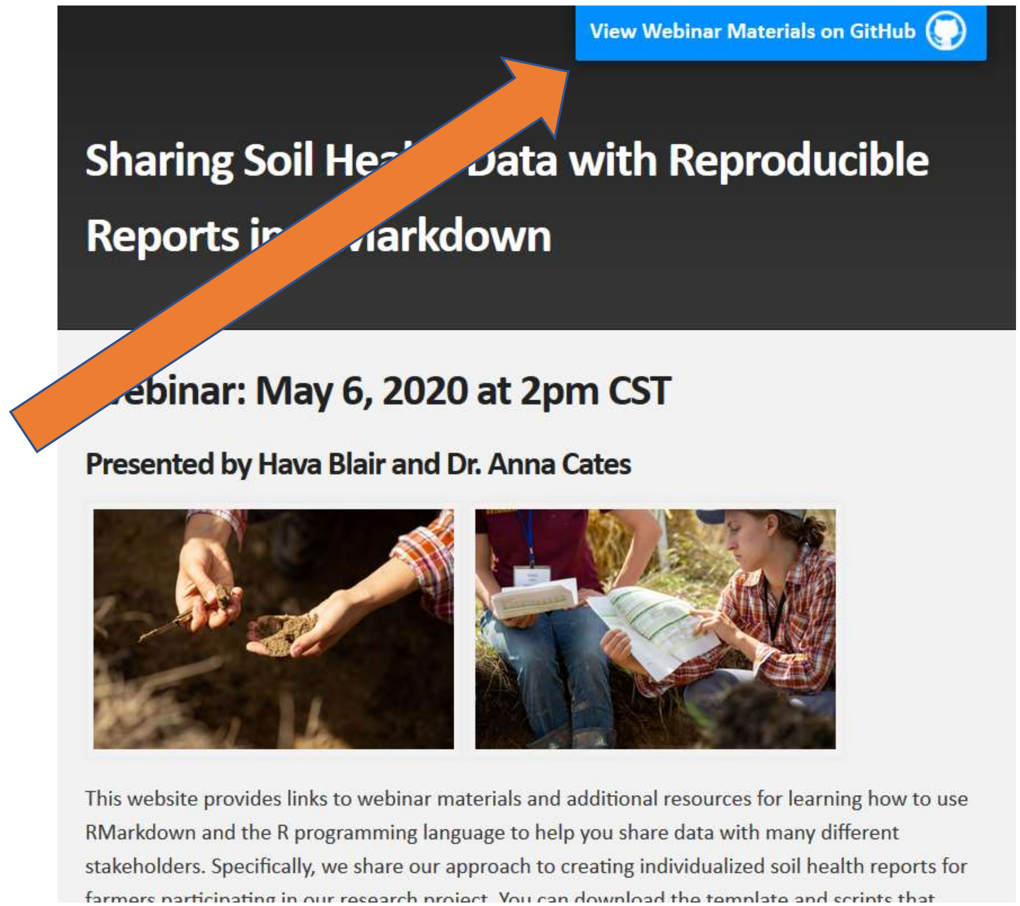
Sharing Soil Health Data with Reproducible Reports in R

May 6, 2020

Hava Blair, Graduate Student
Dr. Anna Cates, State Soil Health Specialist
University of Minnesota

For slides and code:
havablair.github.io



Goal for today

Share a strategy and tools for communicating data about soil health to stakeholders

Outline

1. research: overview of our project

2. strategy: reproducible & automated reports

3. tools: R, RStudio, RMarkdown

4. communicating data: education, research, reporting

Original image from Carol M. Highsmith's America, Library of Congress collection. Digitally enhanced by rawpixel.

Our research

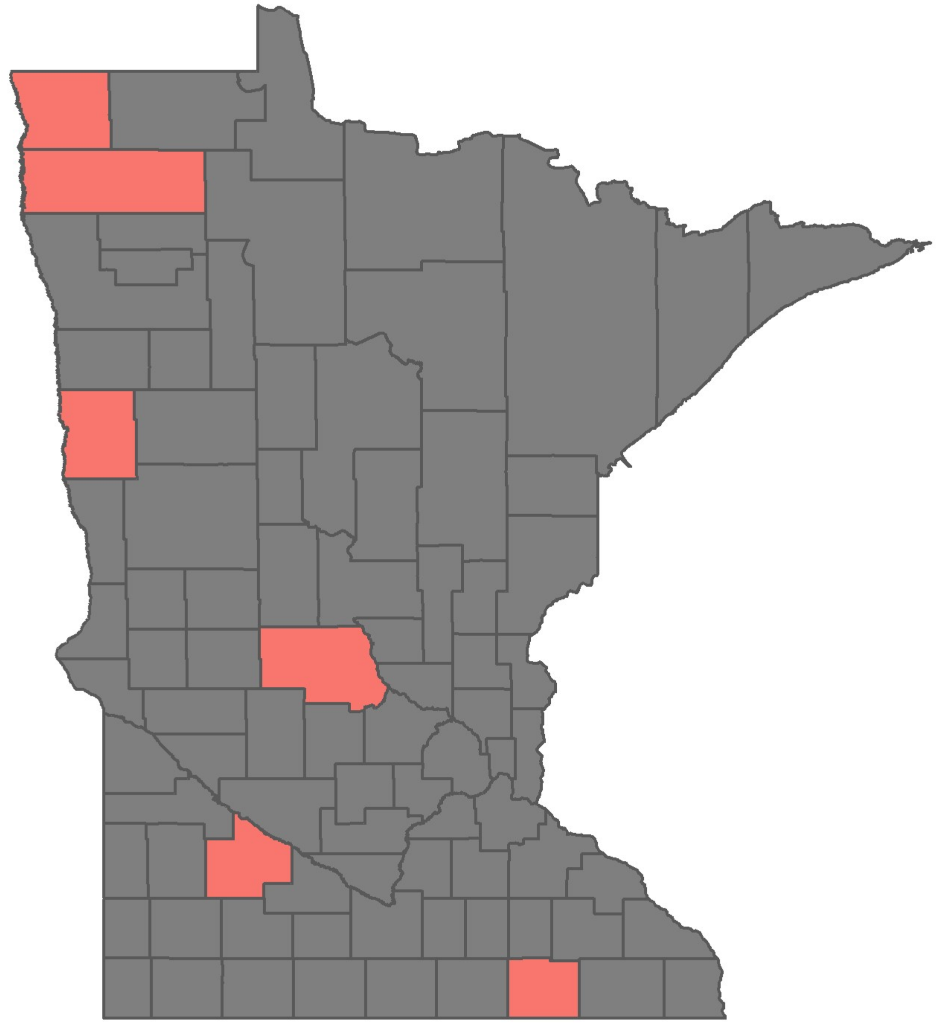
How can we better understand and foster soil health management in cool climates and heavy soils?

Our objectives

- Collect soil health data statewide in MN with standardized methods
- Collect & harmonize regional soil health datasets
- Establish a soil health indicator database and public interface.
- Increase capacity for knowledge sharing and social networks

Partners & Cooperators

- 27 farmer cooperators in 6 counties
- Local government
- State government
- Non-profit



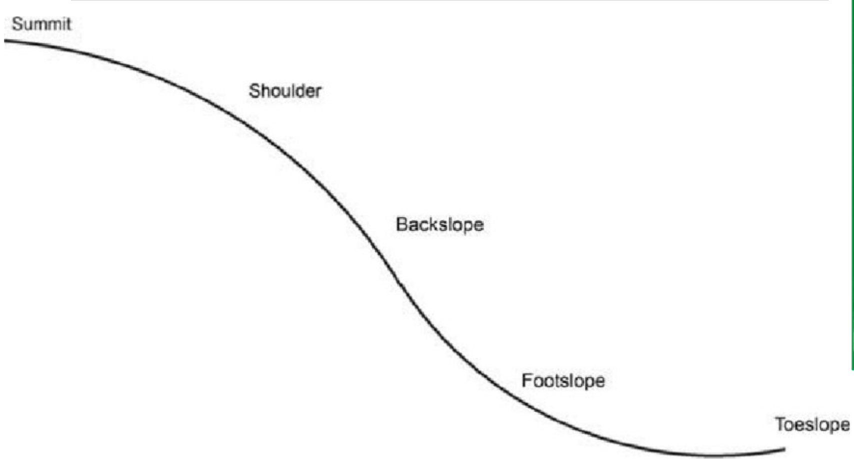
Our research aims to capture soil health changes and variability due to:

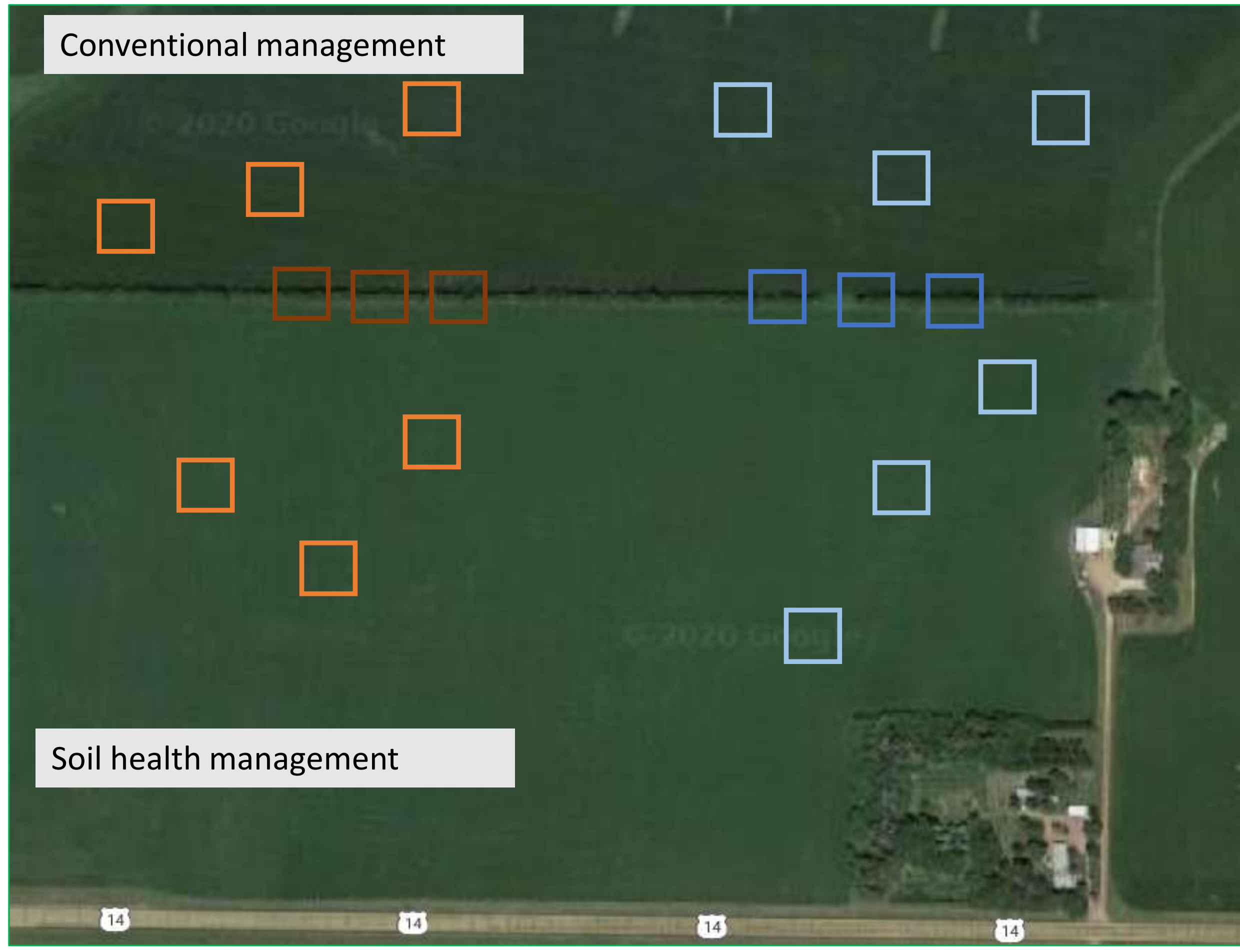
- Management: soil health & conventional
- Hillslope position / soil map unit
- In reference to a “natural area”
- Region

Research Design

Sample Locations

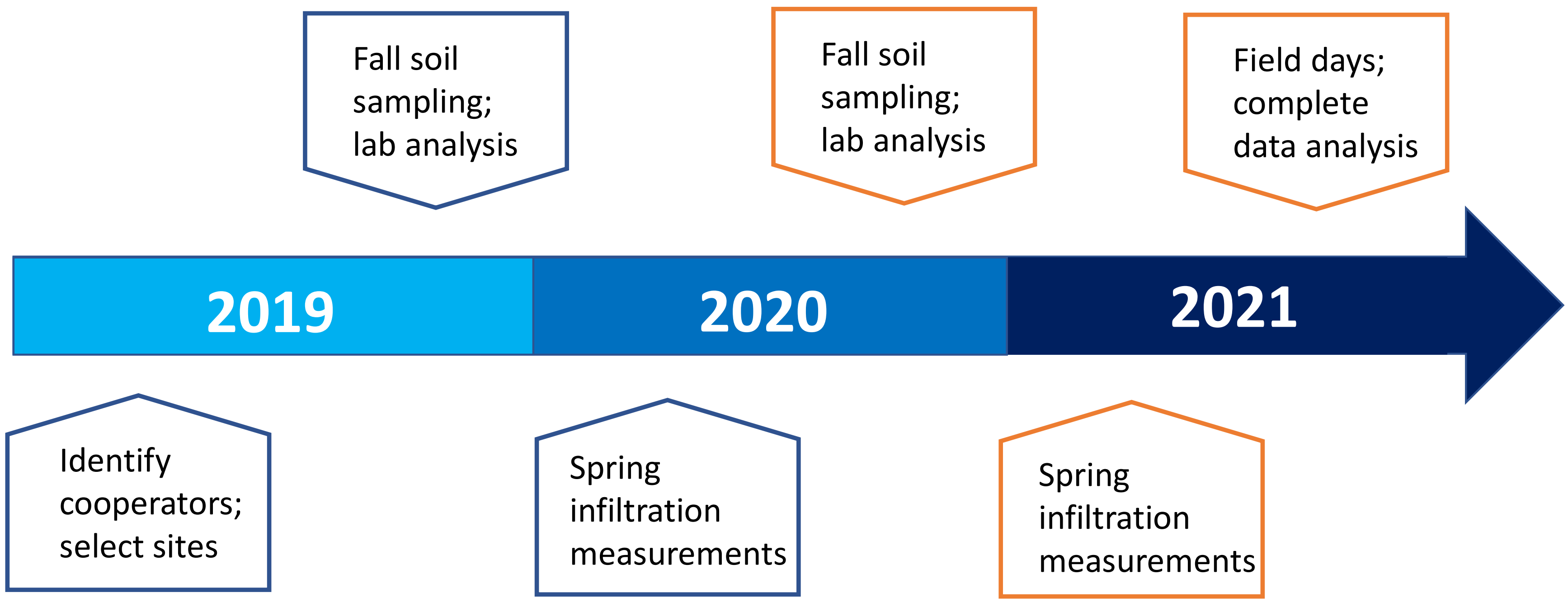
- Field: upper position soil map unit
- Natural area: upper position soil map unit
- Field: lower position soil map unit
- Natural area: lower position soil map unit





Dokoohaki, Hamze & Gheysari, Mahdi & Mehnatkesh, Abdolmohammad & Ayoubi, Shamsollah. (2015). Applying the CSM-CERES-Wheat model for rainfed wheat with specified soil characteristic in undulating area in Iran. Archives of Agronomy and Soil Science. 10.1080/03650340.2014.984696.

Overall Project Timeline



Soil Health Indicators

Done	In Progress	To do
Soil organic matter % (LOI)	Aggregate stability	Bulk density
Potentially mineralizable N	Extracellular enzyme activities	Total organic C, total N
24-hr mineralizable carbon	Microbial biomass (chloroform fumigation extraction)	Phospholipid fatty acid profiles of soil microbial community
pH, P, K		Soil protein N (ACE protein)

How can we share data with farmers?

How can we share data with farmers?

and…

What’s valuable to farmers?

