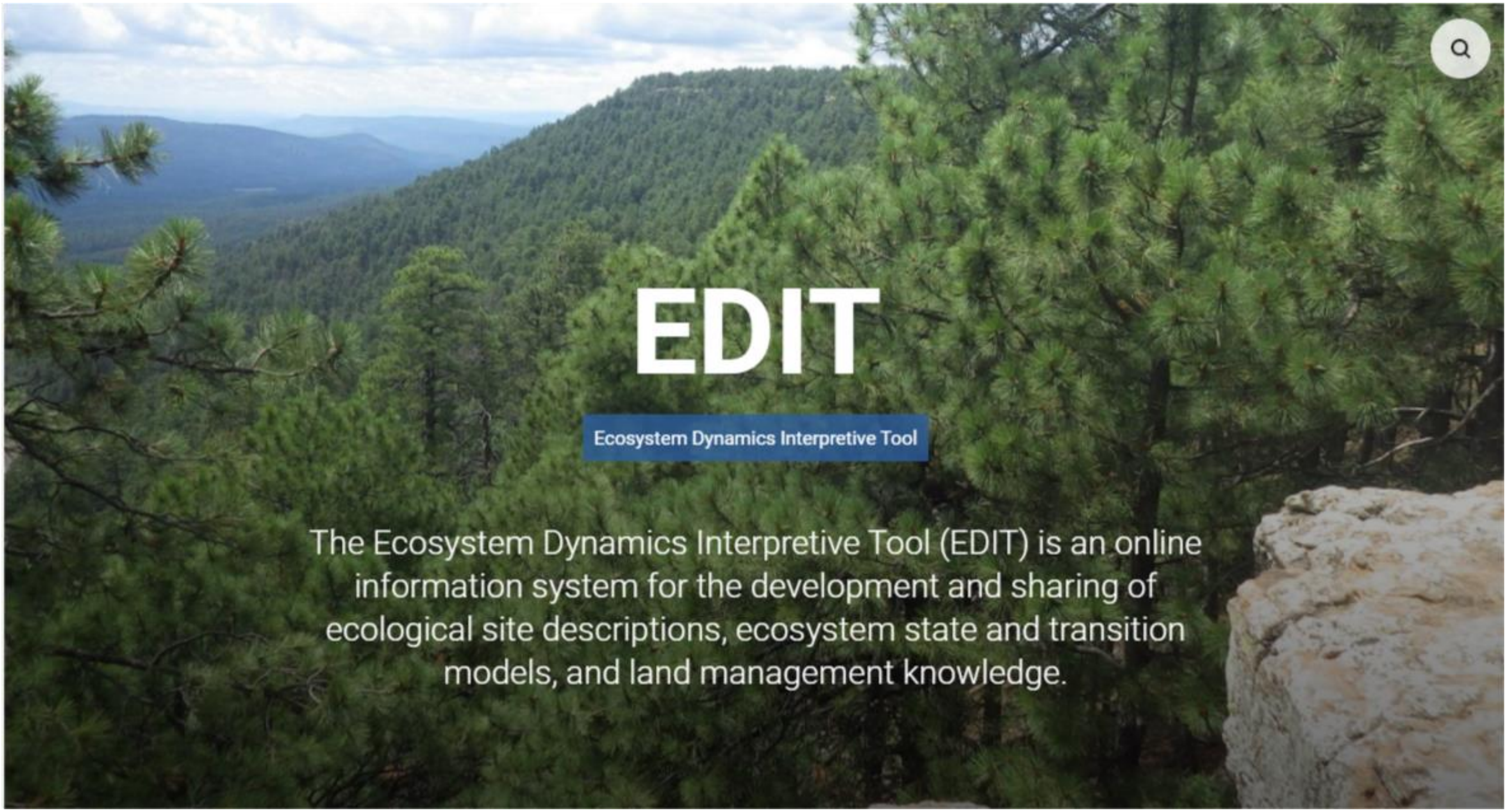
Native | Introduced | Both | Absent/Unreported
Native, No County Data | Introduced, No County Data | Both, No County Data

Native Status:
L48 AK HI PR VI NAV CAN GL SPM NA

Niotaze Series–
Albaquic Hapludalf

Ecosystem Dynamic Interpretive Tool - EDIT

Ecological site descriptions (nmsu.edu)



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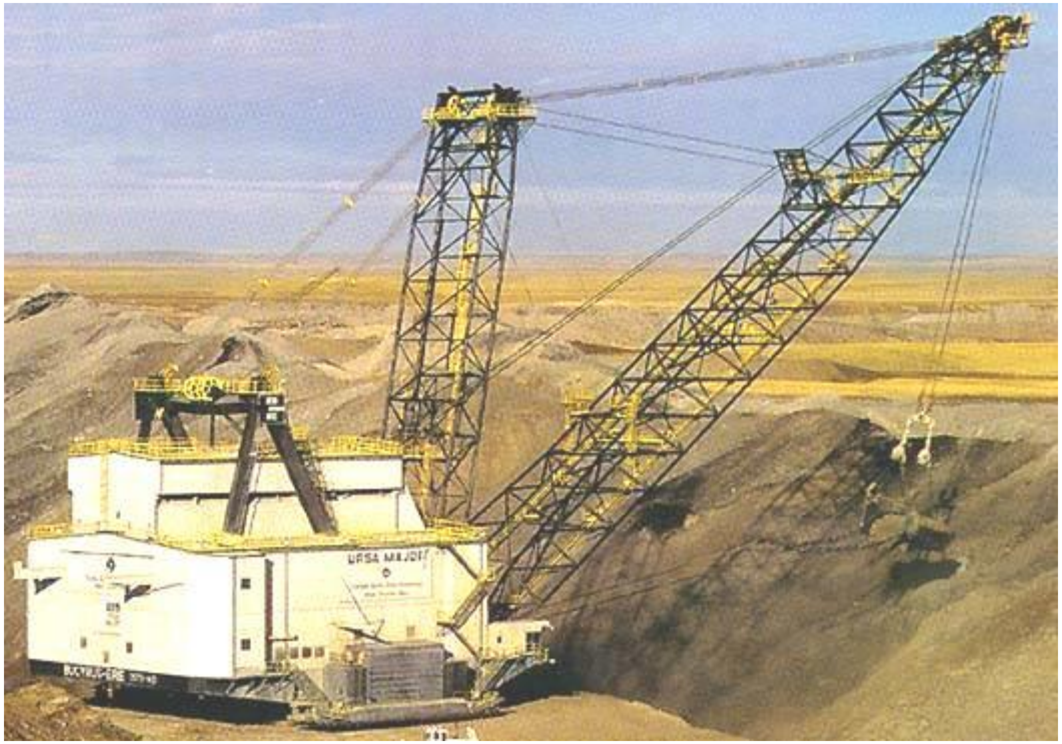
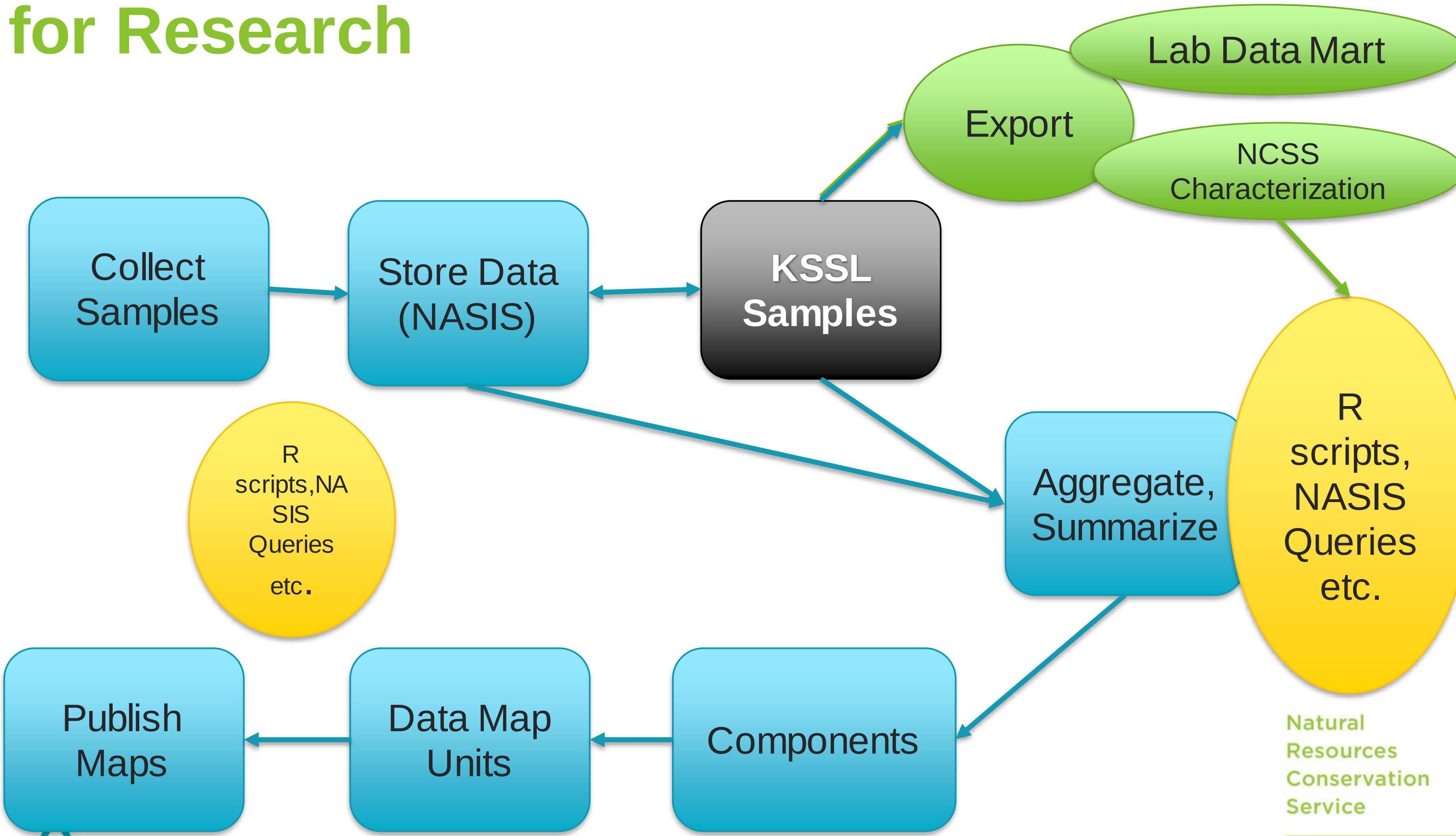
FIN

