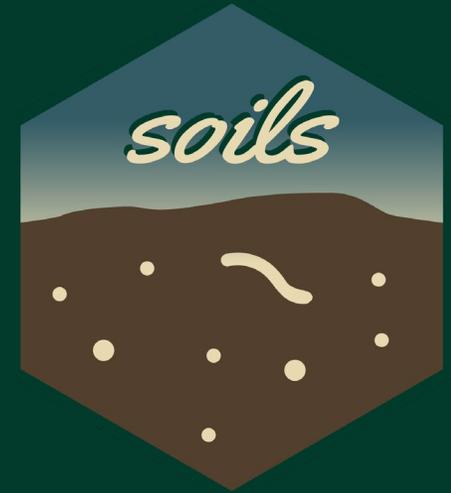


# {soils}: an R package for soil health reporting



Jadey Ryan

Data Scientist , WSDA

Making Soils Data Actionable

April 3, 2024



Washington  
State Department of  
Agriculture



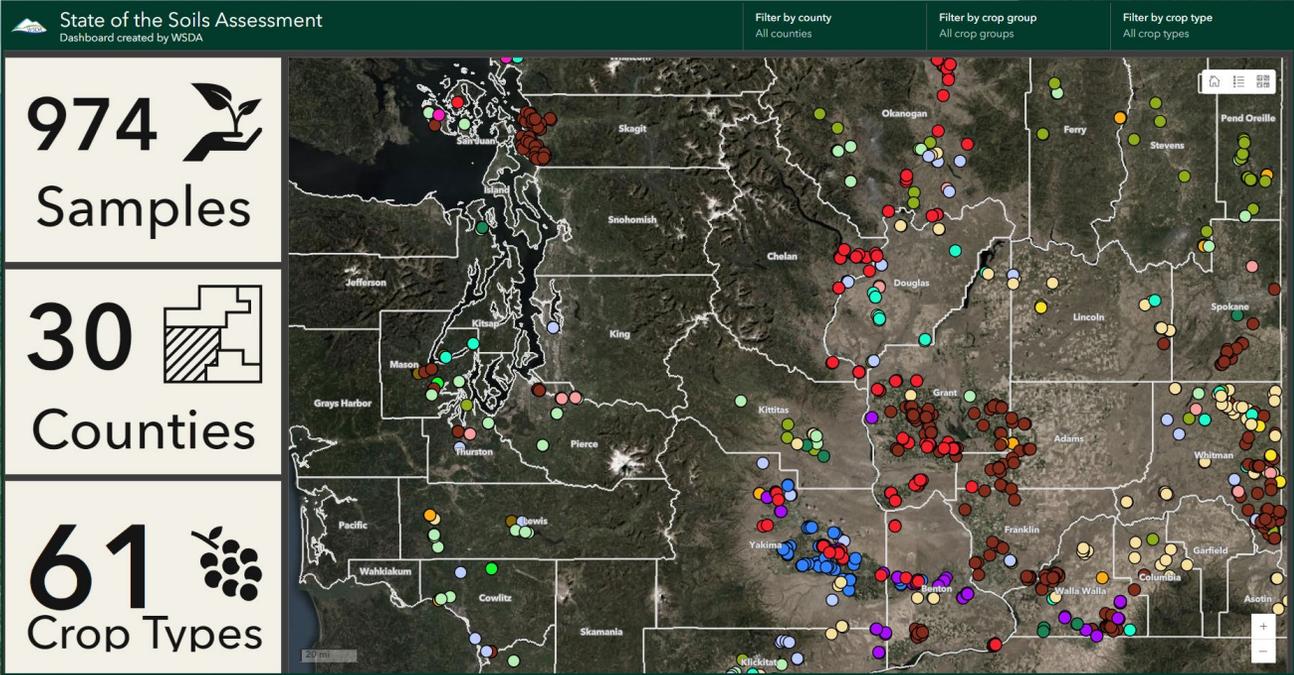
WASHINGTON STATE  
UNIVERSITY

**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! →





# 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

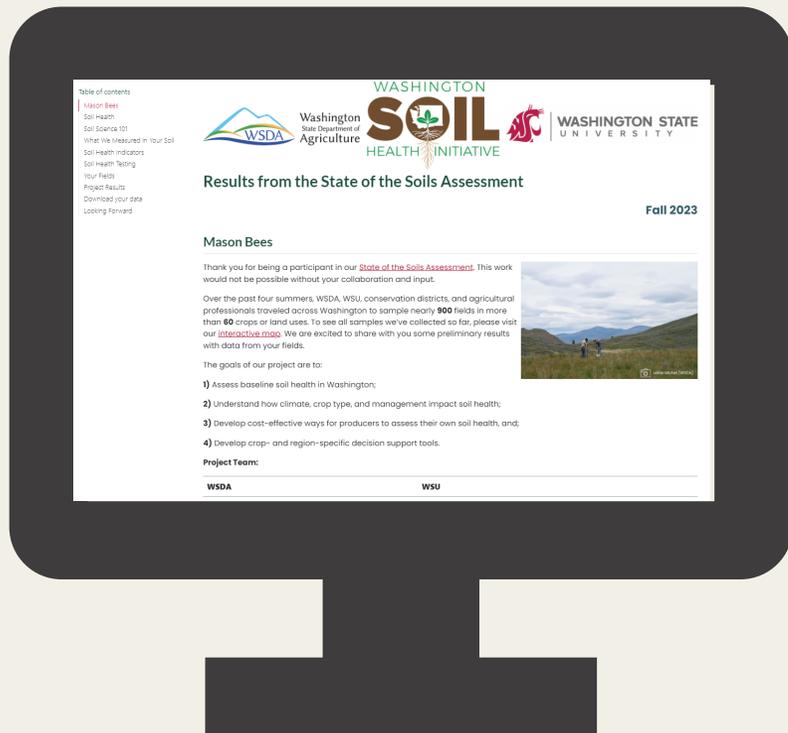
# Access soil health data

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# 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.

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 Malquham, 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 plant living nature of soils and the importance of soil microorganisms. Healthy soils reduce the effects of climate change, filter air and water, increase crop production, and support rural economies.

### Qualities of a Healthy Agricultural Soil

- Good soil tillage allows roots to penetrate
- Near neutral pH (6–8) maximizes nutrient availability for most crops, and minimizes soil acidity
