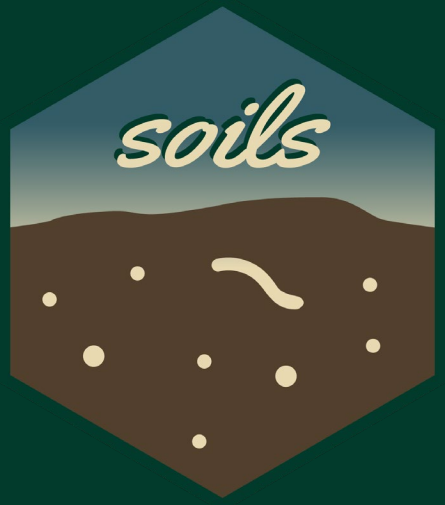
{soils}: an R package for soil health reporting



Jadey Ryan
Data Scientist , WSDA

Making Soils Data Actionable

April 3, 2024

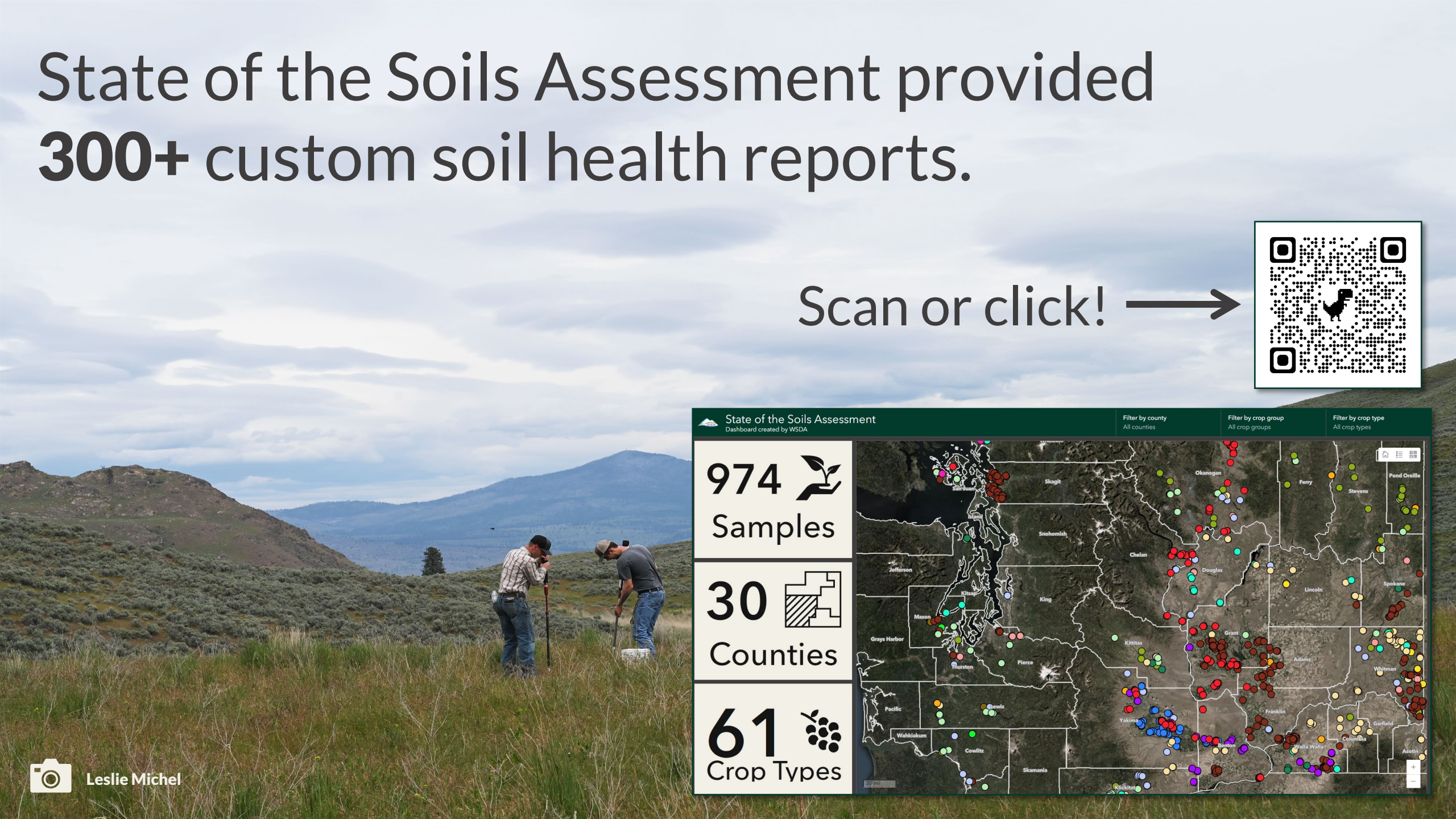
Washington State Department of Agriculture

WASHINGTON STATE UNIVERSITY

Coauthors:
Molly McIlquham, Kwabena Sarpong, Leslie Michel , Teal Potter, Deirdre Griffin LaHue, and Dani Gelardi

State of the Soils Assessment provided **300+** custom soil health reports.

Scan or click! →



Leslie Michel

How do we use reports to make soils data actionable?

Help participants:

Access their soil health data

Interpret within their crop & region context

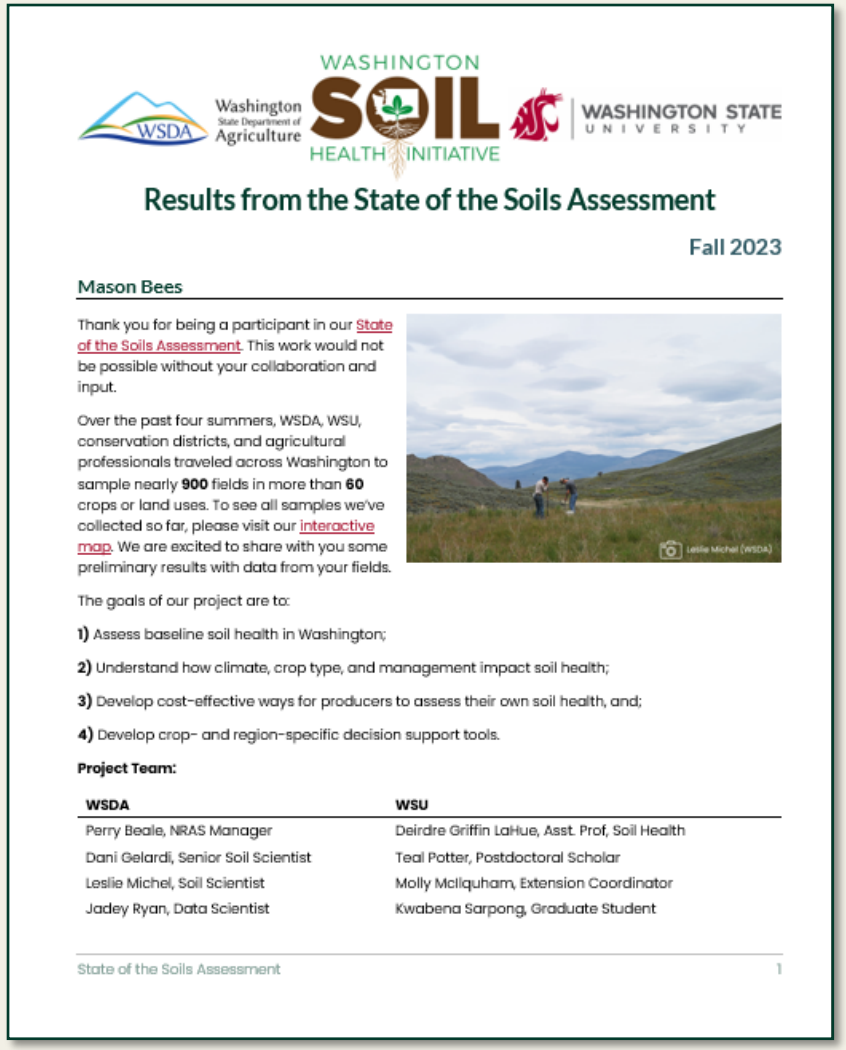
Translate into informed management decisions

Access soil health data

Provide the report in multiple formats

Interactive HTML

Printable PDF



WASHINGTON SOIL HEALTH INITIATIVE

Washington State Department of Agriculture

WSDA

WASHINGTON STATE UNIVERSITY

Results from the State of the Soils Assessment

Fall 2023

Mason Bees

Thank you for being a participant in our State of the Soils Assessment. This work would not be possible without your collaboration and input.

Over the past four summers, WSDA, WSU, conservation districts, and agricultural professionals traveled across Washington to sample nearly **900** fields in more than **60** crops or land uses. To see all samples we've collected so far, please visit our interactive map. We are excited to share with you some preliminary results with data from your fields.

Leslie Michel (WSDA)

The goals of our project are to:

1) Assess baseline soil health in Washington;

2) Understand how climate, crop type, and management impact soil health;

3) Develop cost-effective ways for producers to assess their own soil health, and;

4) Develop crop- and region-specific decision support tools.

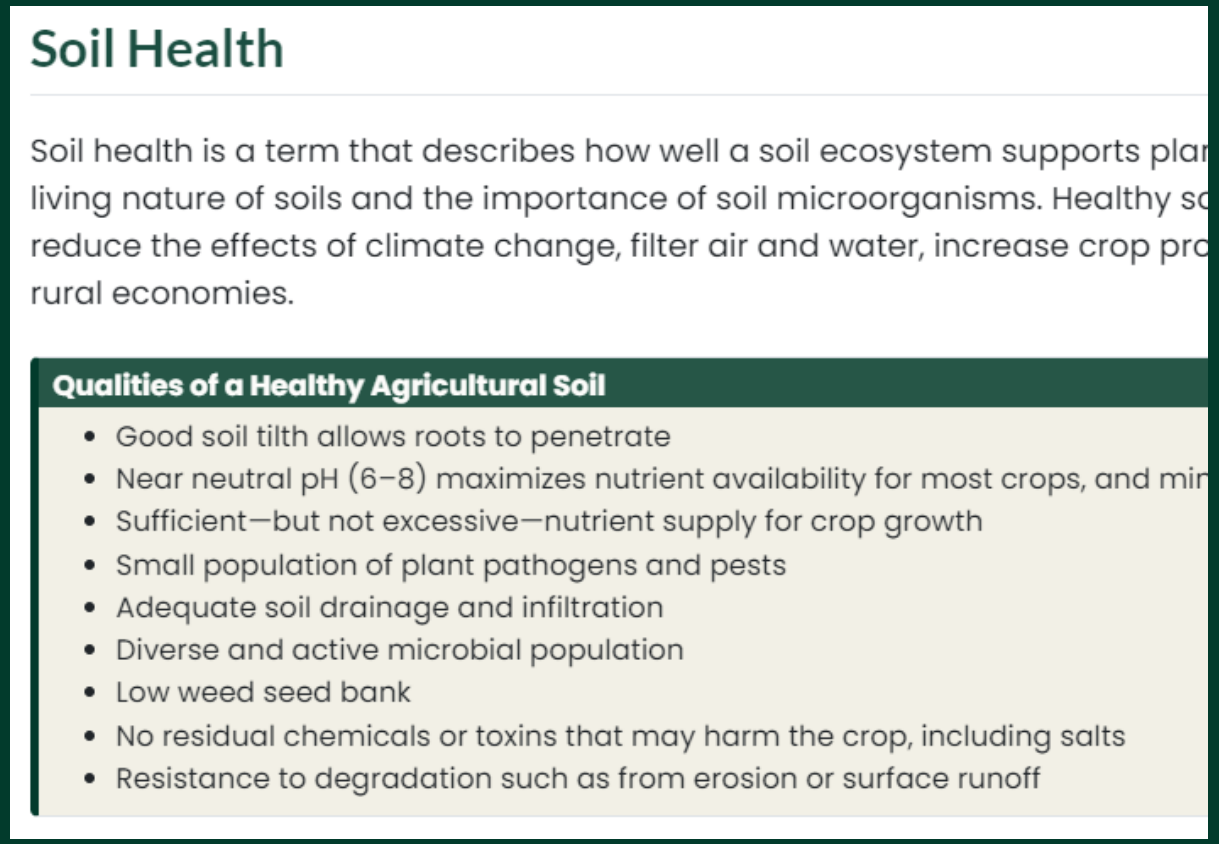
Project Team:

WSDA	WSU
Perry Beale, NRAS Manager	Deirdre Griffin LaHue, Asst. Prof, Soil Health
Dani Gelardi, Senior Soil Scientist	Teal Potter, Postdoctoral Scholar
Leslie Michel, Soil Scientist	Molly McIlquham, Extension Coordinator
Jadey Ryan, Data Scientist	Kwabena Sarpong, Graduate Student