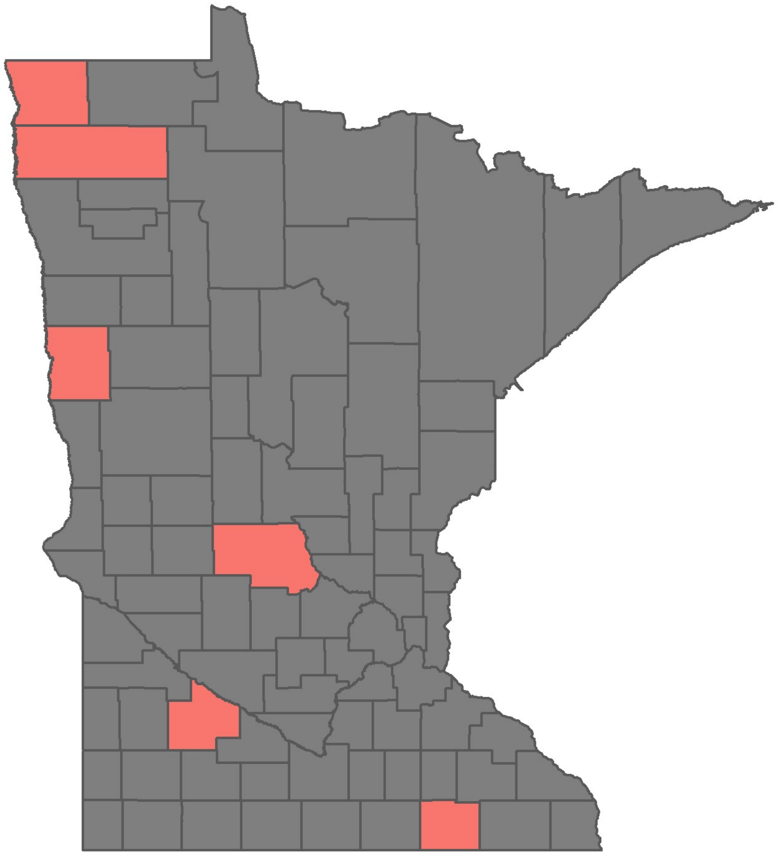
What will it take to share results with farmers?

Back of the envelope calculation….

27 unique farms x 12 indicators x 2 soil map units = 648 possible graphs!!

27 unique farms x 12 indicators x 2 soil map units = 648 possible graphs!!

That's lots of copying and pasting!



Report Goals:

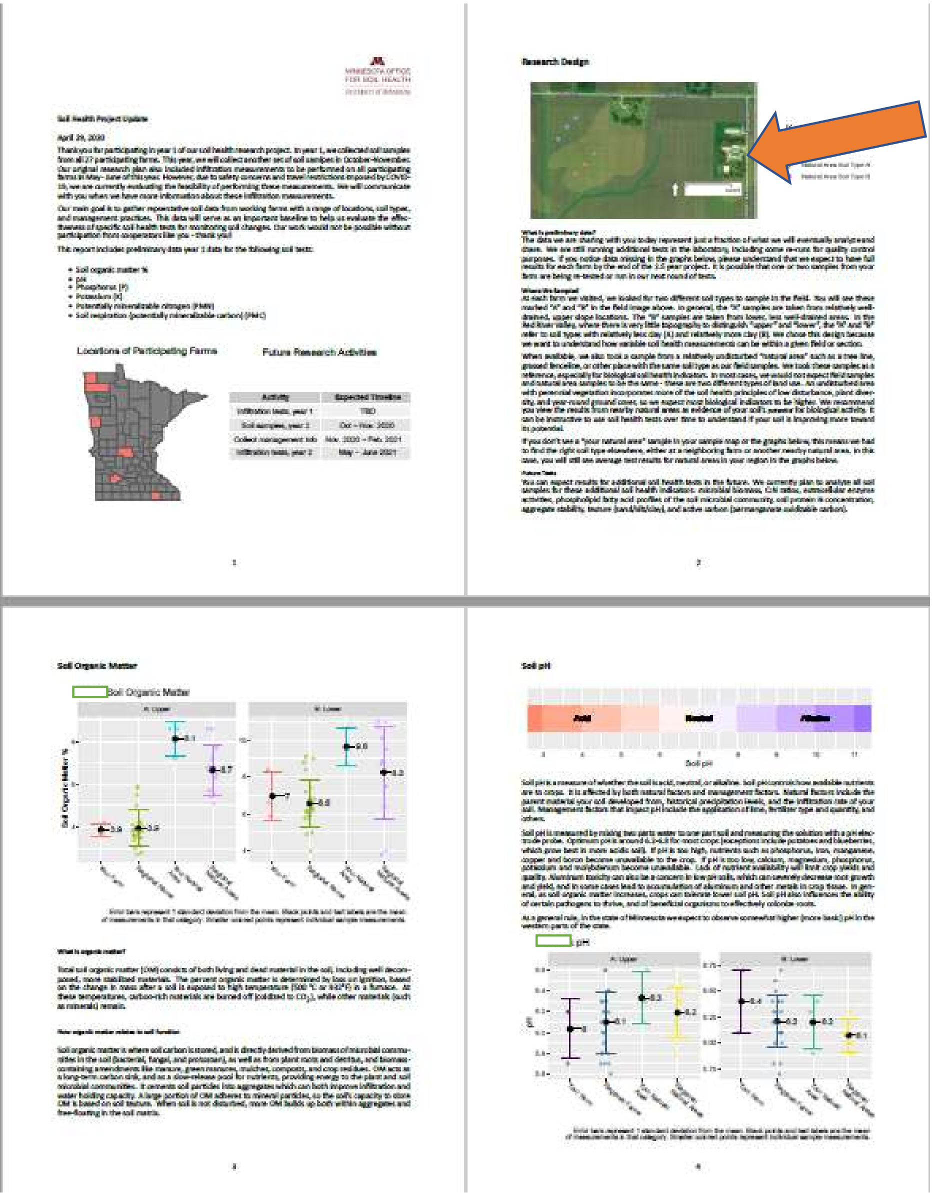
share preliminary data, keep in touch with farmers

show farmers how their soil tests compare to regional values

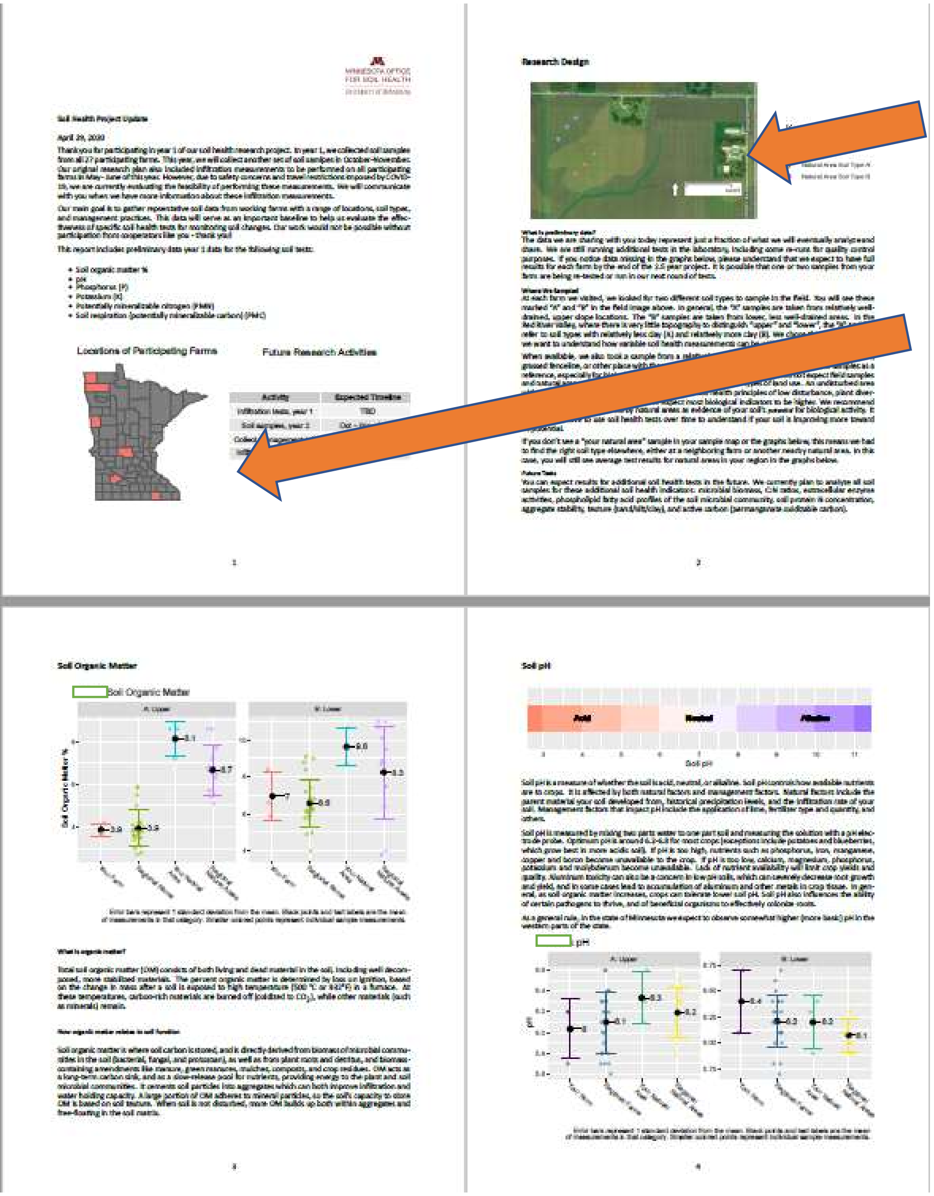
find a way to <u>automate</u> and <u>reproduce</u> the process

What is in the reports?