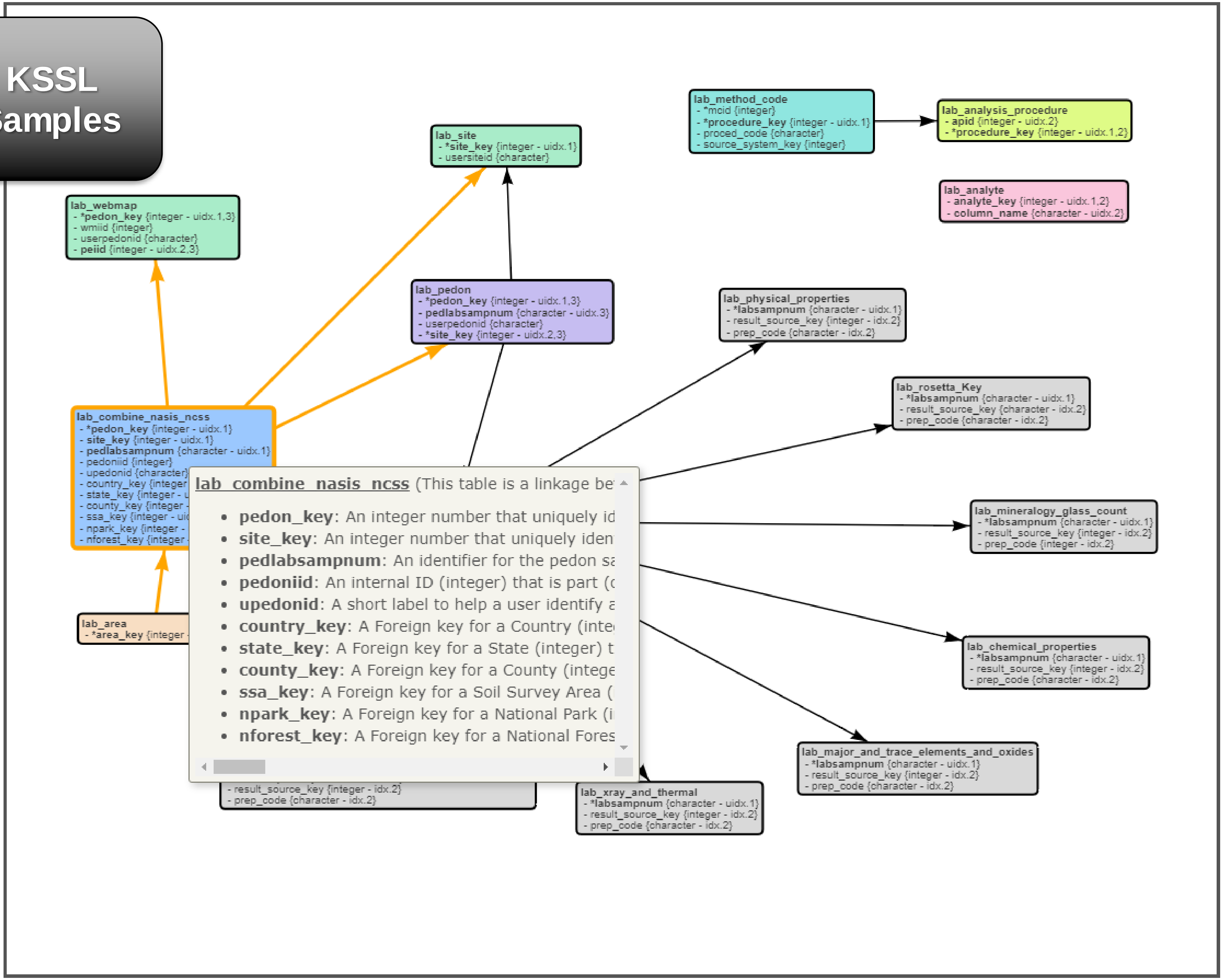


Dig Technology

Key Steps In Collecting Soil Survey Data for Research



KSSL Samples



USDA
United States Department of Agriculture

Field Book for Describing and Sampling Soils, version 3.0

Field Book for Describing and Sampling Soils

The Field Book for Describing and Sampling Soils, version 3.0 (*Schoeneberger, Wysocki, Benham, and Soil Survey Staff, 2012*) is a 4" x 7" spiral-bound publication printed on waterproof paper. Page tabs mark Field Book chapters and sections for quick, easy reference. Early chapters address Site Description, Soil Profile/Pedon Description, and

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Soil Data Access Related Tables: Tables and Columns