- 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 your soil. Soil health measurements are made through soil health tests. We can measure soil health with a range of indicators, each with different properties, which can relate to important soil functions. Each indicator is affected differently by management.

To learn more about management practices that support healthy soil, visit the [National Conservation Service \(NRCS\) principles of building soil health](#).

**Interpret  
within crop &  
region context**

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# Synthesize the latest research

## What We Measured in Your Soil

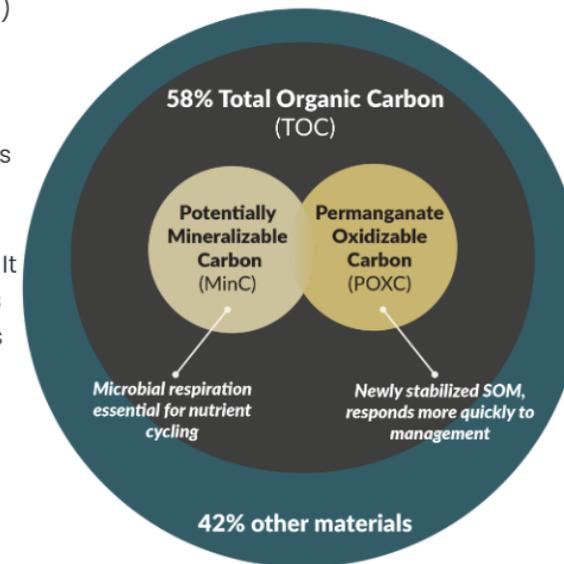


**Soil Organic Matter (SOM)** is the portion of soils not made up of minerals, air, and water, but is instead composed of animal, plant, and microbial matter in various stages of decomposition. SOM is comprised of approximately 58% organic carbon (to convert total organic carbon (TOC) to SOM, an easy 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)** (MinC, frequently referred to as “Soil Respiration”) measures the release of carbon dioxide (CO<sub>2</sub>) from soil. This measurement is done in a laboratory incubation under controlled conditions “ideal” for microbes. The term mineralization refers to the