State of the Soils Assessment 1

Make reports self-contained

Use plain language

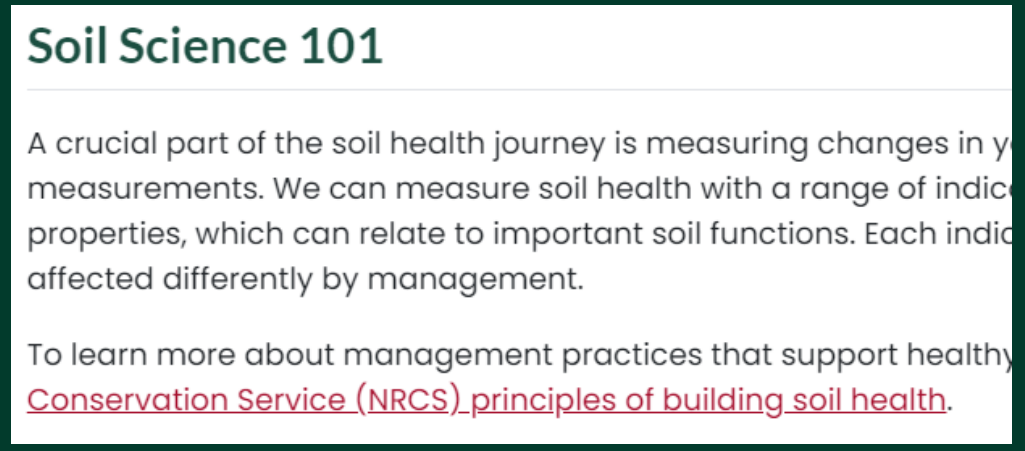


Soil Health

Soil health is a term that describes how well a soil ecosystem supports plar
living nature of soils and the importance of soil microorganisms. Healthy so
reduce the effects of climate change, filter air and water, increase crop pro
rural economies.

Qualities of a Healthy Agricultural Soil

- Good soil tilth allows roots to penetrate
- Near neutral pH (6–8) maximizes nutrient availability for most crops, and min
- Sufficient—but not excessive—nutrient supply for crop growth
- Small population of plant pathogens and pests
- Adequate soil drainage and infiltration
- Diverse and active microbial population
- Low weed seed bank
- No residual chemicals or toxins that may harm the crop, including salts
- Resistance to degradation such as from erosion or surface runoff



Soil Science 101

A crucial part of the soil health journey is measuring changes in y
measurements. We can measure soil health with a range of indic
properties, which can relate to important soil functions. Each indic
affected differently by management.

To learn more about management practices that support healthy
Conservation Service (NRCS) principles of building soil health.

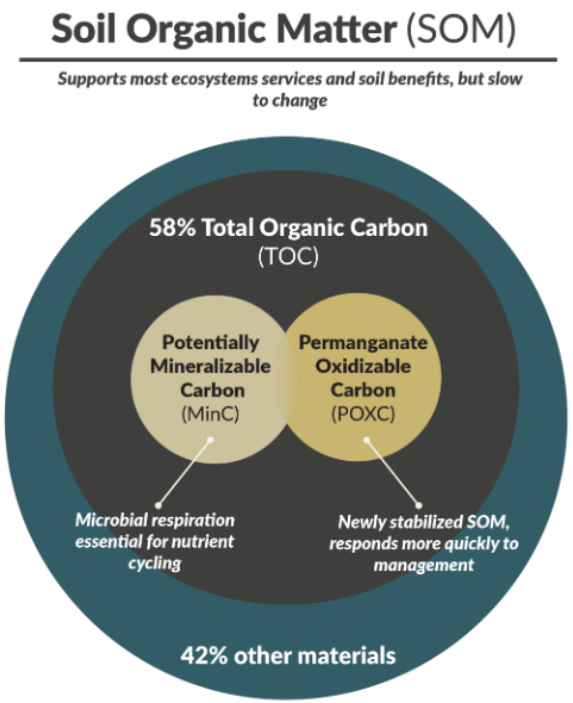
Interpret within crop & region context

Synthesize the latest research

What We Measured in Your Soil

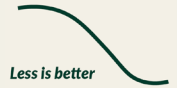
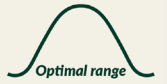
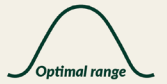
Physical | Biological | Chemical

Soil Organic Matter (SOM) is the portion of soils not made up of minerals, air, and water, but is instead composed of animal, plant, and microbial matter in various stages of decomposition. SOM is comprised of approximately 58% organic carbon (to convert total organic carbon (TOC) to SOM, an easy rule of thumb is to simply multiply by 2). The remaining portion of SOM includes other essential plant nutrients such as nitrogen, phosphorous, and sulfur. SOM varies by inherent soil and landscape properties such as texture, mineralogy, precipitation, and temperature. It is also greatly impacted by management. To learn more about how to increase SOM, read about the NRCS principles of building soil health. SOM underlies many of the benefits and ecosystem services that soils provide. It has a large impact on almost all other soil properties and is often used as a primary indicator of soil health. However, SOM can be slow to change as the result of management. Because of this, many other indicators have been developed to detect more sensitive components in SOM. Keep reading to learn more.



Potentially Mineralizable Carbon (MinC, frequently referred to as "Soil Respiration") measures the release of carbon dioxide (CO_2) from soil. This measurement is done in a laboratory incubation under controlled conditions "ideal" for microbes. The term mineralization refers to the