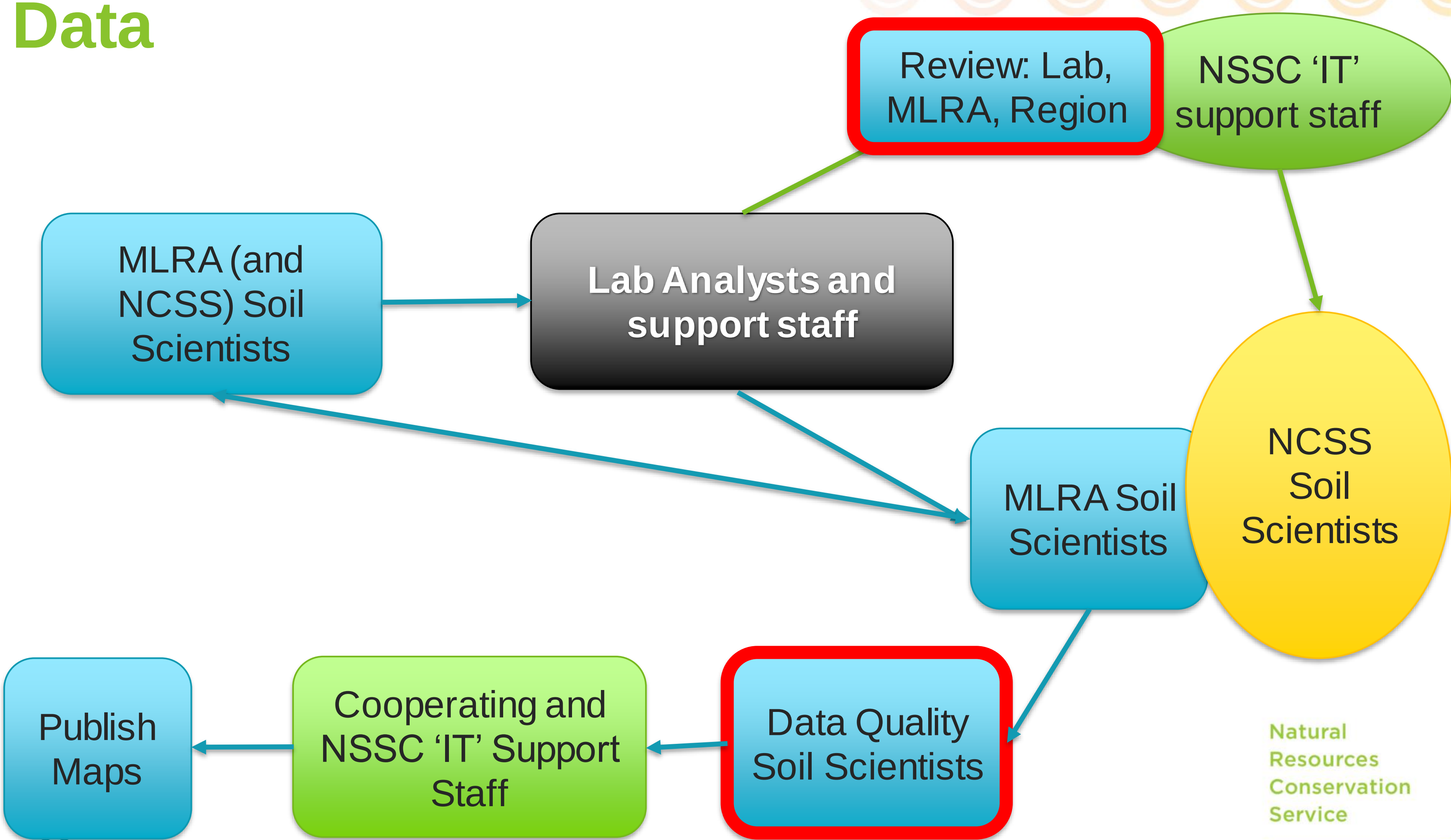
Open in Acrobat

Logical Name	Table Physical Name	Table Label	TabHelp	Default Seq-uence	Logical Name	Physical Name	Column Label	Logical_Data_Type	Physical_Data_Type	Not_Null	Col-umn Dis-play Size	Precis-ion	Mini-mum	Maxi-mum	UOM	Domain Name
chorizon_aashto	chaashto	Horizon AASHTO	The Horizon AASHTO table contains the American Association of State Highway Transportation Officials classification(s) for the referenced horizon. One row in this table is marked as the representative AASHTO classification for the horizon.	1	aashto_group_classification	aashtocl	AASHTO	Choice	Varchar	no	30					aashto_group_classification
chorizon_aashto	chaashto	Horizon AASHTO	The Horizon AASHTO table contains the American Association of State Highway Transportation Officials classification(s) for the referenced horizon. One row in this table is marked as the representative AASHTO classification for the horizon.	2	rv_indicator	rvindicator	RV?	Boolean	Char	yes	3					
chorizon_aashto	chaashto	Horizon AASHTO	The Horizon AASHTO table contains the American Association of State Highway Transportation Officials classification(s) for the referenced horizon. One row in this table is marked as the representative AASHTO classification for the horizon.	3	chorizon_key	chkey	Chorizon Key	Integer	Int	yes	30					
chorizon_aashto	chaashto	Horizon AASHTO	The Horizon AASHTO table contains the American Association of State Highway Transportation Officials classification(s) for the referenced horizon. One row in this table is marked as the representative AASHTO classification for the horizon.	4	chor_aashto_key	chaashtokey	Chorizon AASHTO Key	Integer	Int	yes	30					
chorizon_consistence	chconsistence	Horizon Consistence	The Horizon Consistence table contains descriptive terms of soil consistence—rupture resistance, plasticity, and stickiness—for the referenced horizon. One row in this table is marked as having the representative characteristics for the horizon.	1	rupture_resist_block_moist	rupresblkmst	Rupture Moist	Choice	Varchar	no	30					rupture_resist_block_moist

SSURGO Refresh Instructions

nrcs.usda.gov/

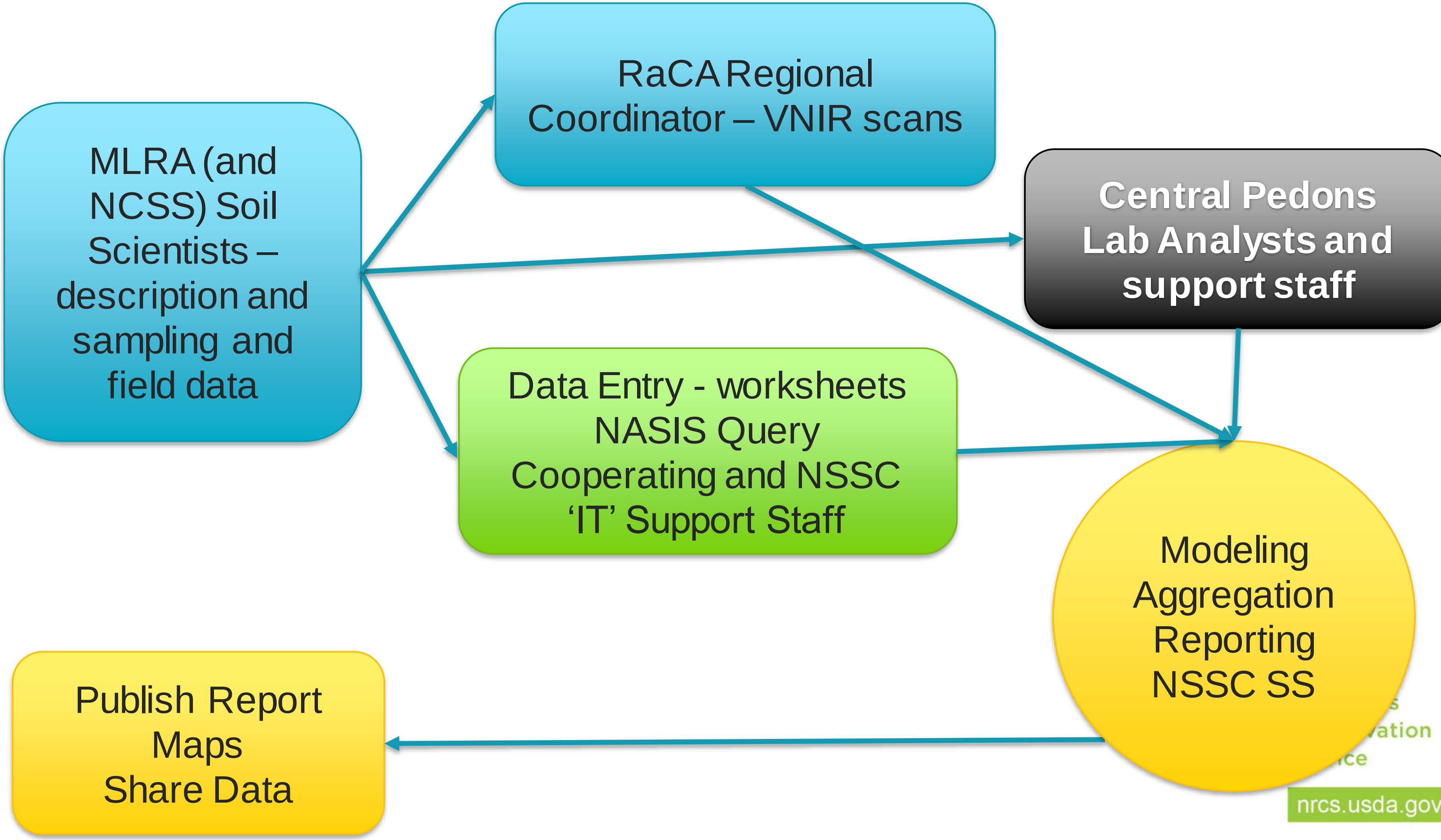
People in the Key Steps In Soil Survey Data



Dynamic – 2 uses in our databases

- **Data hierarchy**
  - Site
    - Site observation (date 1)
      - Pedon
        - Horizon
    - Site observation (date 2)
      - Pedon
        - Horizon
- **Info used to Infer Dynamics**
  - Land Use and Management Information
    - Space for time
  - Specific Date and Condition (weather) information
  - Links to projects and context to make decisions
- **Ecological Site Descriptions**
  - Infer time

People in the Key Steps In RaCA



United States Department of Agriculture

RaCA Data

Methodology and Guidance Documents

- **Used Standard Data Collection and Storage**
- **Expert NSSC queries to existing systems**
- **Expert – manual matching**

- **Additional methodology documentation**
  - Posted to website

- **Raw data lives on my computer as a very large excel file**
  - Partially due to sensitivity of locations (not public)
  - Partially due to one-time nature of special project
  - We added some fields to NASIS for this project that are now – misused……

Natural Resources Conservation Service

nrcs.usda.gov/

Dynamic Soil Property Hub

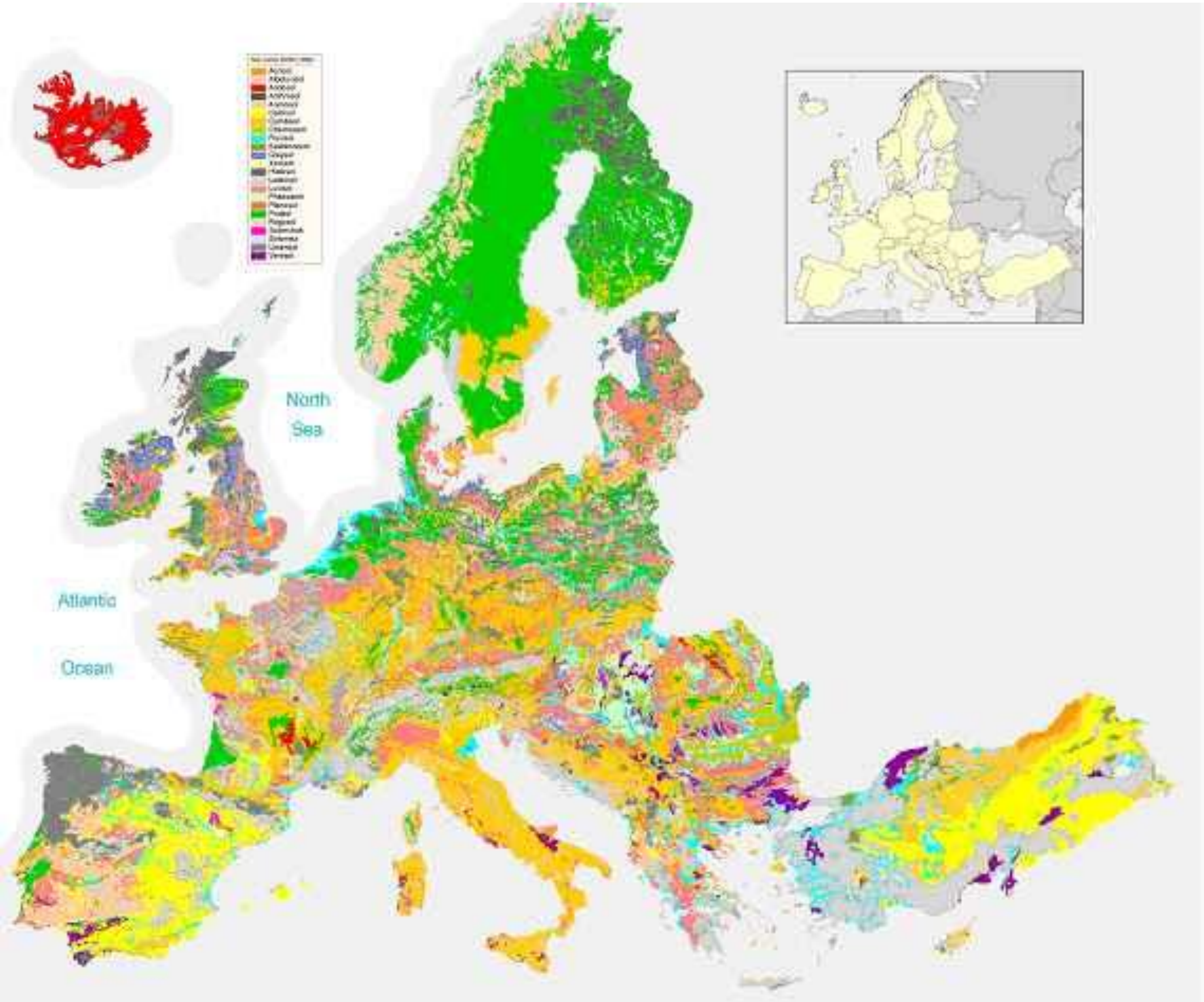
This isn't done, but it's under development