Pictures



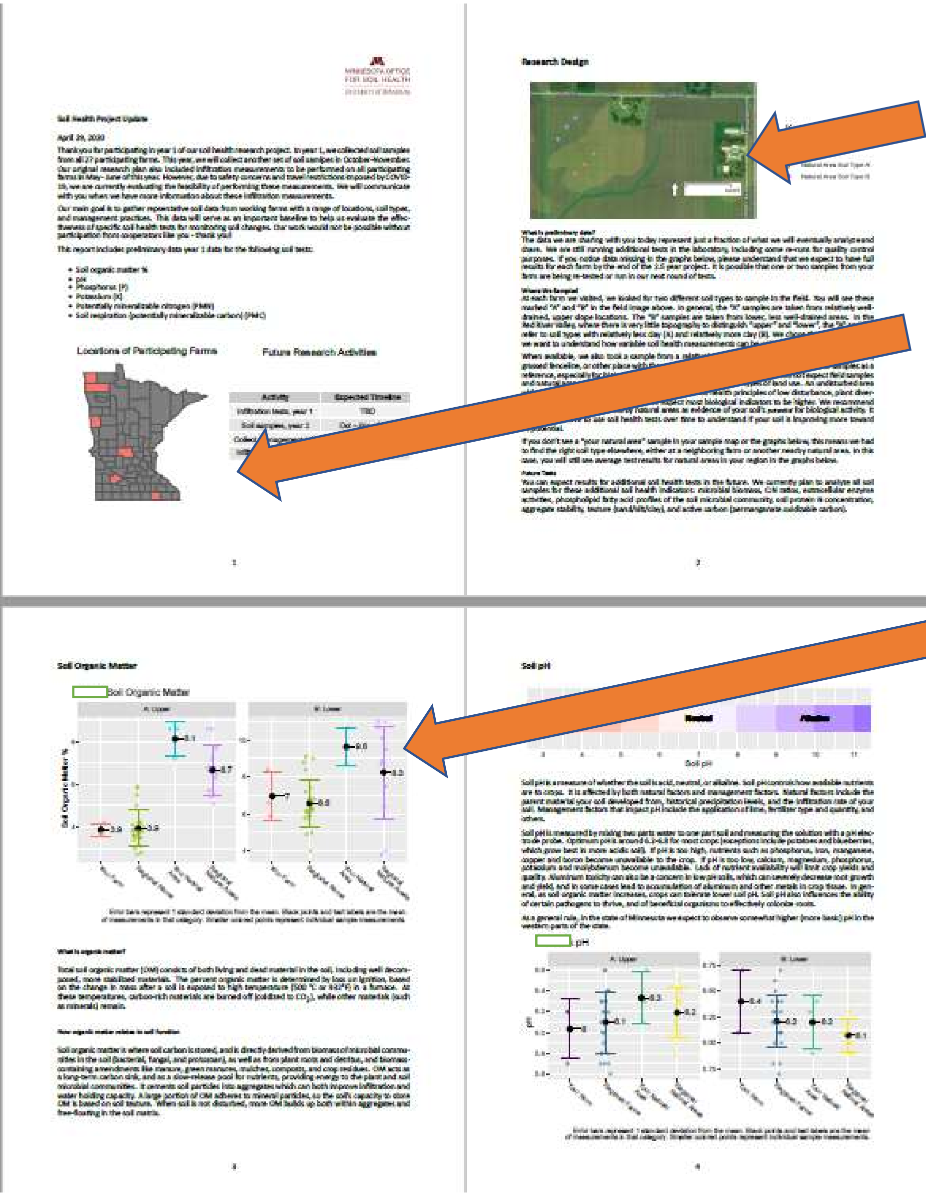
What is in the reports?



Pictures

Maps

What is in the reports?

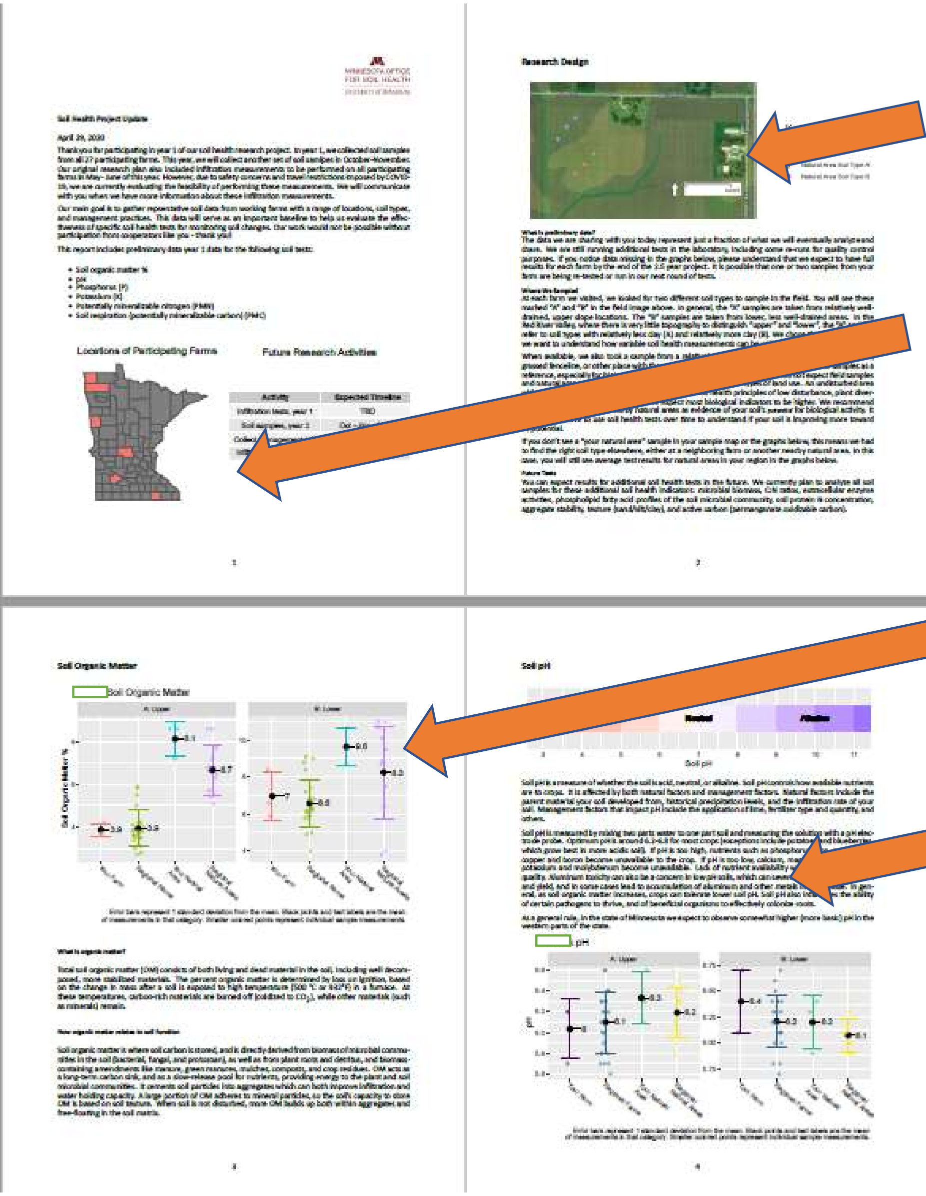


Pictures

Maps

Graphs

What is in the reports?