## Soil Organic Matter (SOM)

*Supports most ecosystems services and soil benefits, but slow to change*



# Offer context for interpretation

Soil Health Indicator	Soil Function	Scoring Curve Type
<b>Measure every 1-3 years</b>		
<b>ACE Soil Protein</b>	Nutrient cycling, biodiversity & habitat, filtering & resilience	 <i>More is better</i>
<b>Aggregate Stability</b>	Physical support, water relations, biodiversity & habitat, filtering & resilience	 <i>More is better</i>
<b>Electrical Conductivity (EC)</b>	Physical support, nutrient cycling, filtering & resilience	 <i>Less is better</i>
<b>Mineralizable Carbon (MinC)</b>	Nutrient cycling, biodiversity & habitat, filtering & resilience	 <i>More is better</i>
<b>Permanganate Oxidizable Carbon (POXC)</b>	Biodiversity & habitat, nutrient cycling, filtering & resilience	 <i>More is better</i>
<b>Potentially Mineralizable Nitrogen (PMN)</b>	Nutrient cycling, biodiversity & habitat, filtering & resilience	 <i>More is better</i>
<b>Soil pH</b>	Nutrient cycling, filtering & resilience	 <i>Optimal range</i>
<b>Total Nitrogen</b>	Nutrient cycling, biodiversity & habitat, filtering & resilience	 <i>Optimal range</i>
<b>Plant Essential Nutrients</b>	Nutrient cycling	 <i>Optimal range</i>

more is better,  
less is better,  
optimal range

# Provide additional resources

## Understanding Soil Health Results

Learn more about interpreting your soil health results



**Understanding soil tests**

SCC Center for Technical Development

Dani Gelardi, WSDA Senior Soil Scientist  
Deirdre Griffin LaHue, WSU Assistant Professor  
March 14<sup>th</sup>, 2023