Offer context for interpretation

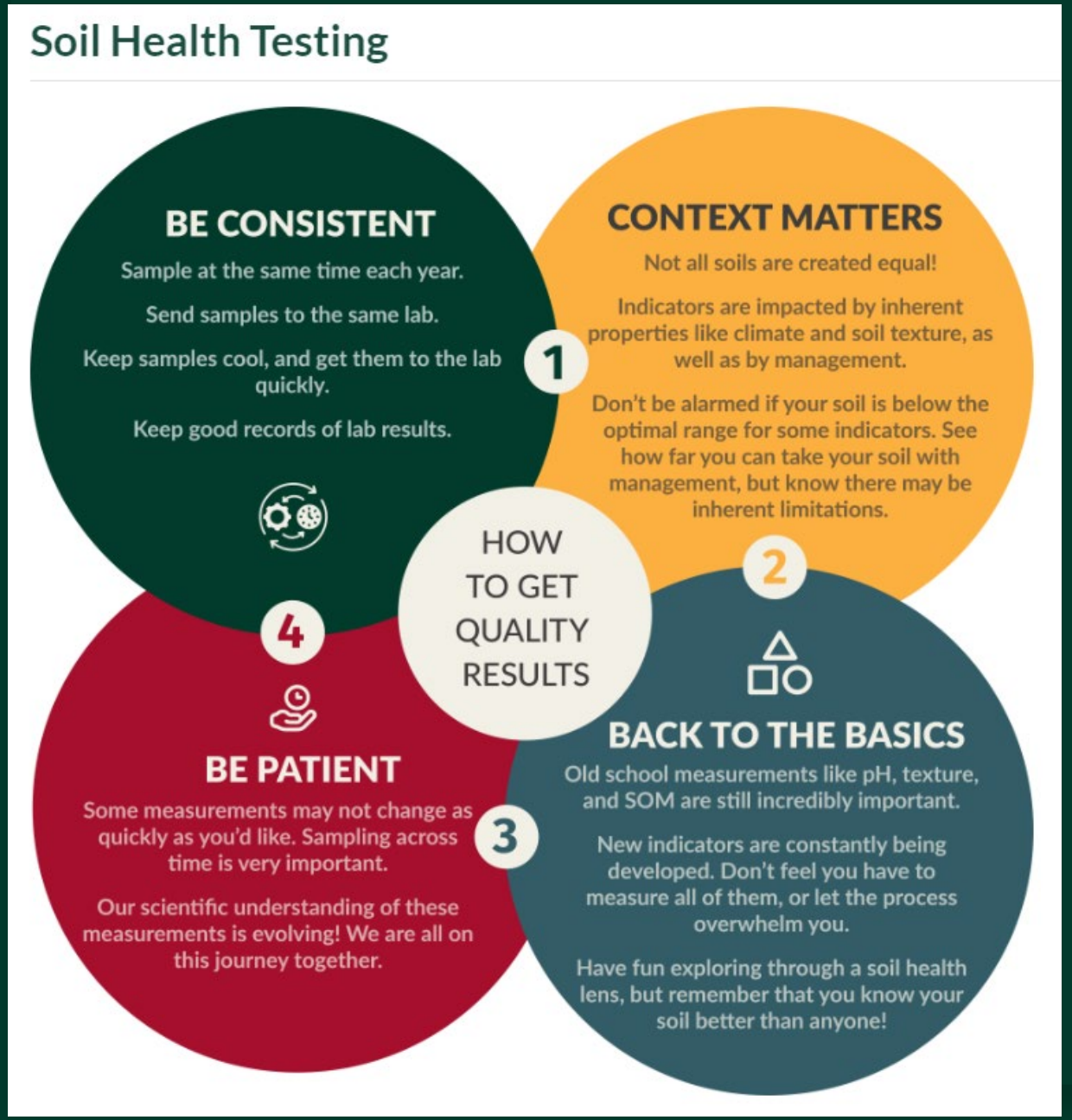
Soil Health Indicator	Soil Function	Scoring Curve Type
Measure every 1-3 years		
ACE Soil Protein	Nutrient cycling, biodiversity & habitat, filtering & resilience	
Aggregate Stability	Physical support, water relations, biodiversity & habitat, filtering & resilience	
Electrical Conductivity (EC)	Physical support, nutrient cycling, filtering & resilience	
Mineralizable Carbon (MinC)	Nutrient cycling, biodiversity & habitat, filtering & resilience	
Permanganate Oxidizable Carbon (POXC)	Biodiversity & habitat, nutrient cycling, filtering & resilience	
Potentially Mineralizable Nitrogen (PMN)	Nutrient cycling, biodiversity & habitat, filtering & resilience	
Soil pH	Nutrient cycling, filtering & resilience	
Total Nitrogen	Nutrient cycling, biodiversity & habitat, filtering & resilience	
Plant Essential Nurients	Nutrient cycling	

more is better,
less is better,
optimal range

Provide additional resources

Understanding Soil Health Results

Learn more about interpreting your soil health resul

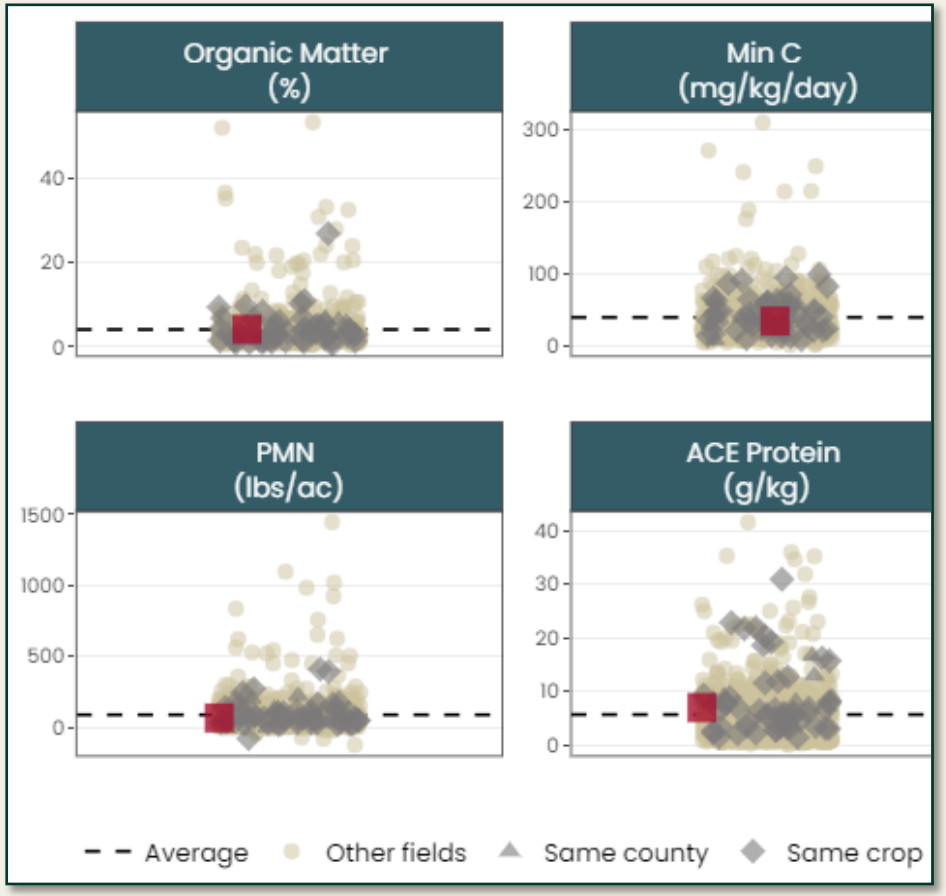


Compare with samples from same **crop, region, & project** in **table & plot representations**

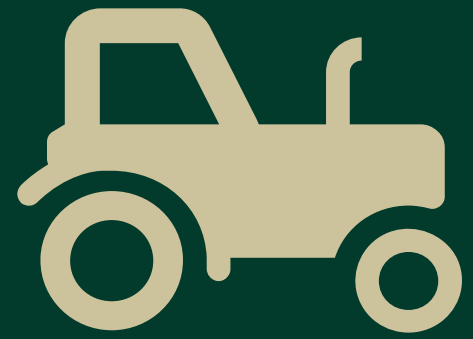
Biological Measurements

Field or Average	Organic Matter	Min C	POXC	PMN	ACE Protein
	%	mg/kg/day	ppm	lbs/ac	g/kg
01	4.2	33.5	462	66.62	6.99
Cowlitz Average (11 Fields)	5.0	40.0	630	120.00	9.00
Native Land Average (54 Fields)	4.2	42.0	520	91.00	8.00
Project Average (877 Fields)	4.2	39.0	450	89.00	5.70