- **Link data from multiple NRCS/USDA sources**
    - Enhanced conservation practice information
- **Apply models - interpretations with all data**
- **Develop new models**

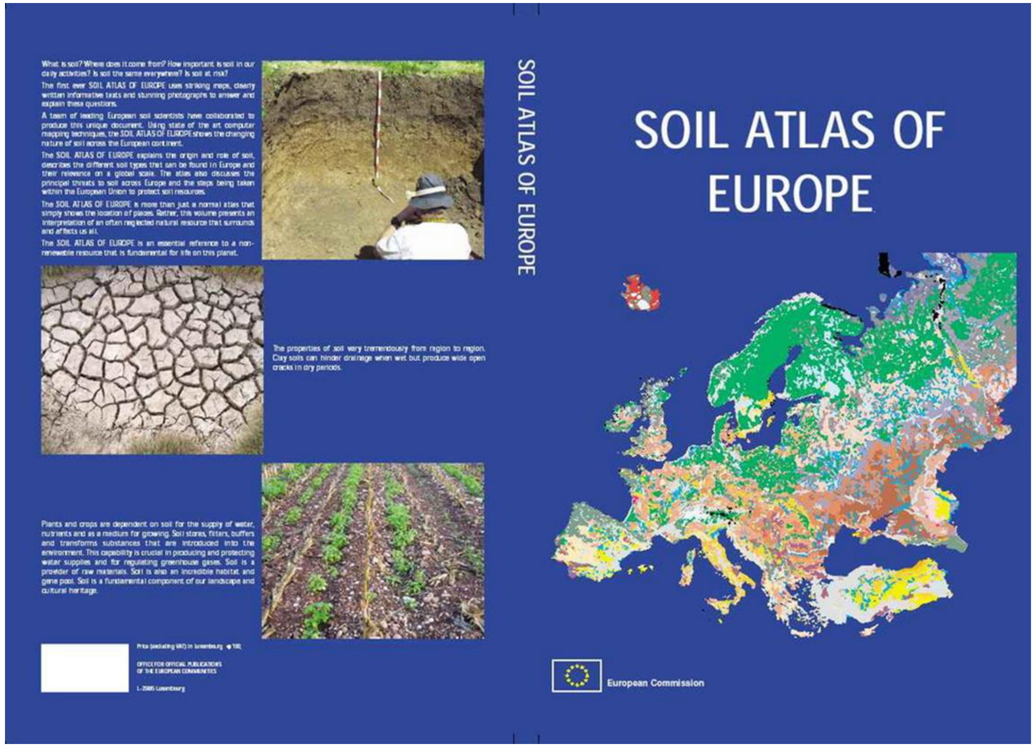
- **Embed metadata – models and data use – to make predictions and assessments for decision makes**

- **First test – apply SHAPE to CIG-Soil Health Demo Trial data**
- **First DB test – DSP4SH projects; first group finished Oct 2020**
    - Many cooperators: (mostly) standard methods and data elements
    - Combining management information – very difficult

How did it start?
Building a common understanding of European soil properties



Montanarella, L., Jones, R.J.A., Grimm, M., Hollis, J.M., Jones, A.R. & Daroussin, J. (**2001**). Soil Map for Europe: Soil classification according to the World Reference Base for Soil Resources, large format map (1065mm x 965mm) scale 1:4,500,000. DG-JRC, European Commission



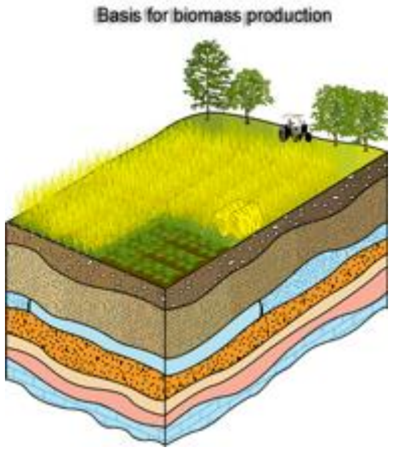
Soil Atlas of Europe, European Soil Bureau Network European Commission, **2005**, 128 pp Office for Official Publications of the European Communities, L-2995 Luxembourg

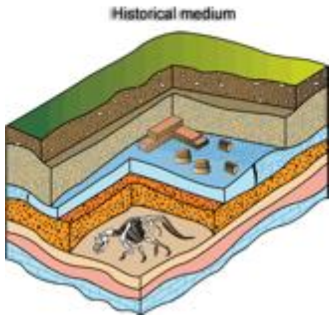
From a common understanding of the European soil resources to a common legal framework for soils in the European Union: The Soil Thematic Strategy, COM(2006) 231

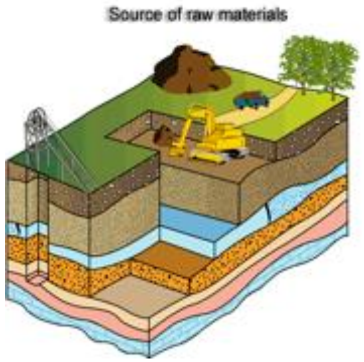
- Overall objective is the protection of **soil functions** and **sustainable use** of soil, based on the following guiding principles:
  - Prevention of soil degradation
  - Restoration of degraded soils
- Sets out the **four pillars** of EU soil policy
- To be implemented by MS
- 2012 Report from the Commission on the implementation of the STS COM(2012)46

Soils deliver multiple services (soil functions as identified in the Soil Thematic Strategy COM(2006) 231):

1. Biomass production, including in agriculture and forestry;
2. Storing, filtering and transforming nutrients, substances and water;
3. Biodiversity pool, such as habitats, species and genes;
4. Physical and cultural environment for humans and human activities;
5. Source of raw materials;
6. Acting as carbon pool;
7. Archive of geological and archeological heritage.

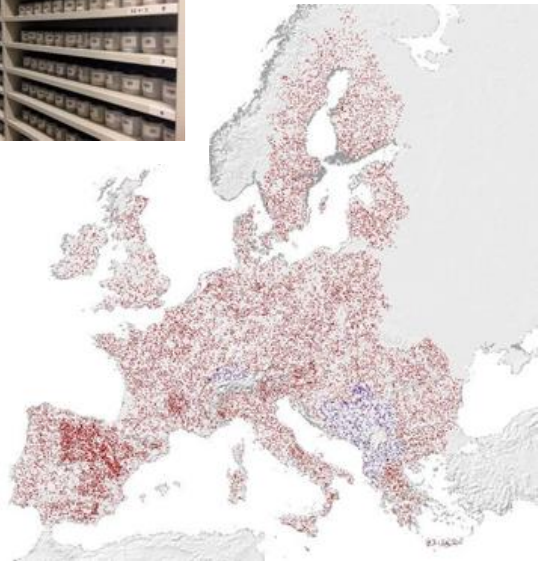






EU-Wide Soil Monitoring

From LUCAS (ca. 25,000 sites) to the EU Integrated Soil Monitoring (ISM) (ca. 250,000 sites)



LUCAS SOIL

- Systematic approach for 25,000 locations across the EU
- Harmonized sampling protocol
- Standard analytical procedures to measure parameters
- Single laboratory
- Data from 2009, 2015, 2018, 2021/2022...
- EU/Regional statistics, point-based applications