WSDA Agriculture  
WASHINGTON SOIL HEALTH INITIATIVE

1:36 / 55:06 • Intro >

## Soil Health Testing



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

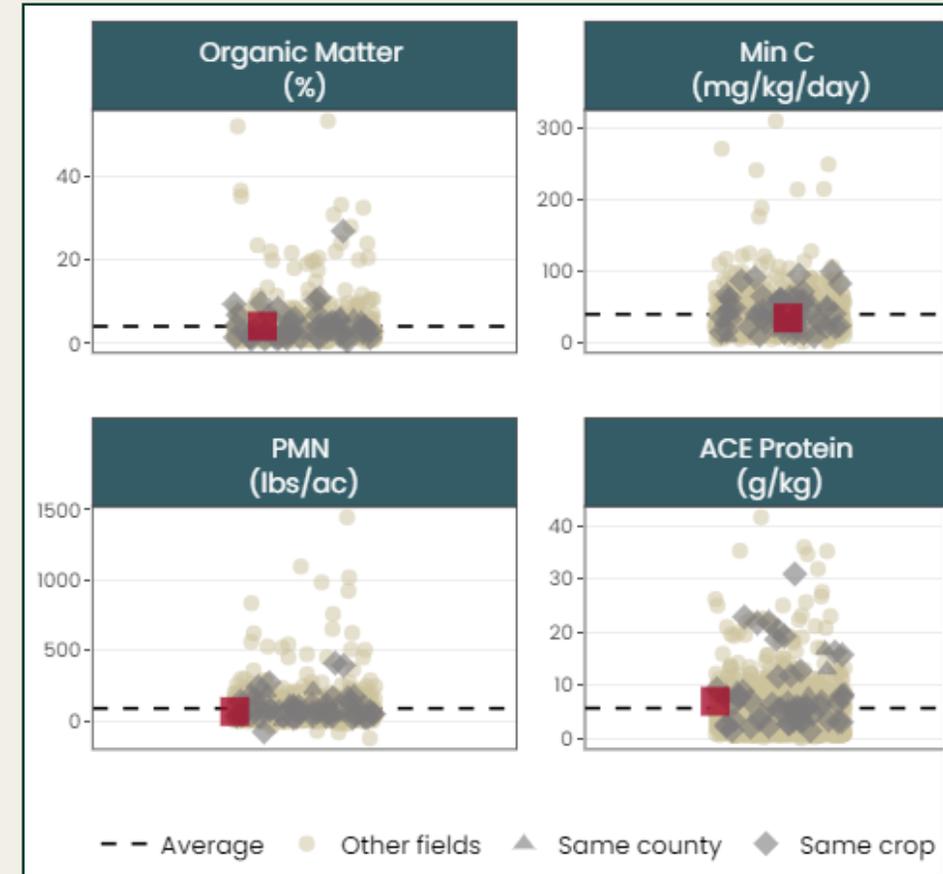
## Biological Measurements



Field or Average	Organic Matter %	Min C mg/kg/day	POXC ppm	PMN lbs/ac	ACE Protein 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  $\geq$  project average have darker backgrounds.

Values  $<$  project average have lighter backgrounds.



**Translate into  
informed  
management  
decisions**

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# Provide amendment recommendations for fertility\*



2918 FERGUSON ST SW, TUMWATER WA 98512 ♦ WWW.THURSTONCD.COM ♦ @THURSTONCD

### 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.	<b>Add a standard application of nitrogen fertilizer next spring.</b>
Phosphorus	56 ppm	Optimal	Current levels should easily meet the needs of your vegetables.	No action needed.

**Making Soils Data Actionable**  
Washington Soil Health Initiative Webinar Series

**Chemical**

Adam Peterson, Thurston Conservation District

49:15

Making Soils Data Actionable: Chemical Indicators with Adam Peterson



\*if qualified and you have enough information

# Science still developing for management recommendations based on soil health



## The State of the 'State of the Soils'

Author: Dani Gelardi, Senior Soil Scientist, Washington State Department of Agriculture

**How did we  
make 300+  
customized  
reports?**

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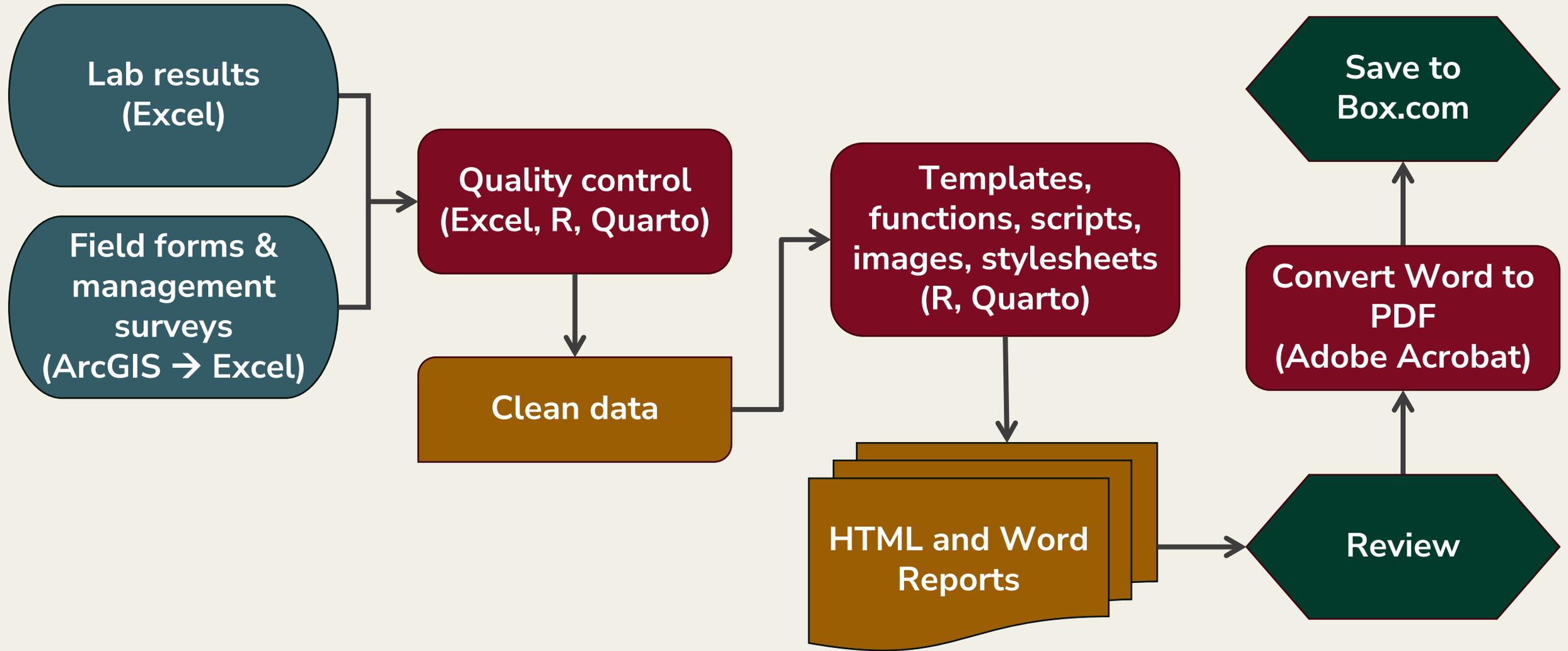