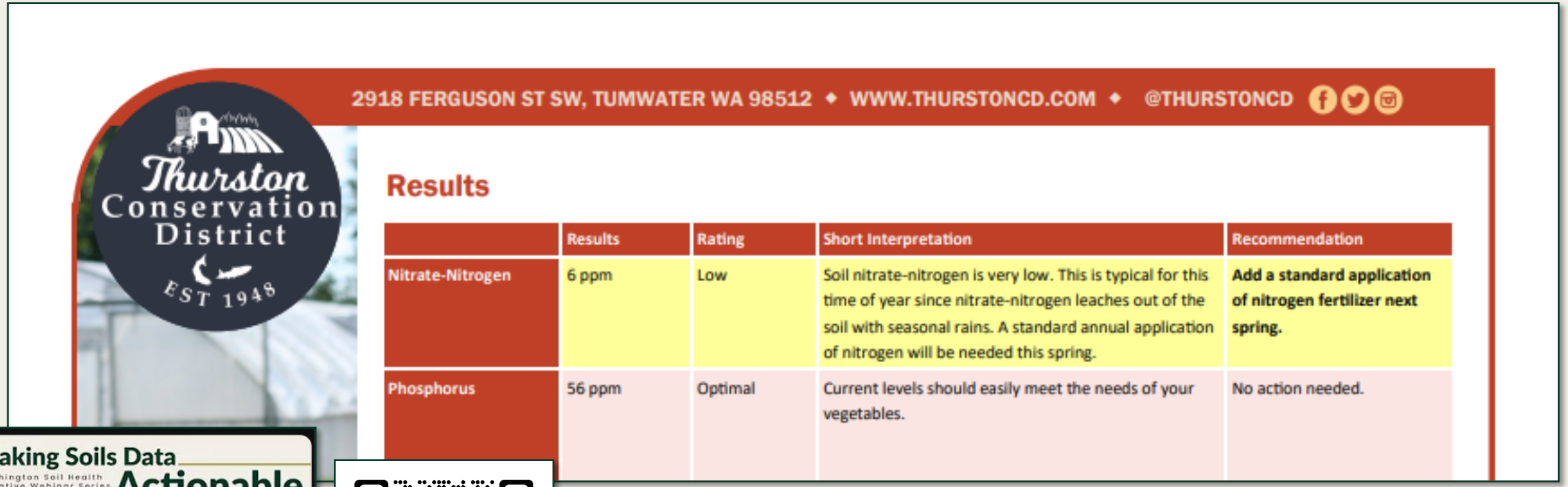
Values ≥ project average have darker backgrounds.
Values < project average have lighter backgrounds.



Translate into informed management decisions



Provide amendment recommendations for fertility*



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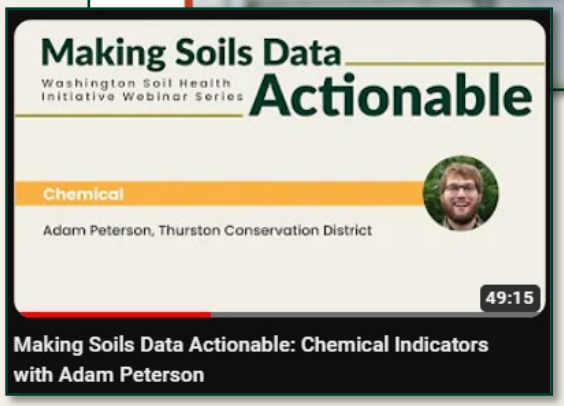
Thurston Conservation District EST 1948

Results

	Results	Rating	Short Interpretation	Recommendation
Nitrate-Nitrogen	6 ppm	Low	Soil nitrate-nitrogen is very low. This is typical for this time of year since nitrate-nitrogen leaches out of the soil with seasonal rains. A standard annual application of nitrogen will be needed this spring.	**Add a standard application of nitrogen fertilizer next spring.**
Phosphorus	56 ppm	Optimal	Current levels should easily meet the needs of your vegetables.	No action needed.