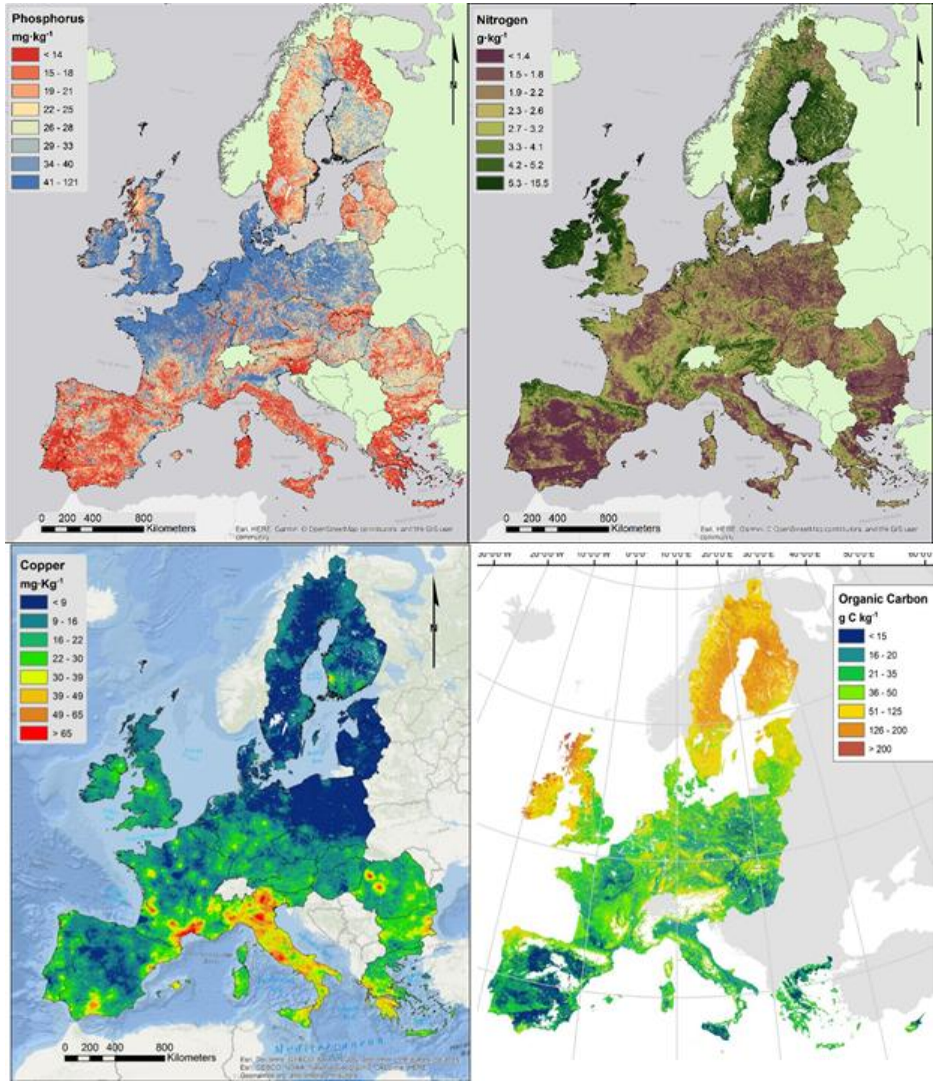
Future expansion within the EUSO

- Systematic approach for ca. 250,000 locations across the EU
- Full integration of National soil monitoring systems

EU-Wide Soil Monitoring

From monitoring chemical, physical and biological soil properties to modelling the spatial distribution of soil properties in the EU

- Coarse fragments
- particle-size distribution (clay, silt, sand)
- pH
- Organic carbon
- Carbonate content
- Total nitrogen content
- Extractable potassium content
- Phosphorous content
- Cation exchange capacity
- Electrical conductivity
- Heavy Metals
- Multispectral properties
- Pesticides (90 substances)
- Neonicotinoid insecticides
- Fungicides (e.g. copper in soils)
- Herbicides
- Antibiotics
- Soil Biodiversity



Target

Operational EU soil monitoring system supporting soil related EU policies fully integrated with National soil monitoring systems in MS

Future deliverables

- **EU soil status reporting (in collaboration with EEA)**
- **Soil pollution indicators** (Zero Pollution Strategy)
- indicators in relation to the **soil aspects** of the **European Green Deal** including the **Farm to Fork**, **Biodiversity** and **Climate Change** Strategies

Implementation

Available

- **ESDAC** as the primary soil knowledge hub for the EU and global data
- **Coordination of EU-wide and global sampling surveys**
  LUCAS Soil since 2009, Africa in 2020
- **Modelling and indicator development**

Missing

- **Integration with EU MS's National soil monitoring systems**

FPI | ESTAT | CLIMA | ENV | AGRI | DEVCO | SANTE

European Green Deal
- Biodiversity Strategy 2030
- Zero Pollution Strategy

European Climate Law

Farm to Fork strategy's international dimensions

Stronger Europe in the World
- Comprehensive Strategy on Africa

Protecting our European Way of Life
- Cooperation towards Sustainable Growth

https://ec.europa.eu/jrc/en/eu-soil-observatory

EU **SOIL** OBSERVATORY

ISRIC – World Soil Information

Vision

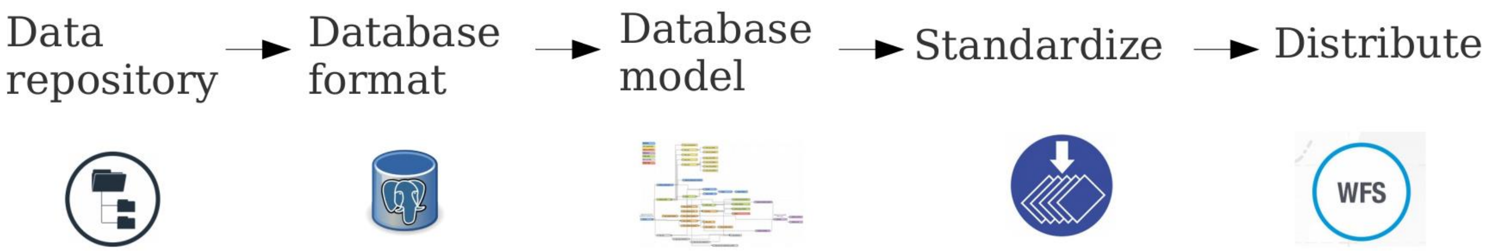
A world where **reliable** and relevant soil information is **freely-available** and **properly used** to address environmental and social challenges.

Workstreams

- Standard setting
- Global data provisioning
- Capacity building
- Applications

ISRIC World Soil Information

World Soil Information System (WoSIS)

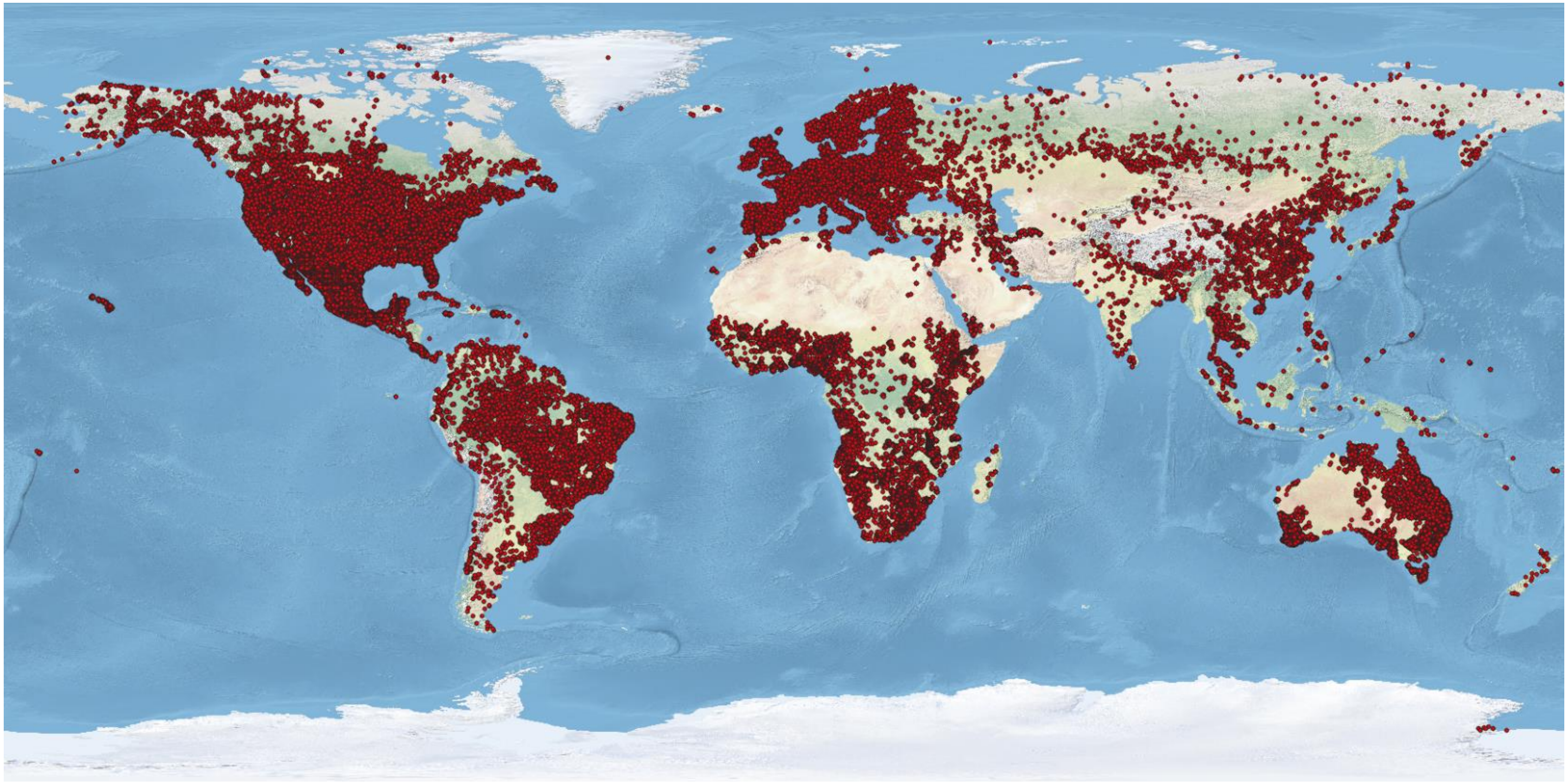


- Profiles shared by a wide range of data providers
- Over 450,000 profiles registered ‘as is’ in DATA repository with their license and lineage.
- Available data are cleansed and standardised using consistent procedures in **WoSIS database** (subject to use licence)