**HTML and  
PDF Reports**

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# ~~Painstakingly by hand in Excel and Word~~





# For technical details, watch this 20-min talk.

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



A screenshot of a video player interface. The video shows a woman, Jadey Ryan, standing at a podium with a 'posit conf (2023)' sign. The presentation slide behind her has a light blue header and a white body. The slide title is 'Parameterized Quarto reports improve understanding of soil health'. Below the title, the presenter's name 'Jadey Ryan' is listed, followed by the names of the project partners: 'Molly McIlquham, Kwabena Sarpong, Leslie Michel, Teal Potter, Deirdre Griffin LaHue, Dani Gelardi'. The event information 'posit::conf(2023) | September 20' is at the bottom of the slide. A WSDA logo is in the bottom right corner of the slide. The video player controls at the bottom show the video is at 0:33 / 19:46, with a play button, volume icon, and other standard controls. The 'posit conf (2023)' logo is also visible in the bottom left of the video player.

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

---



HTML and  
PDF Reports

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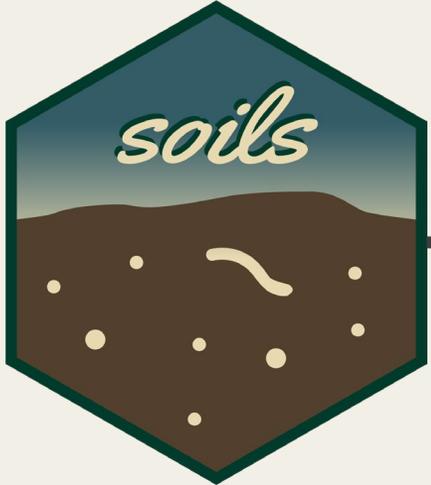
# You\* = scientist, technical service provider, extension staff

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)



```
01_producer-report.qmd
Source Visual Outline
1 ---
2 # EDIT: Replace logo.png in images folder with your own
  and add project name.
3 title: "!(images/logo.png) Results from PROJECT NAME"
4 # EDIT: Subtitle right aligned below title.
5 subtitle: "Fall 2023"
6 # EDIT: Choose a valid producer_id/year combo that
  exists in your dataset.
7 params:
8   producer_id: WUY05
9   year: 2023
10
11 # Shouldn't need to edit the below values unless you
  want to customize.
12 execute:
13   echo: false
14   warning: false
15   message: false
16   output: true
25:17 # !(images/logo.png) Results from PROJECT NAME Quarto
```

Environment Files Plots Console

Home > R > projects > soil-demo

- ..
- .gitignore
- .Rproj.user
- 01\_producer-report.qmd
- 02\_section-template.qmd
- 03\_project-summary.qmd
- 04\_soil-health-background.qmd
- 05\_physical-measurements.qmd
- 06\_biological-measurements.qmd
- 07\_chemical-measurements.qmd
- 08\_looking-forward.qmd
- 09\_acknowledgement.qmd
- data
- images
- R
- resources

# {soils} provides everything you need to:

1

Create an RStudio {soils} project.