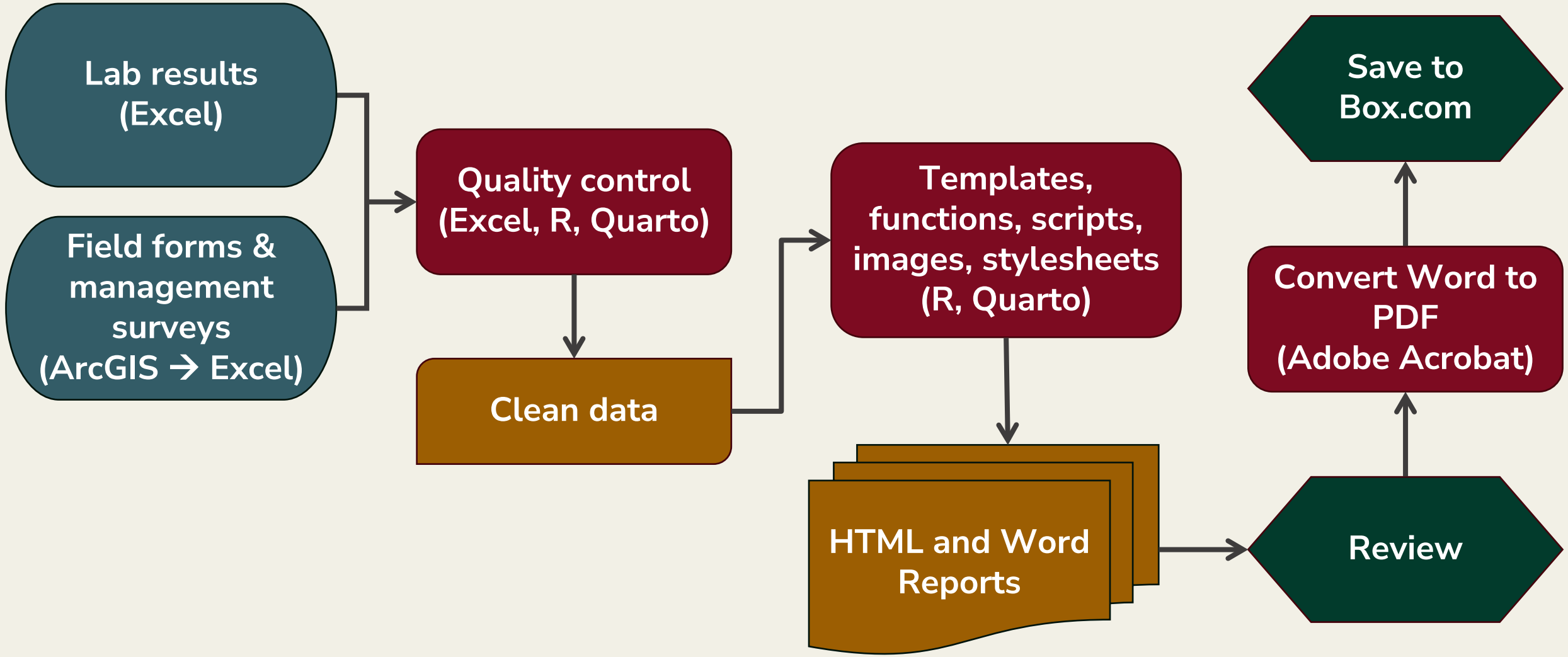


*if qualified and you have enough information

Science still developing for management recommendations based on soil health

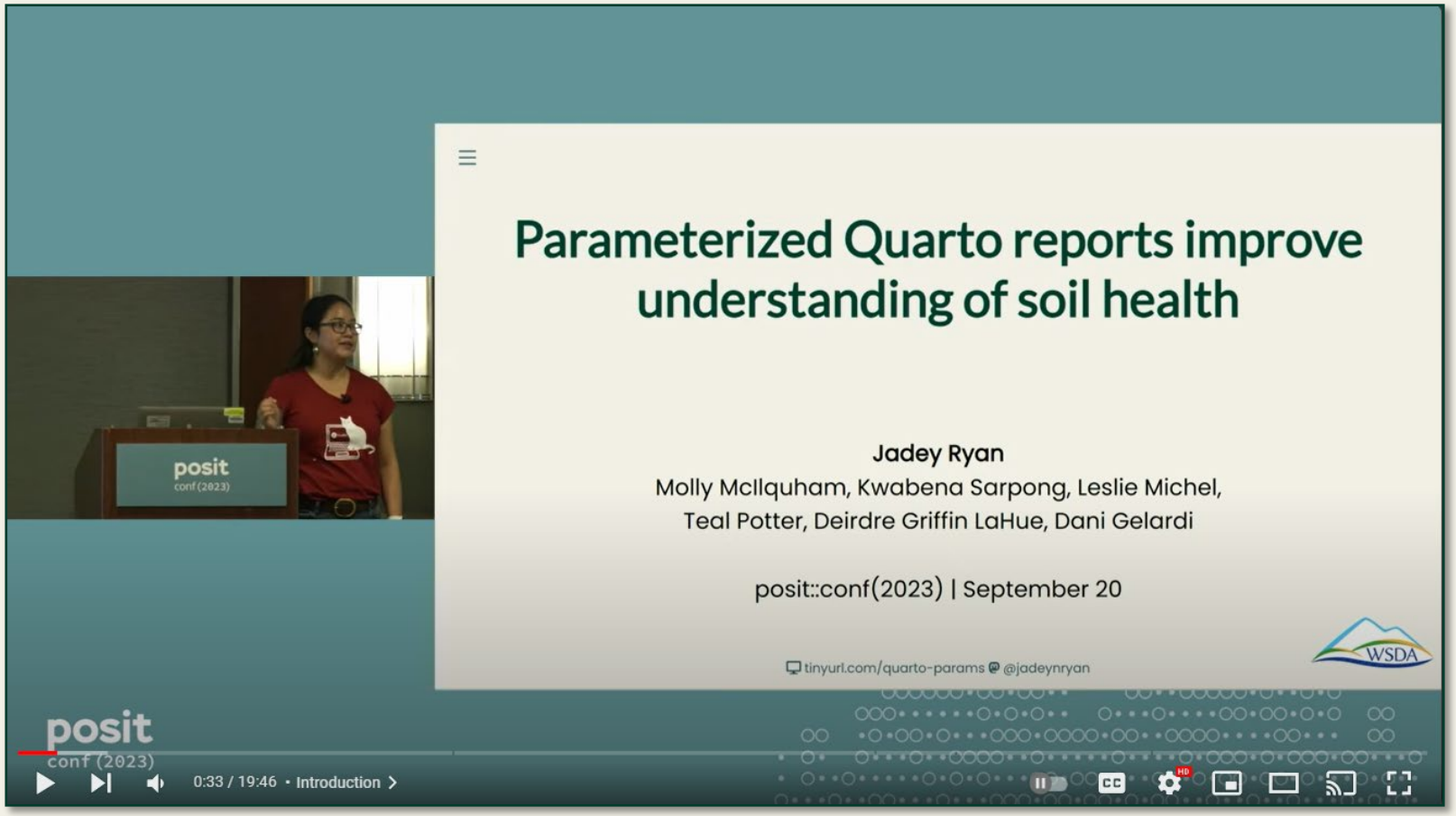
How did we make 300+ customized reports?

~~Painstakingly by hand in Excel and Word~~


Lab results (Excel)
Field forms & management surveys (ArcGIS → Excel)
Quality control (Excel, R, Quarto)
Clean data
Templates, functions, scripts, images, stylesheets (R, Quarto)
HTML and Word Reports
Review
Convert Word to PDF (Adobe Acrobat)
Save to Box.com

For technical details, watch this 20-min talk.

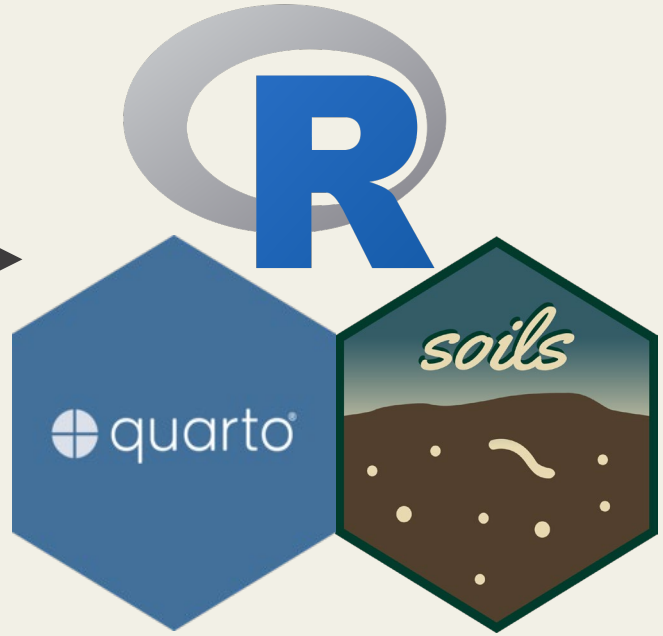
Templates, functions, scripts, images, stylesheets (R, Quarto)



How can {soils} help **you*** make customized reports?