Pictures

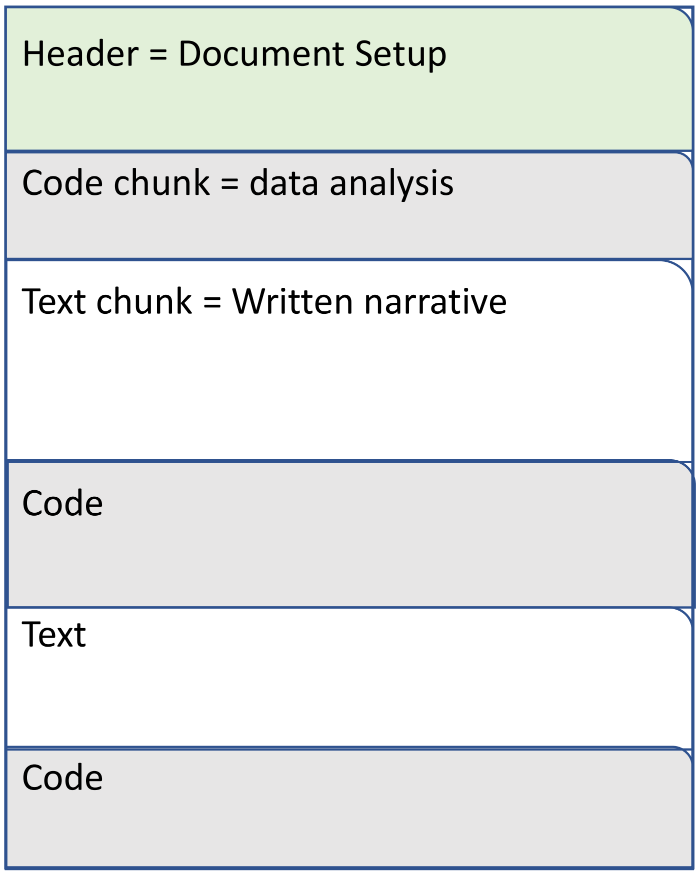
Maps

Graphs

Text

Tools: Quick intro to R and R Markdown

Rmarkdown (Rmd) Document: Generic Format



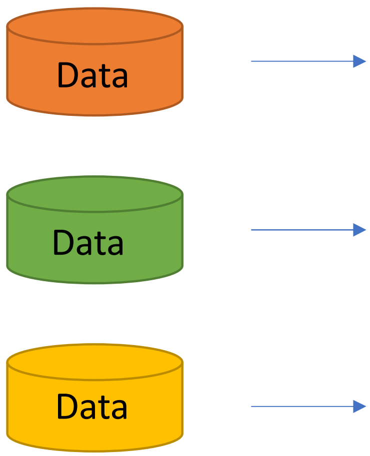
The reports are generated with R Markdown

Many output options: PDF, HTML, Word, and more!

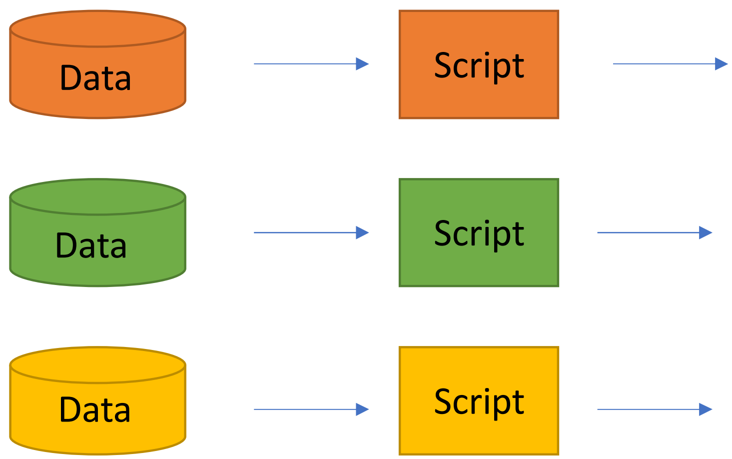
I like to create my Rmd docs in RStudio (free, available online)

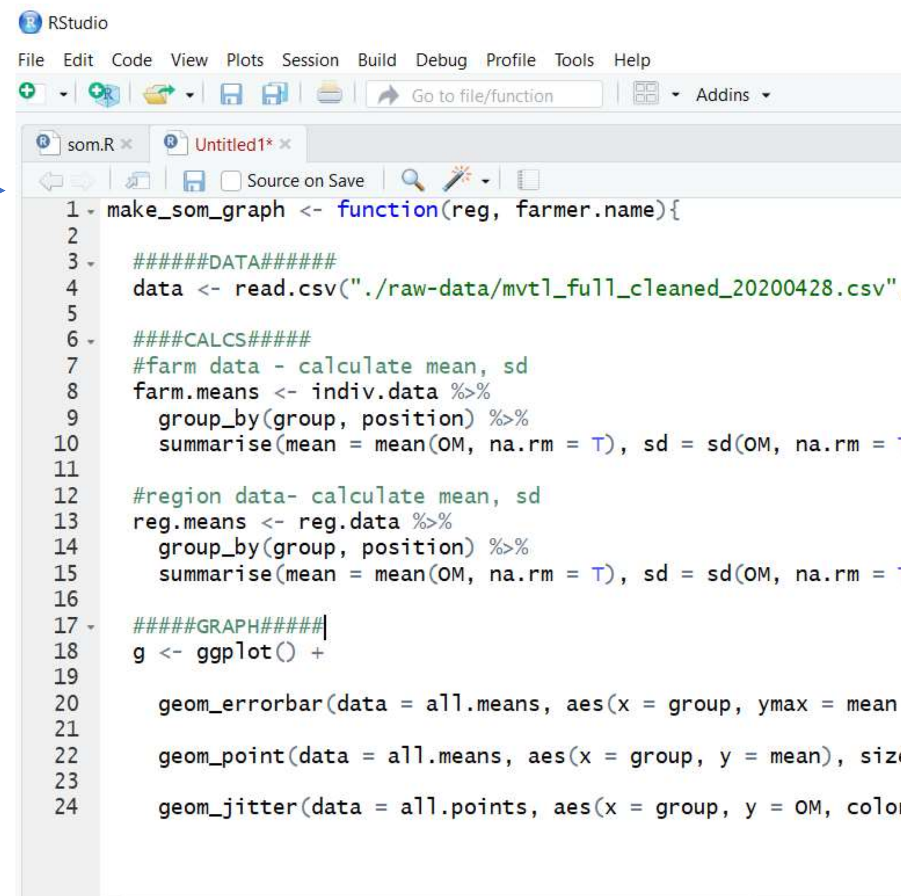
Think of the reports in 4 parts:

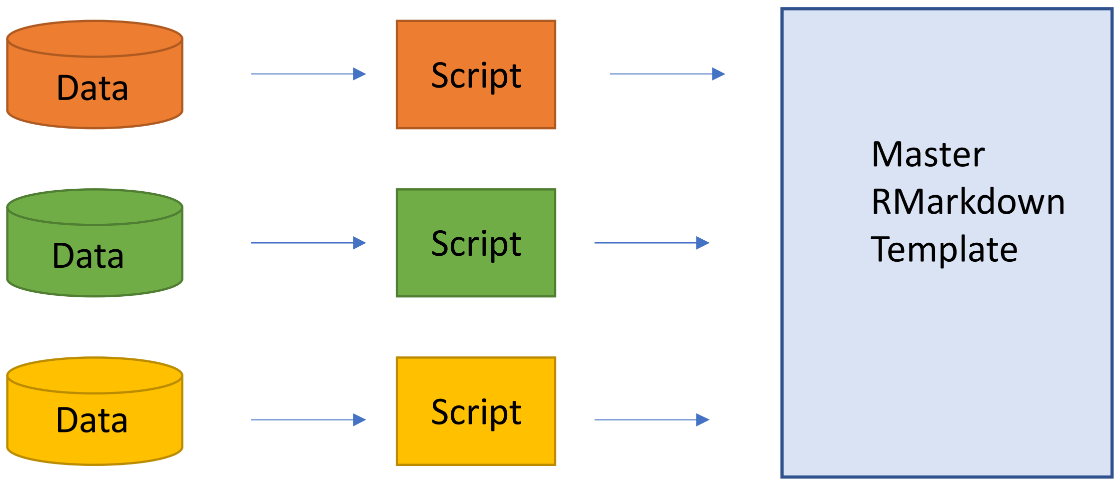
1. Data
2. Scripts = small programs
3. Template = RMarkdown doc
4. Render script = automation



	A	B	C	D	E	F	G	H	I	K	L	M	N
1	Sample.ID	pH	BpH	OM	P_Bray	P_Olsen	K	site	treatment	position	replicate	date.coll	region
2	1	7.4	7.2	5.9	17	9	501	RR1	CV	A	1	20190917	RR
3	2	7.4	7.2	6	12	9	477	RR1	CV	A	2	20190917	RR
4	3	7.5	7.2	5.1	7	6	446	RR1	CV	A	3	20190917	RR
5	4	7.8	7.3	5.7	9	5	393	RR1	SH	A	1	20190917	RR
6	5	7.7	7.3	5.5	10	6	433	RR1	SH	A	2	20190917	RR
7	6	7.8	7.3	5.7	10	5	405	RR1	SH	A	3	20190917	RR
8	7	7.8	7.3	5.7	10	4	381	RR1	CC	A	1	20190917	RR
9	8	7.8	7.4	5.5	10	4	420	RR1	CC	A	2	20190917	RR
10	9	7.8	7.3	5.4	6	5	396	RR1	CC	A	3	20190917	RR
11	10	7.4	7.2	7.4	50	32	608	RR1	UD	A	1	20190917	RR
12	11	7.3	7.2	7.4	44	36	717	RR1	UD	A	2	20190917	RR
13	12	7.4	7.2	8	53	43	785	RR1	UD	A	3	20190917	RR