ISRIC World Soil Information

Source: https://doi.org/10.5194/essd-12-299-2020

WoSIS snapshot 2020

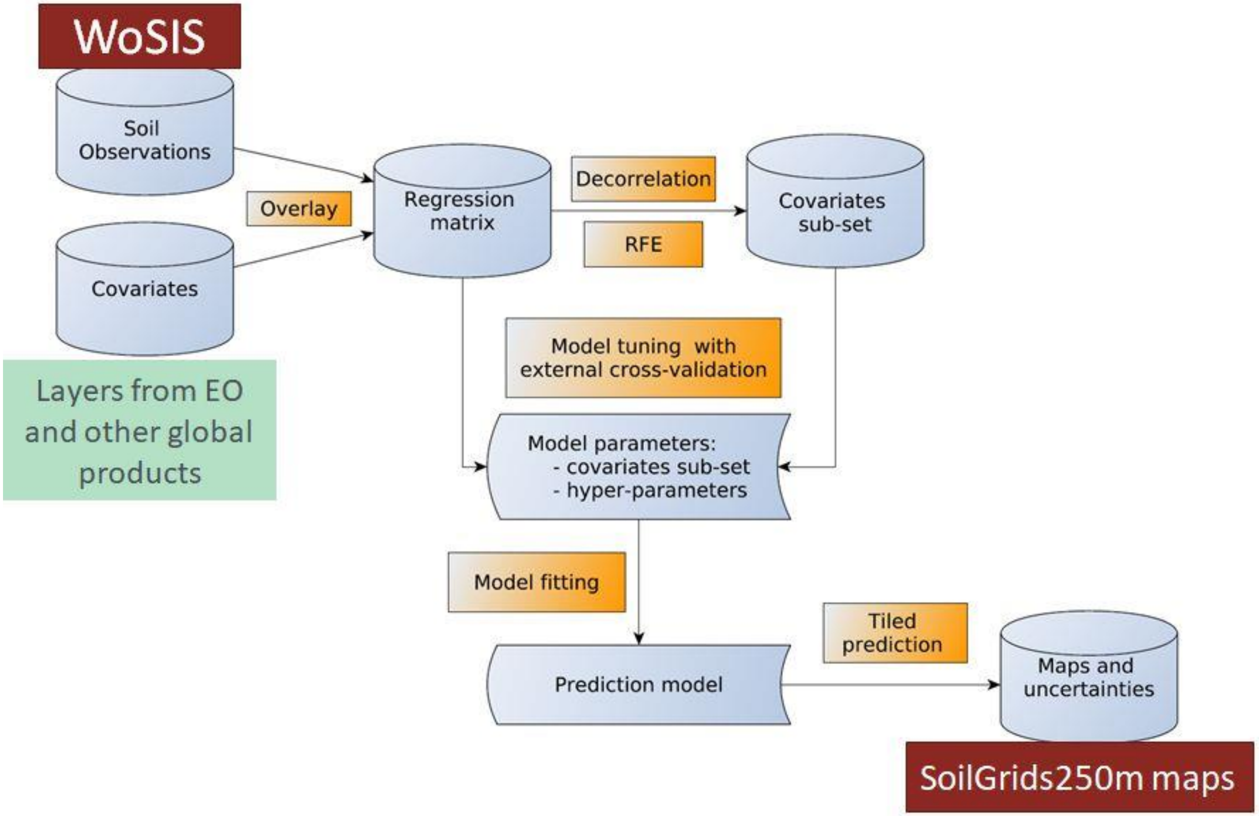


- ~196,000 **standardized** profiles in *public* 2020 WoSIS snapshot (CC-BY)
- Additional ~42,000 profiles can only be used for SoilGrids™ applications.

ISRIC World Soil Information

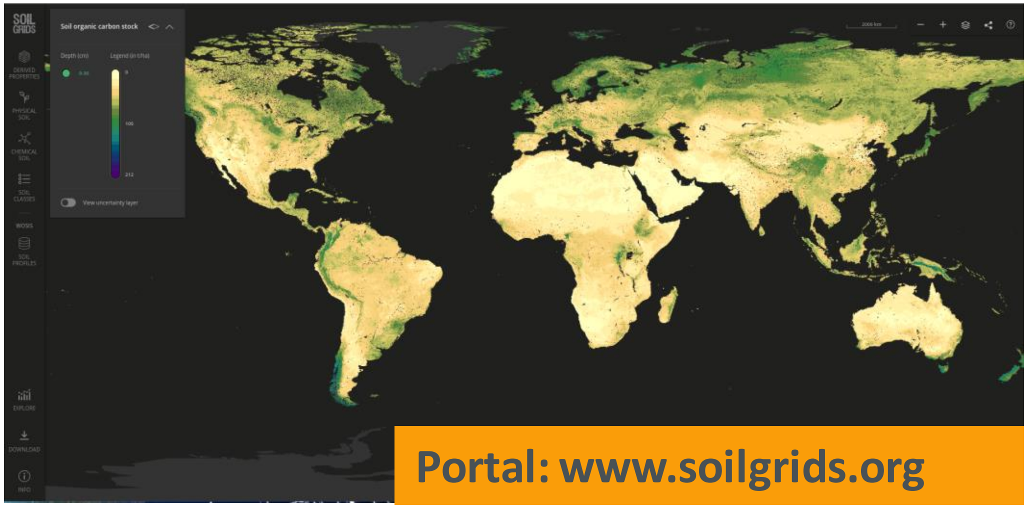
Data paper: https://doi.org/10.5194/essd-2019-164
Dataset: https://doi.org/10.17027/isric-wdcsoils.20190901
Latest (dynamic) version: WFS link (*http://maps.isric.org/mapserv?map=/map/wosis_latest.map*)

SoilGrids: soil property maps with quantified uncertainty



State-of-the-art **modelling** methods (cross-validation, model selection, texture) with **data** inputs (points/covariates) consistency with **open-source** computational infrastructure with **reproducible** workflow including mapping of the **uncertainty.**

Serving point data and maps jointly

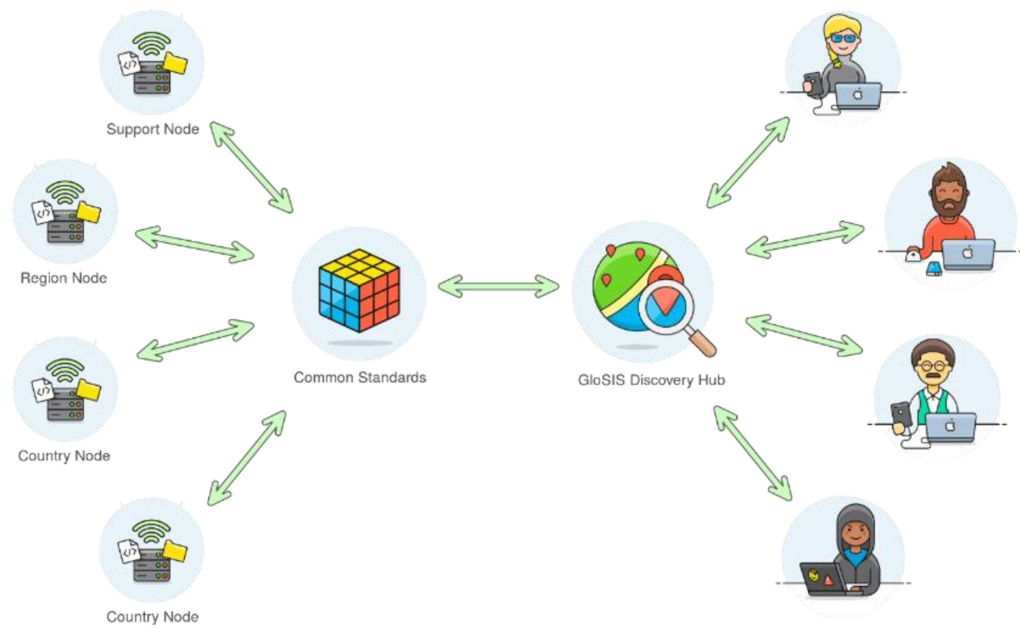


Portal: www.soilgrids.org

Google Earth Engine

Some other remarks

- Towards soil functions, ecosystem services
- Users: global users and academia
- For local impact: national systems are needed
- GLOSIS: federated soil information system, FAO-GSP