You* = scientist, technical service provider, extension staff

1. comfortable with or willing to learn →

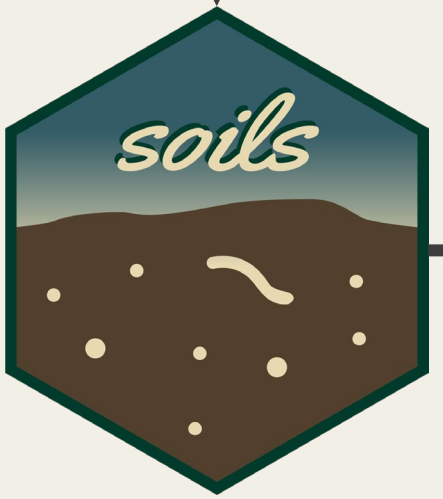


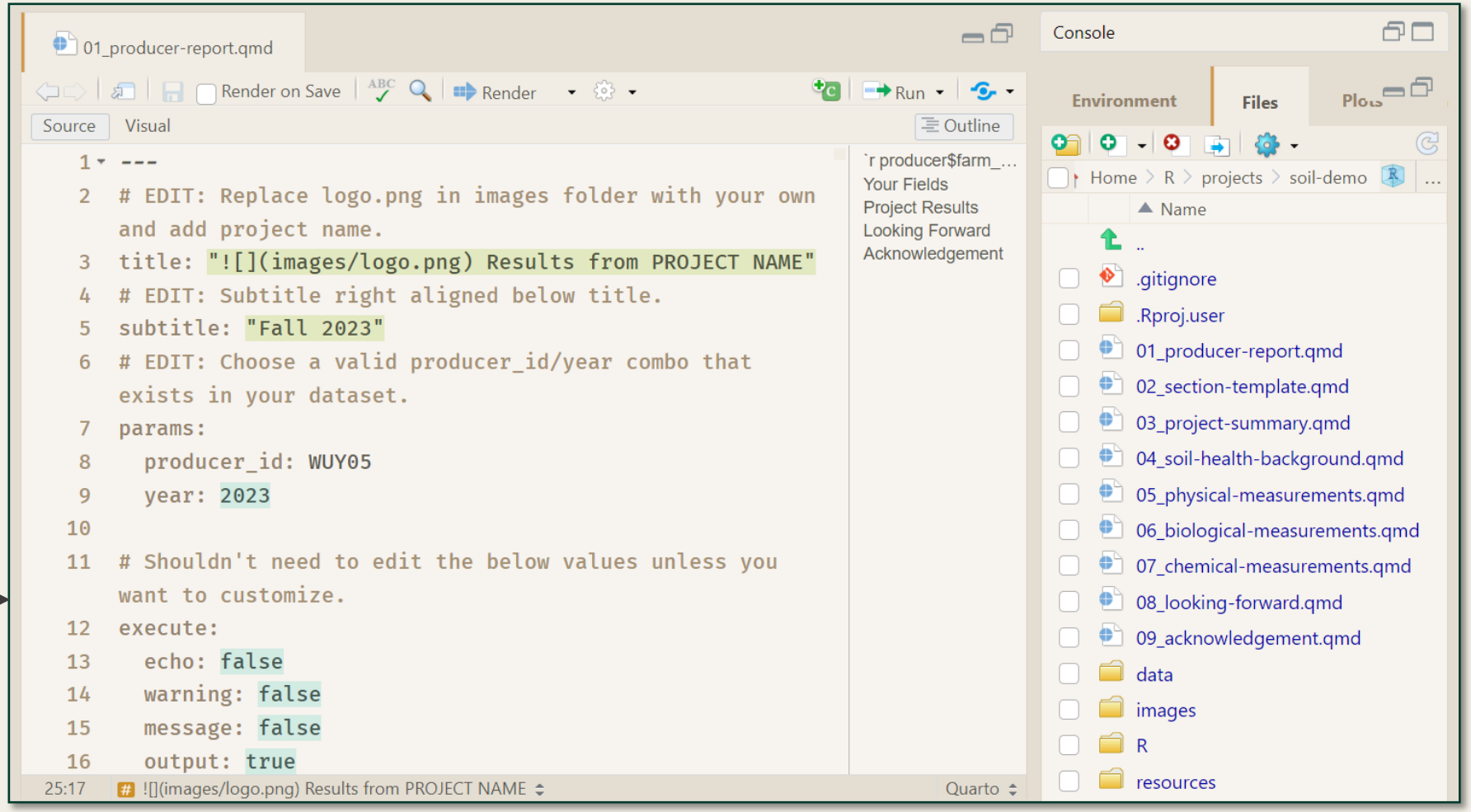
2. have soil survey data*

*for any organization and region

*for multiple survey participants

Templates, functions, scripts, images, stylesheets (R, Quarto)



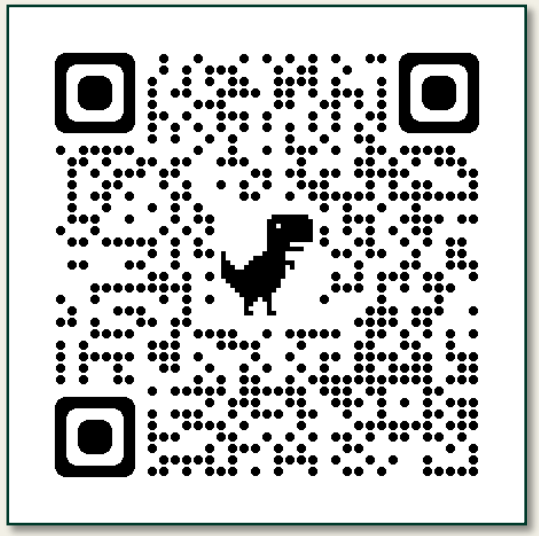


{soils} provides everything you need to:

1. Create an RStudio {soils} project.
2. Import your soil health survey data.
3. Modify the report content.
4. Automatically generate custom soil health reports.

How do you get started?

{soils} package website



soils 1.0.0 | Primers | Tutorials | Examples | Functions

soils

Overview

Introducing {soils}: an R package for all your soil health data visualization and reporting needs. {soils} provides an RStudio project template to generate customized, interactive soil health reports. These reports include plots and tables to show how the participant's results compare to simple averages of results from samples of the same crop, same county, and across the entire project.