Data
Script
Data
Script
Data
Script


RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
som.R
Untitled1*
Source on Save
make_som_graph <- function(reg, farmer.name){
#####DATA######
data <- read.csv("./raw-data/mvtl_full_cleaned_20200428.csv",
####CALCS#####
#farm data - calculate mean, sd
farm.means <- indiv.data %>%
group_by(group, position) %>%
summarise(mean = mean(OM, na.rm = T), sd = sd(OM, na.rm =
#region data- calculate mean, sd
reg.means <- reg.data %>%
group_by(group, position) %>%
summarise(mean = mean(OM, na.rm = T), sd = sd(OM, na.rm =
#####GRAPH#####
g <- ggplot() +
geom_errorbar(data = all.means, aes(x = group, ymax = mean
geom_point(data = all.means, aes(x = group, y = mean), size
geom_jitter(data = all.points, aes(x = group, y = OM, color


Data
Script
Data
Script
Data
Script
Master
RMarkdown
Template

The template: bring it all together

Header: document set-up

Code chunk: call script, make graph

Text chunk: narrative explanation

Code

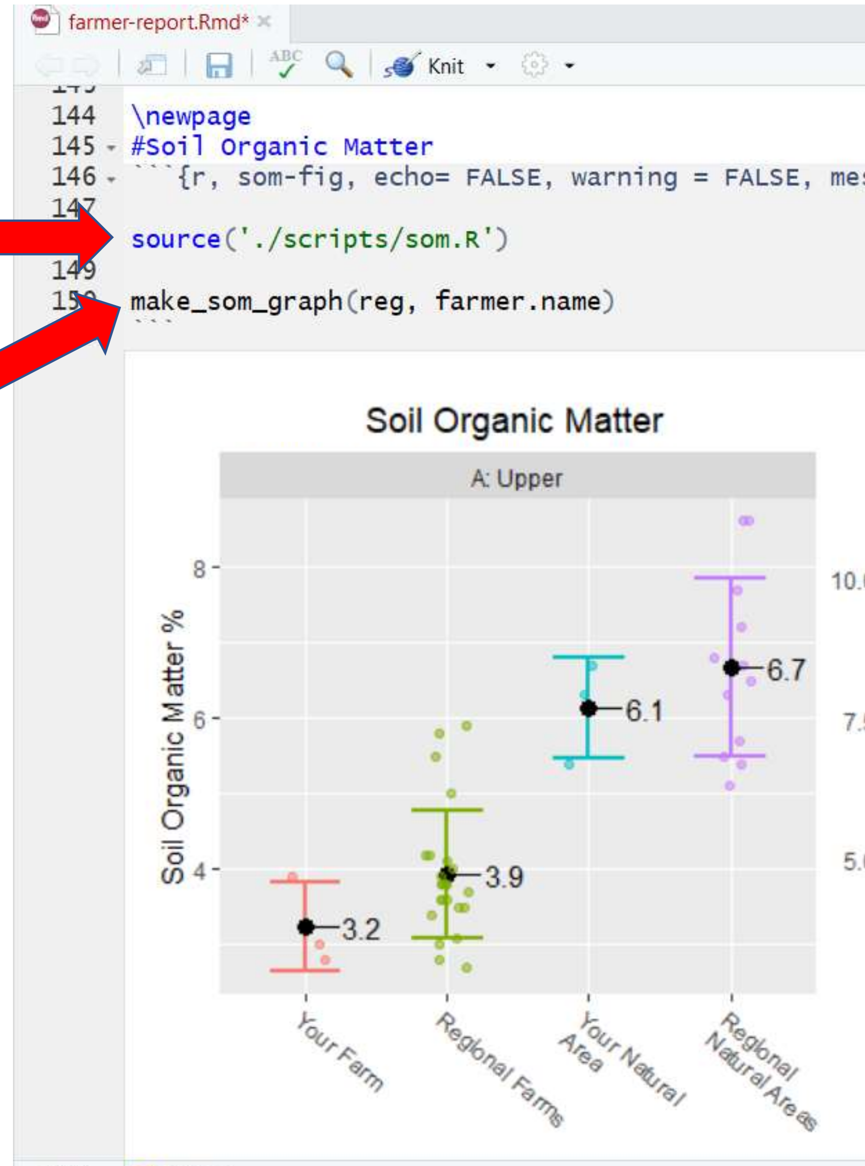
Text

Code

Rmd template:
external scripts & functions

A call to the external script (program)

A function from your script that analyzes data and makes a graph



How do you get from template to PDF?

Header: document set-up

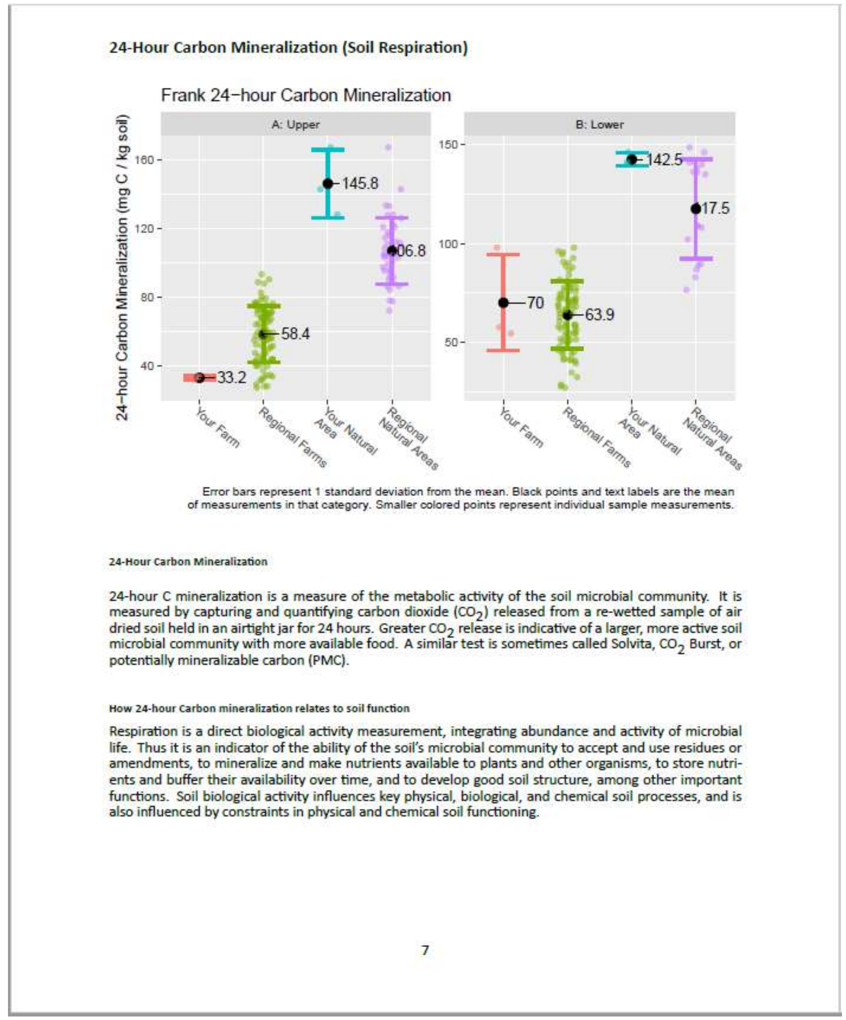
Code chunk: call script, make graph

Text chunk: explain graph

Code chunk: make nice graph

Text chunk

Code chunk: draw pretty map



24-Hour Carbon Mineralization (Soil Respiration)

Error bars represent 1 standard deviation from the mean. Black points and text labels are the mean of measurements in that category. Smaller colored points represent individual sample measurements.