Samantha Weintraub
Research Scientist, Battelle
National Ecological Observatory Network
Exploring a Dynamic Soil Information System Workshop
March 2-4, 2021

NSF | neon Operated by Battelle

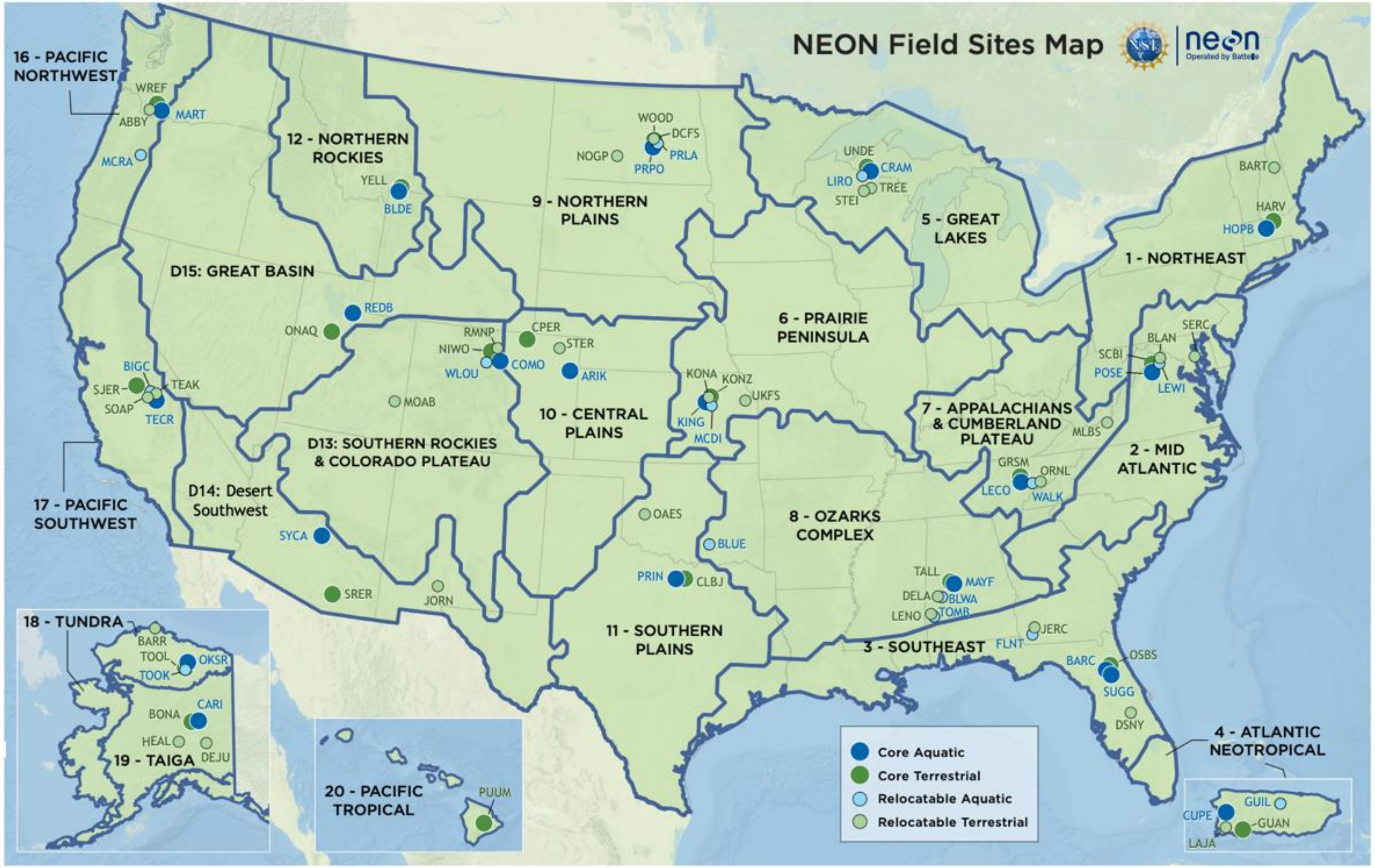
Collecting and sharing integrated soil data at the National Ecological Observatory Network

This material is based upon work supported by NSF's National Ecological Observatory Network which is a major facility fully funded by the National Science Foundation

What is NEON?

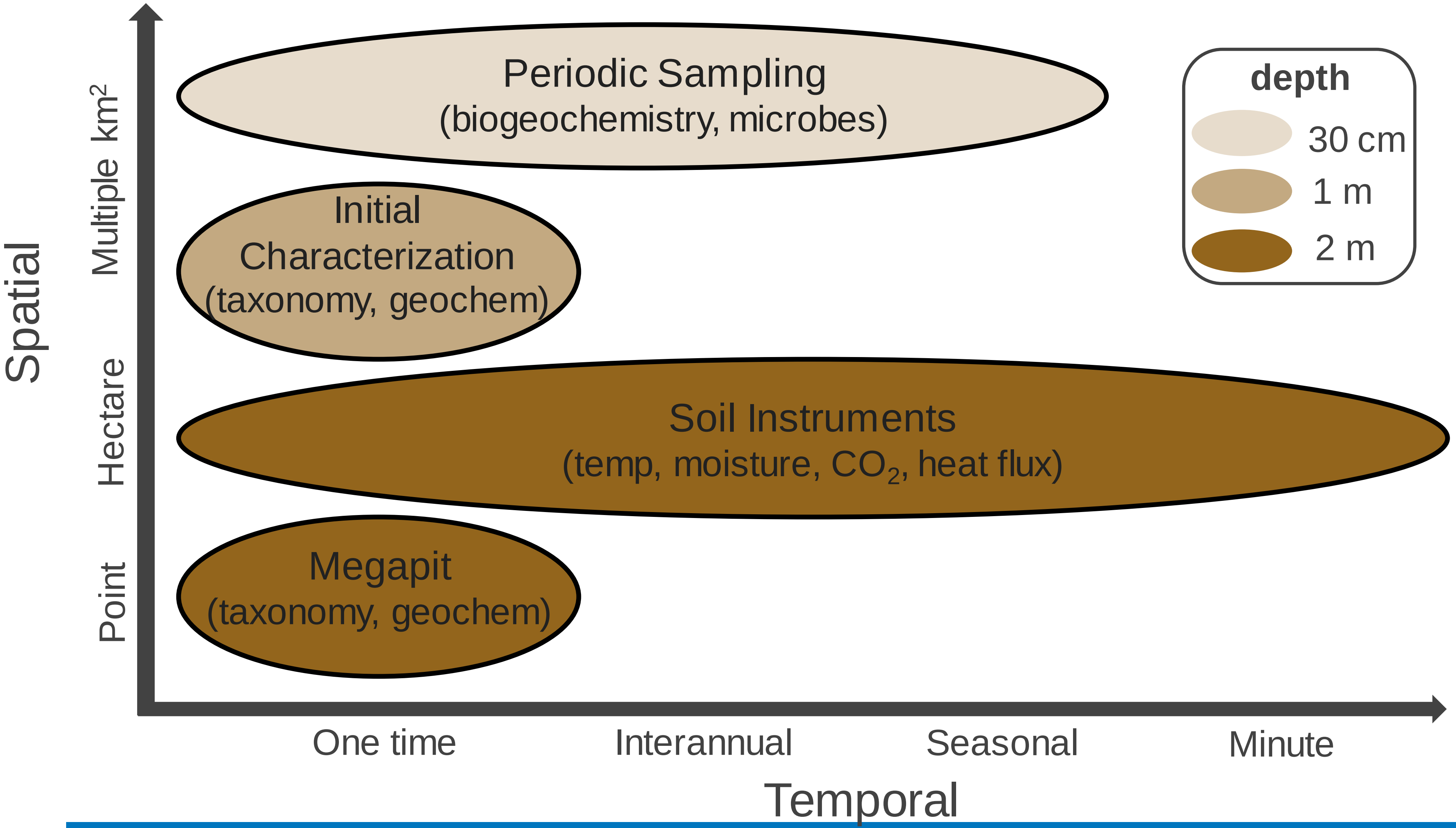
- Continental-scale U.S. observatory collecting long-term ecological data to understand how US ecosystems are changing