2

Import your soil health survey data.

3

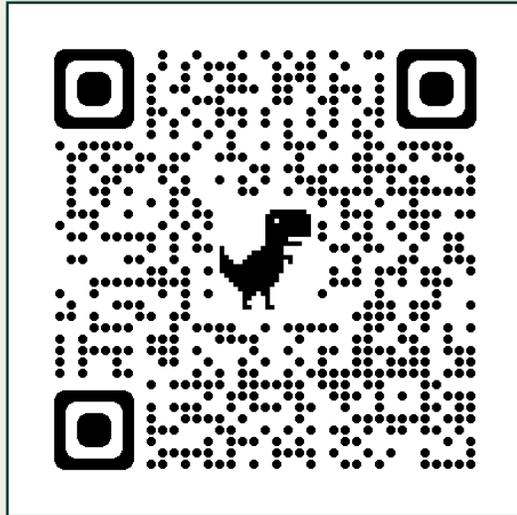
Modify the report content.

4

Automatically generate custom soil health reports.

# How do you get started?

## {soils} package website

A screenshot of the {soils} package website. The page has a dark green header with navigation links: 'soils 1.0.0', a home icon, 'Primers', 'Tutorials', 'Examples', and 'Functions'. The main content area is white with a dark green sidebar on the right. The sidebar contains sections for 'Links' (Browse source code, Report a bug), 'License' (Full license, MIT + file LICENSE), 'Citation' (Citing soils), and 'Developers' (Jadey N Ryan, Molly McIlquham, Kwabena A Sarpong, Leslie M Michel, Teal S Potter, Deirdre Griffin LaHue, Dani L Gelardi). The main content area has a 'soils' title with a hexagonal logo, an 'Overview' section, and a 'Requirements' section. The Overview section introduces the package and its purpose. The Requirements section lists dependencies like Quarto and RStudio, and mentions that MS Word is needed for rendering Word documents.

soils 1.0.0 Primers ▾ Tutorials ▾ Examples Functions Search

## 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](#)

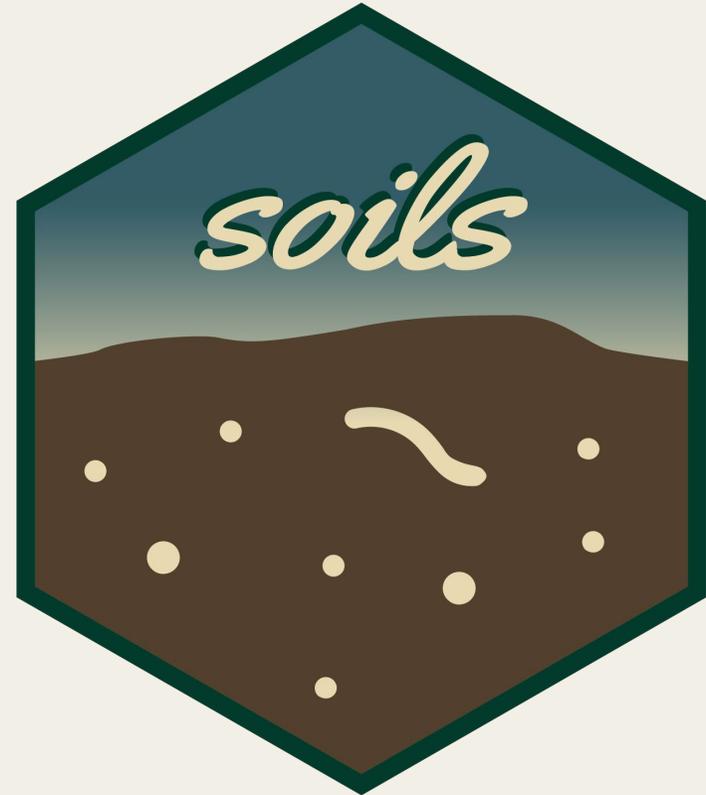
#### Citation

- [Citing soils](#)