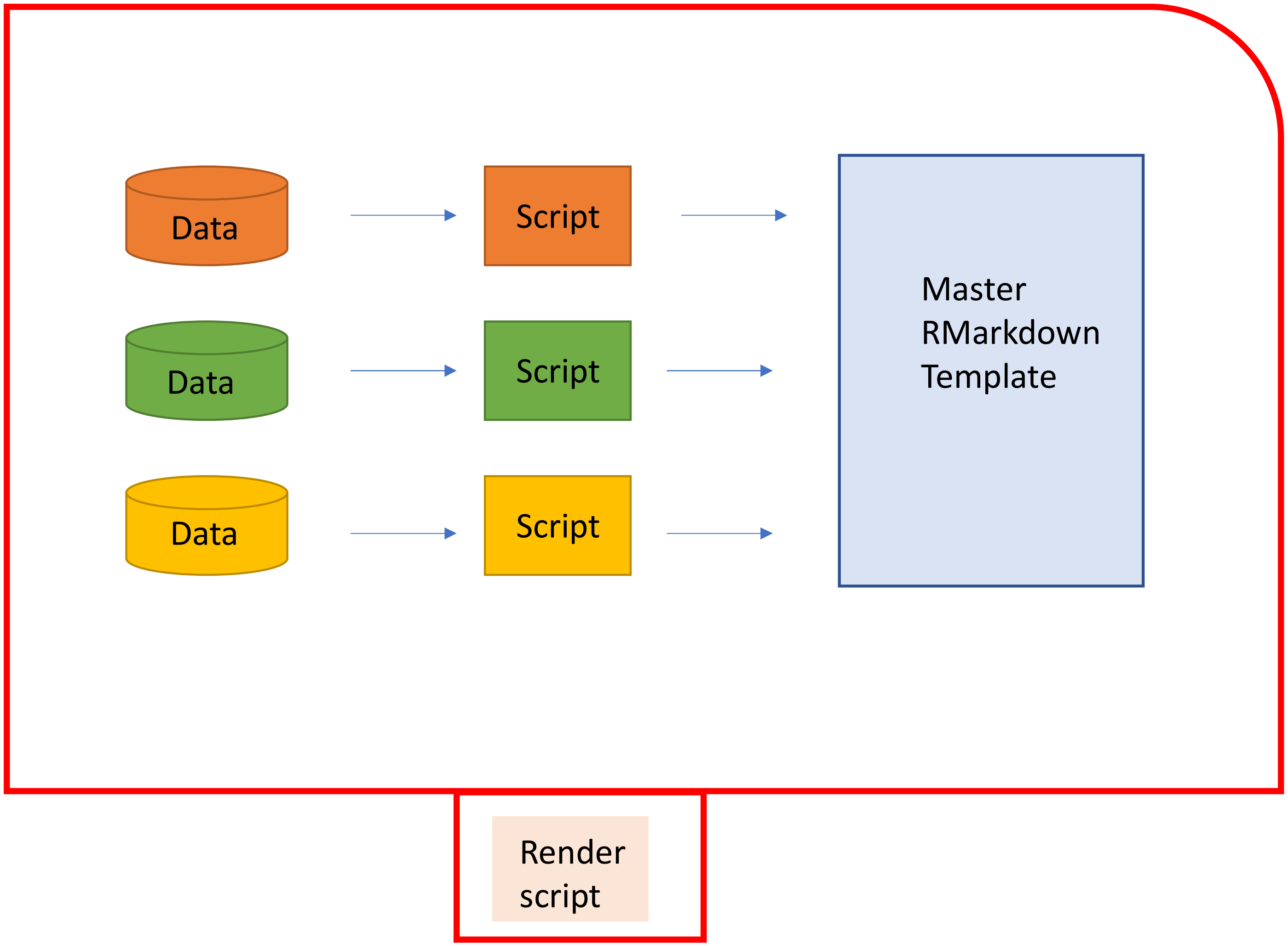
24-Hour Carbon Mineralization

24-hour C mineralization is a measure of the metabolic activity of the soil microbial community. It is measured by capturing and quantifying carbon dioxide (CO_2) released from a re-wetted sample of air dried soil held in an airtight jar for 24 hours. Greater CO_2 release is indicative of a larger, more active soil microbial community with more available food. A similar test is sometimes called Solvita, CO_2 Burst, or potentially mineralizable carbon (PMC).

How 24-hour Carbon mineralization relates to soil function

Respiration is a direct biological activity measurement, integrating abundance and activity of microbial life. Thus it is an indicator of the ability of the soil's microbial community to accept and use residues or amendments, to mineralize and make nutrients available to plants and other organisms, to store nutrients and buffer their availability over time, and to develop good soil structure, among other important functions. Soil biological activity influences key physical, biological, and chemical soil processes, and is also influenced by constraints in physical and chemical soil functioning.

7


Data
Script
Data
Script
Data
Script
Master RMarkdown Template
Render script

Render script

- Automate: Let your computer do the repetitive stuff!

- Short program that helps automate your report using the variables you define

- We give the render script a list of our 27 farmers and their regions; it calls the template to make 27 individualized reports

Render script

Create a list with one line for every farmer who needs a report

iterate.R

Source on Save

```r

library(tidyverse)

cig_names<-read.csv("./raw-data/cig_names_master.csv", strings/

input.list <- cig_names %>%
  select(farmer, region) %>%
  distinct(farmer, region)


render_report = function(farmer, region){
  rmarkdown::render(
    "./farmer-report.Rmd", params = list(
      farmer = farmer,
      region = region
    ),
    output_file = paste0("./outputs/reports/", farmer, "-2019-
  )
}


pwalk(input.list, render_report)
```

Render script

Create a list with one line for every farmer who needs a report

Define the variables (parameters) used to make the reports.

iterate.R

Source on Save

```
library(tidyverse)

cig_names<-read.csv("./raw-data/cig_names_master.csv", strings

input.list <- cig_names %>%
  select(farmer, region) %>%
  distinct(farmer, region)


render_report = function(farmer, region){
  rmarkdown::render(
    "./farmer-report.Rmd", params = list(
      farmer = farmer,
      region = region
    ),
    output_file = paste0("./outputs/reports/", farmer, "-2019-
  )
}


pwalk(input.list, render_report)
```

Render script

iterate.R

Source on Save

Create a list with one line for every farmer who needs a report

Define the variables (parameters) used to make the reports.

Specify output file names

```r

library(tidyverse)

cig_names<-read.csv("./raw-data/cig_names_master.csv", strings

input.list <- cig_names %>%
  select(farmer, region) %>%
  distinct(farmer, region)


render_report = function(farmer, region){
  rmarkdown::render(
    "./farmer-report.Rmd", params = list(
      farmer = farmer,
      region = region
    ),
    output_file = paste0("./outputs/reports/", farmer, "-2019-
  )
}


pwalk(input.list, render_report)
```

Render script

Create a list with one line for every farmer who needs a report

Define the variables (parameters) used to make the reports.

Specify output file names

This function looks at each line of your list and creates (renders) a report for each

iterate.R

Source on Save

```r

library(tidyverse)

cig_names<-read.csv("./raw-data/cig_names_master.csv", strings

input.list <- cig_names %>%
  select(farmer, region) %>%
  distinct(farmer, region)


render_report = function(farmer, region){
  rmarkdown::render(
    "./farmer-report.Rmd", params = list(
      farmer = farmer,
      region = region
    ),
    output_file = paste0("./outputs/reports/", farmer, "-2019-
  )
}


pwalk(input.list, render_report)
```

Let’s take a tour of our report

MINNESOTA OFFICE FOR SOIL HEALTH
University of Minnesota

Soil Health Project Update

May 05, 2020

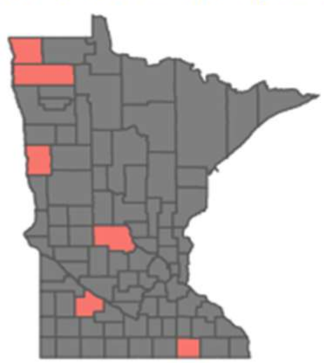
Thank you for participating in year 1 of our soil health research project. In year 1, we collected soil samples from all 27 participating farms. This year, we will collect another set of soil samlpes in October-November. Our original research plan also included infiltration measurements to be performed on all participating farms in May - June of this year. However, due to safety concerns and travel restrictions imposed by COVID-19, we are currently evaluating the feasibility of performing these measurements. We will communicate with you when we have more information about these infiltration measurements.

Our main goal is to gather repsentative soil data from working farms with a range of locations, soil types, and management practices. This data will serve as an important baseline to help us evaluate the effectiveness of specific soil health tests for monitoring soil changes. Our work would not be possible without participation from cooperators like you - thank you!