81 FIELD SITES	181 DATA PRODUCTS
47 terrestrial	15 **soil** data products

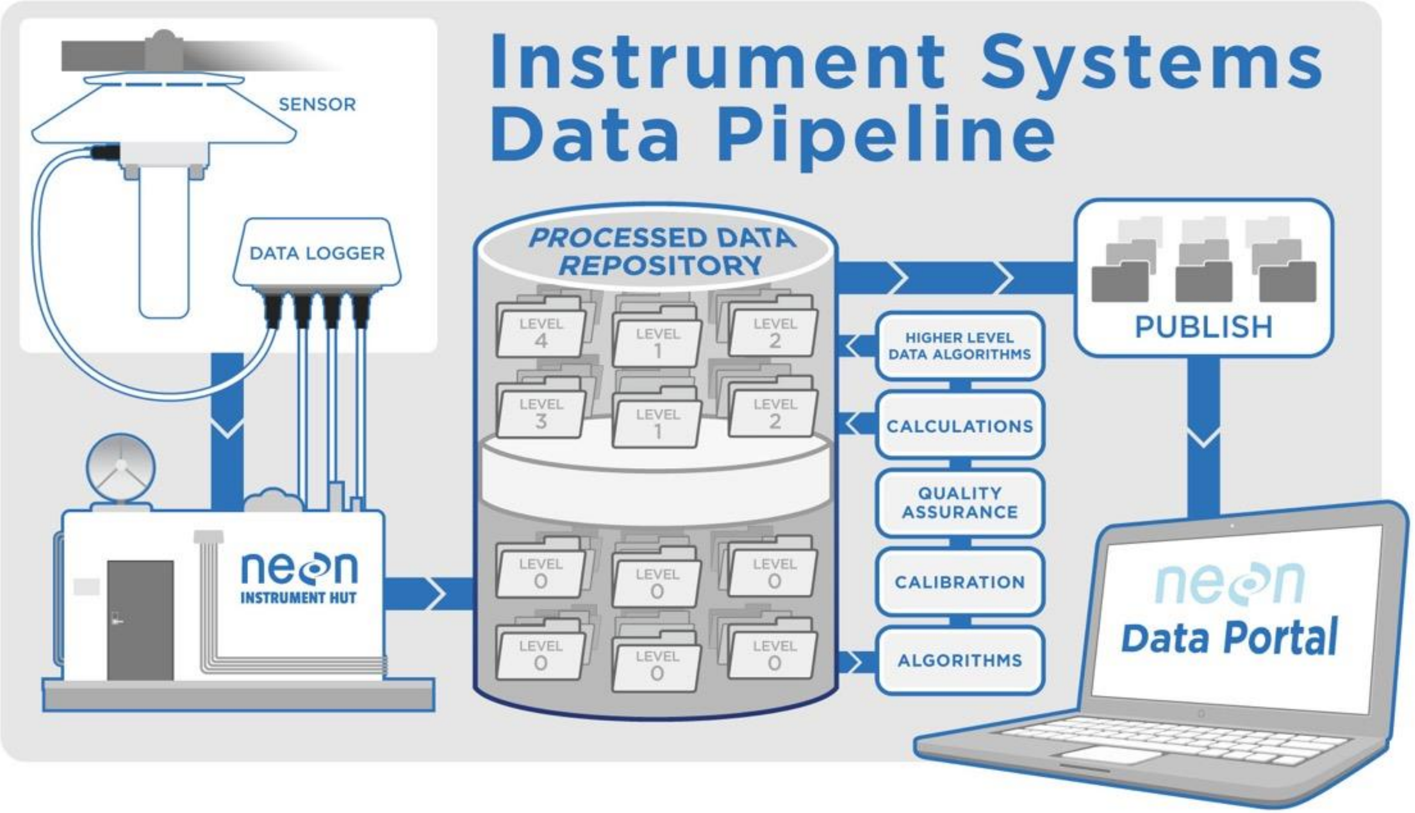


More info: www.neonscience.org

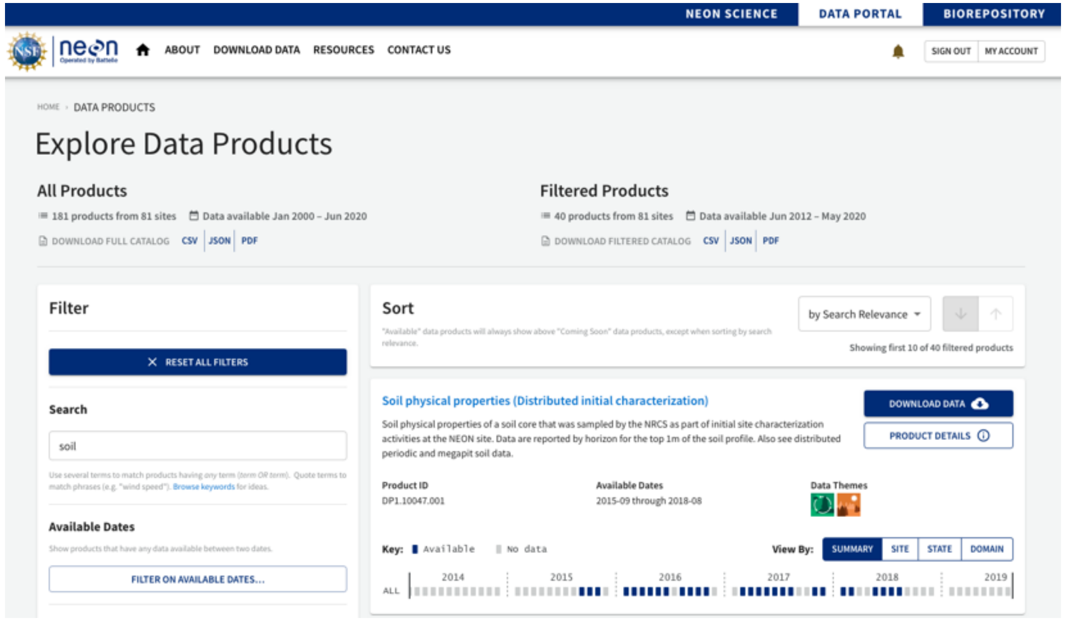
NEON soil data products and archives



How are data ingested, curated, and shared



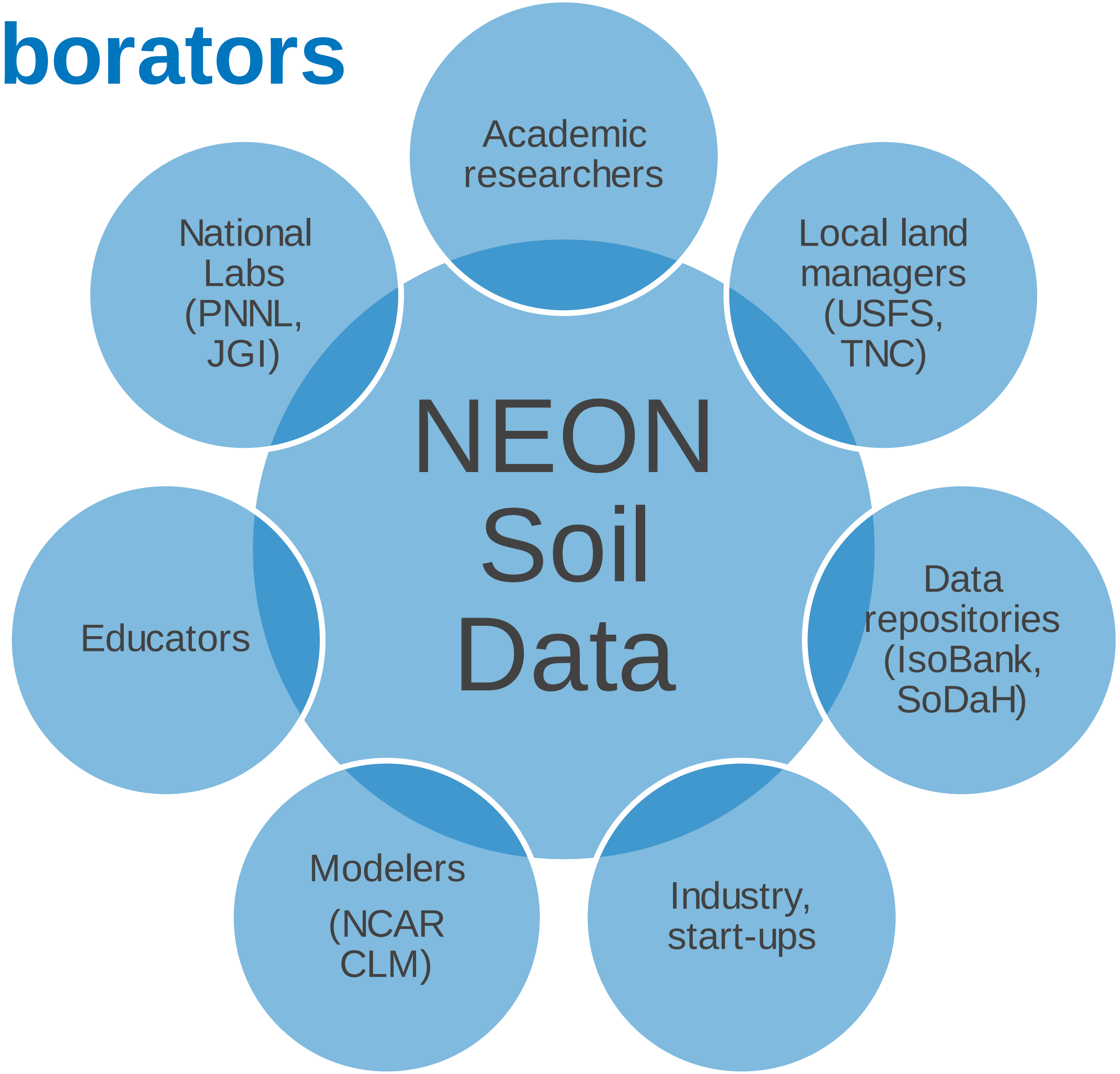
Similar pipeline for Observational Data



data.neonscience.org

- Learn about protocols & data processing
- Download free, open data (or use API)

Soil data users and collaborators



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