Any scientist leading a soil health survey can use {soils} to create custom reports for all survey participants. Democratize your data by giving back to the farmers and land managers who contributed soil samples to your survey project. Use these reports to empower each participant to explore and better understand their data.

The Washington State Department of Agriculture and Washington State University produced {soils} as part of the Washington Soil Health Initiative.

Requirements

The report template uses Quarto, which is the next-generation version of R Markdown.

We assume you're using RStudio v2022.07 or later for editing and previewing Quarto documents. We **strongly recommend** you use the latest release of RStudio for support of all Quarto features. You can also download and install the latest version of Quarto independently from RStudio.

To render Microsoft Word (MS Word) documents, you must have MS Word installed and activated.

Links
Browse source code
Report a bug

License
Full license
MIT + file LICENSE

Citation
Citing soils

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Maintainer, author
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Teal S Potter
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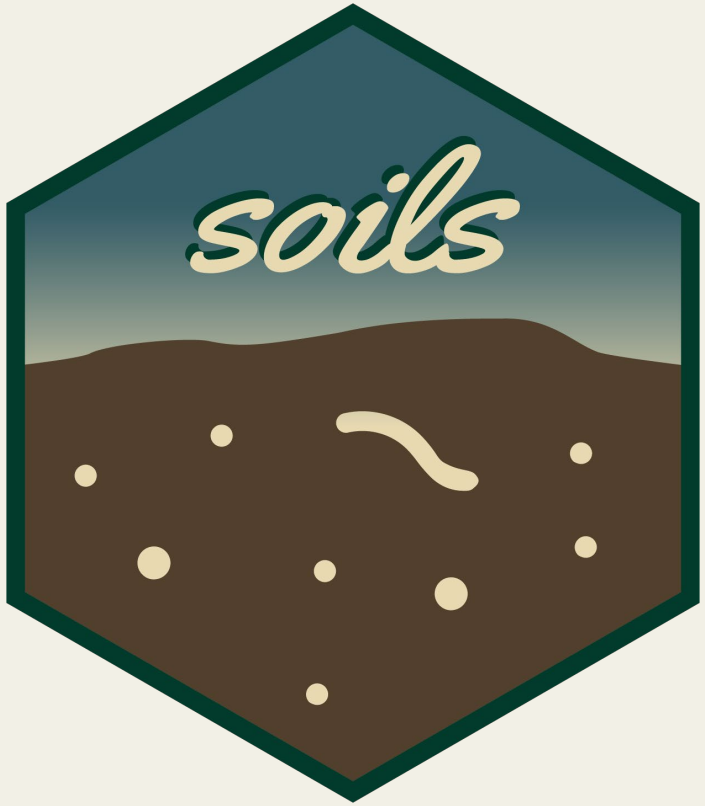
Deirdre Griffin LaHue
Author
Dani L Gelardi
Author

Demo

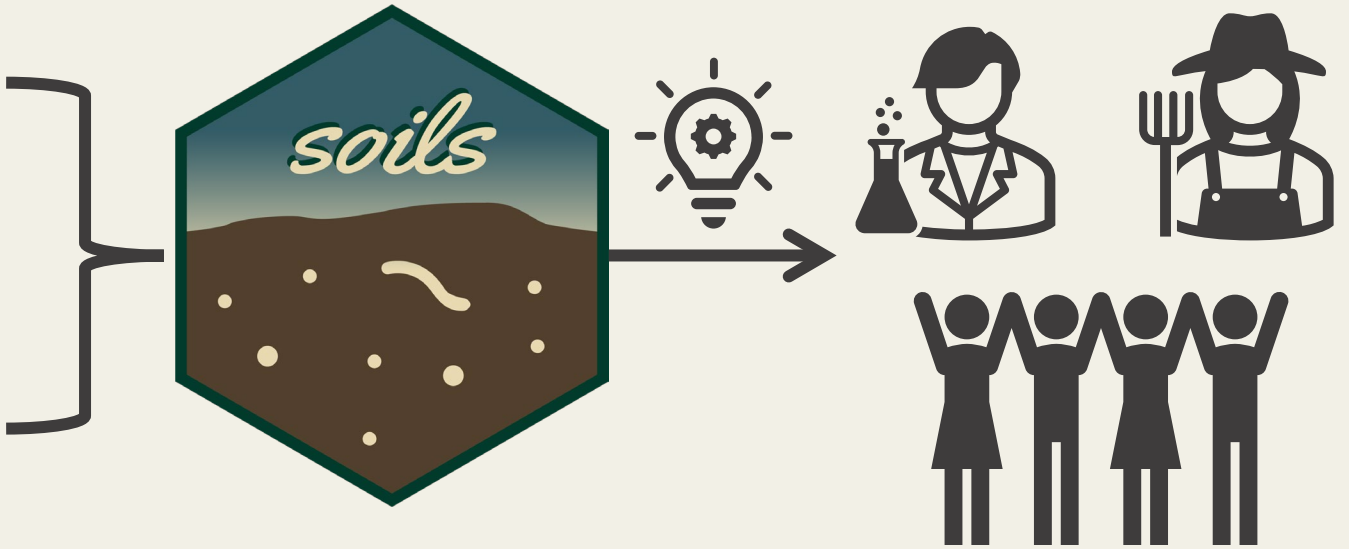


How do we make soils data actionable?

Access soil health data

Interpret within crop & region context

Translate into informed management decisions

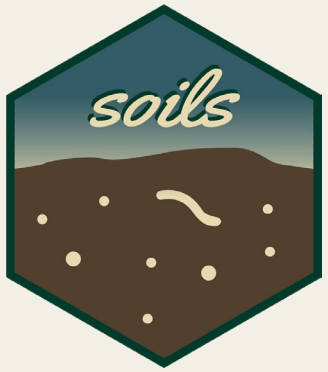


next phase of the State of the Soils

Resources to learn R, Quarto, and {soils}

- RStudio Education: different starting points to begin learning R
- *R for Data Science (2ed)*: book by Wickham et al. (2023)

- Get Started with Quarto: intro and tutorial
- FAQ RMarkdown to Quarto: for Rmarkdown users
- 20-min technical talk: Parameterized soil health reports with Quarto
- Intermediate Quarto Workshop: Parameterized reports with Quarto



- {soils} package website: package documentation & tutorials
- GitHub repository: source code and files
- WaSHI blog post about {soils}

Questions? Comments? Ideas?

Jadey Ryan
jryan@agr.wa.gov

GitHub Issues

WASHINGTON SOIL HEALTH INITIATIVE

WSDA Washington State Department of Agriculture

WASHINGTON STATE UNIVERSITY

Leslie Michel