#### Developers

- Jadey N Ryan  
Maintainer, author
- Molly McIlquham  
Author
- Kwabena A Sarpong  
Author
- Leslie M Michel  
Author
- Teal S Potter  
Author
- Deirdre Griffin LaHue  
Author
- Dani L Gelardi  
Author

# Demo

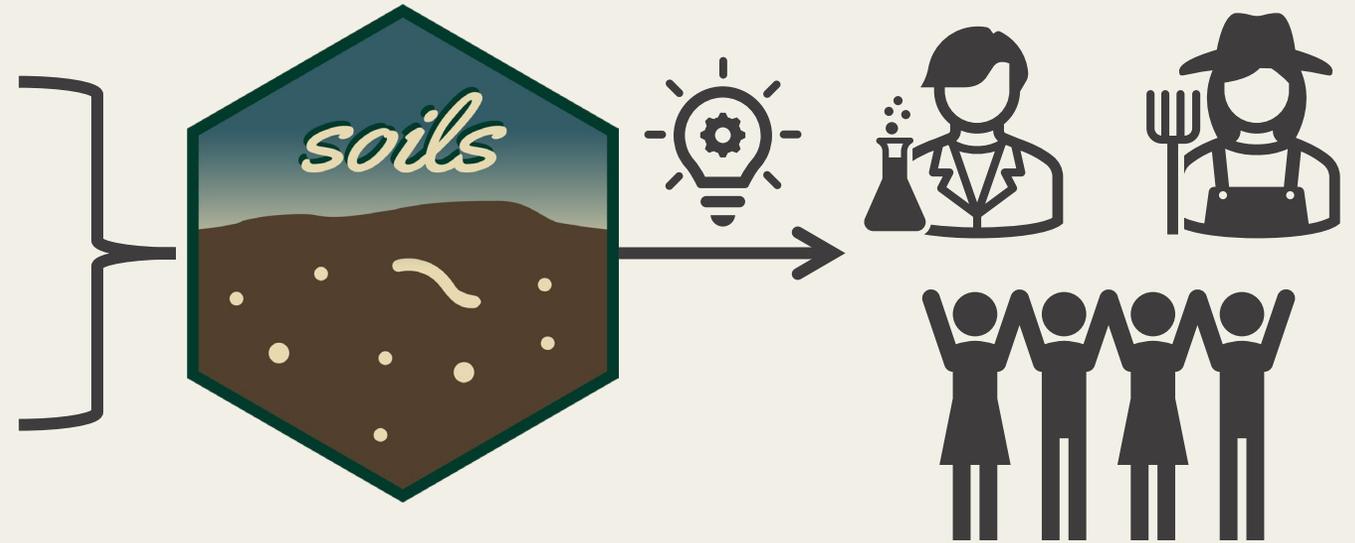


# How do we make soils data actionable?

 **Access** soil health data

 **Interpret** within crop & region context

 **Translate** into informed management decisions



next phase of the  
**State of the Soils**

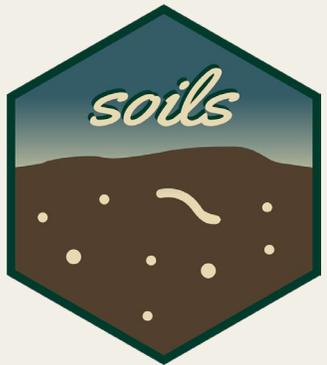
# Resources to learn R, Quarto, and {soils}



- [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  
State Department of  
Agriculture



WASHINGTON STATE  
UNIVERSITY



Leslie Michel