This report includes preliminary data year 1 data for the following soil tests:

- Soil organic matter %
- pH
- Phosphorus (P)
- Potassium (K)
- Potentially mineralizable nitrogen (PMN)
- Soil respiration (potentially mineralizable carbon) (PMC)

Locations of Participating Farms



Future Research Activities

Activity	Expected Timeline
Infiltration tests, year 1	TBD
Soil samples, year 2	Oct – Nov. 2020
Collect management info	Nov. 2020 – Feb. 2021
Infiltration tests, year 2	May – June 2021

MINNESOTA OFFICE FOR SOIL HEALTH
UNIVERSITY OF MINNESOTA

Soil Health Project Update

May 05, 2020

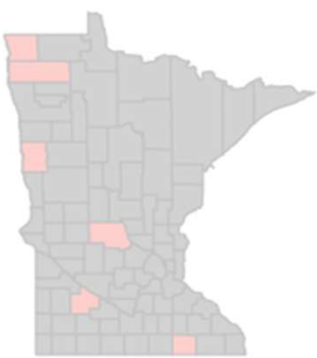
Thank you for participating in year 1 of our soil health research project. In year 1, we collected soil samples from all 27 participating farms. This year, we will collect another set of soil samlpes in October-November. Our original research plan also included infiltration measurements to be performed on all participating farms in May - June of this year. However, due to safety concerns and travel restrictions imposed by COVID-19, we are currently evaluating the feasibility of performing these measurements. We will communicate with you when we have more information about these infiltration measurements.

Our main goal is to gather repsentative soil data from working farms with a range of locations, soil types, and management practices. This data will serve as an important baseline to help us evaluate the effectiveness of specific soil health tests for monitoring soil changes. Our work would not be possible without participation from cooperators like you - thank you!

This report includes preliminary data year 1 data for the following soil tests:

- Soil organic matter %
- pH
- Phosphorus (P)
- Potassium (K)
- Potentially mineralizable nitrogen (PMN)
- Soil respiration (potentially mineralizable carbon) (PMC)

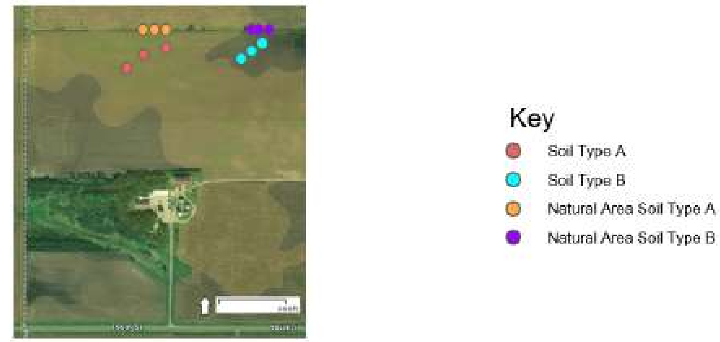
Locations of Participating Farms



Future Research Activities

Activity	Expected Timeline
Infiltration tests, year 1	TBD
Soil samples, year 2	Oct – Nov. 2020
Collect management info	Nov. 2020 – Feb. 2021
Infiltration tests, year 2	May – June 2021

Research Design



What is preliminary data?

The data we are sharing with you today represents just a fraction of what we will eventually analyze and share. We are still running additional tests in the laboratory, including some re-runs for quality control purposes. If you notice data missing in the graphs below, please understand that we expect to have full results for each farm by the end of the 2.5 year project. It is possible that one or two samples from your farm are being re-tested or run in our next round of tests.

Where We Sampled

At each farm we visited, we looked for two different soil types to sample in the field. You will see these marked "A" and "B" in the field image above. In general, the "A" samples are taken from relatively well-drained, upper slope locations. The "B" samples are taken from lower, less well-drained areas. In the Red River Valley, where there is very little topography to distinguish "upper" and "lower", the "A" and "B" refer to soil types with relatively less clay (A) and relatively more clay (B). We chose this design because we want to understand how variable soil health measurements can be within a given field or section.

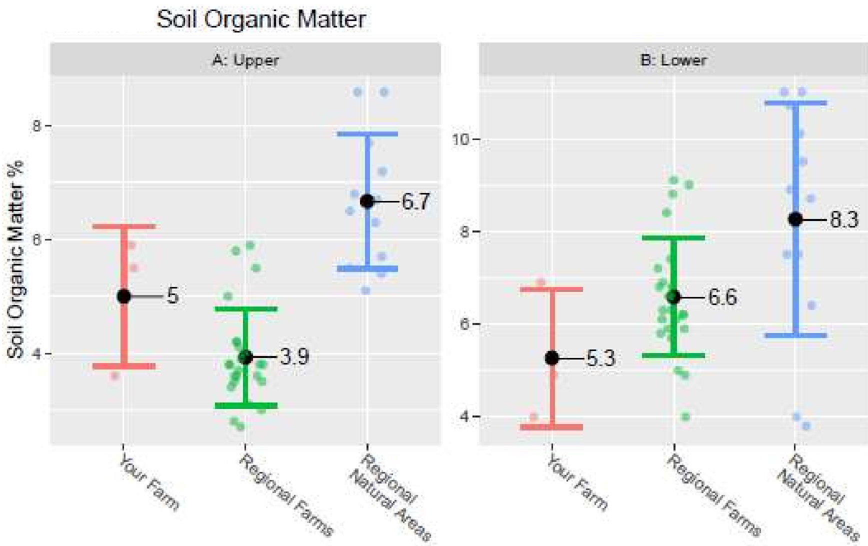
When available, we also took a sample from a relatively undisturbed "natural area" such as a tree line, grassed fenceline, or other place with the same soil type as our field samples. We took these samples as a reference, especially for biological soil health indicators. In most cases, we would not expect field samples and natural area samples to be the same - these are two different types of land use. An undisturbed area with perennial vegetation incorporates more of the soil health principles of low disturbance, plant diversity, and year-round ground cover, so we expect most biological indicators to be higher. We recommend you view the results from nearby natural areas as evidence of your soil's *potential* for biological activity. It can be instructive to use soil health tests over time to understand if your soil is improving more toward its potential.

If you don't see a "your natural area" sample in your sample map or the graphs below, this means we had to find the right soil type elsewhere, either at a neighboring farm or another nearby natural area. In this case, you will still see average test results for natural areas in your region in the graphs below.

Future Tests

You can expect results for additional soil health tests in the future. We currently plan to analyze all soil samples for these additional soil health indicators: microbial biomass, C:N ratios, extracellular enzyme activities, phospholipid fatty acid profiles of the soil microbial community, soil protein N concentration, aggregate stability, texture (sand/silt/clay), and active carbon (permanganate oxidizable carbon).

Soil Organic Matter



Error bars represent 1 standard deviation from the mean. Black points and text labels are the mean of measurements in that category. Smaller colored points represent individual sample measurements.

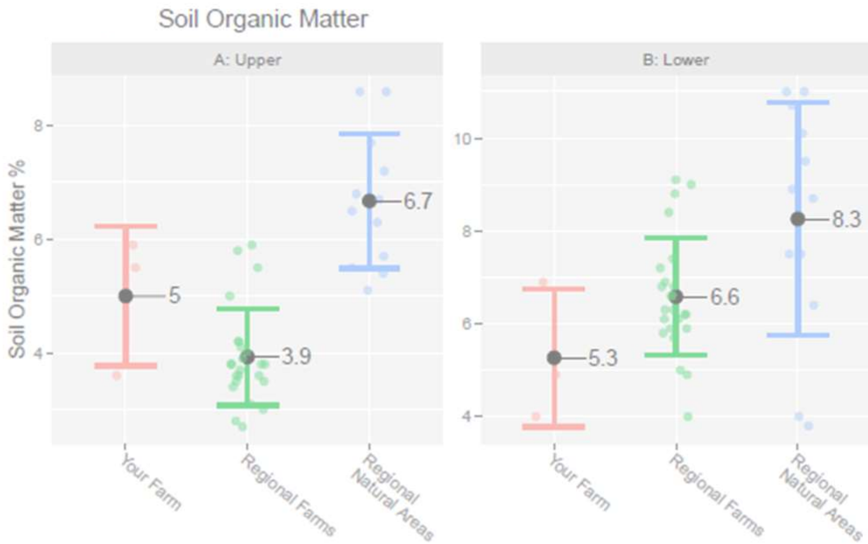
What is organic matter?

Total soil organic matter (OM) consists of both living and dead material in the soil, including well decomposed, more stabilized materials. The percent organic matter is determined by loss on ignition, based on the change in mass after a soil is exposed to high temperature (500 °C or 932°F) in a furnace. At these temperatures, carbon-rich materials are burned off (oxidized to CO_2), while other materials (such as minerals) remain.

How organic matter relates to soil function

Soil organic matter is where soil carbon is stored, and is directly derived from biomass of microbial communities in the soil (bacterial, fungal, and protozoan), as well as from plant roots and detritus, and biomass-containing amendments like manure, green manures, mulches, composts, and crop residues. OM acts as a long-term carbon sink, and as a slow-release pool for nutrients, providing energy to the plant and soil microbial communities. It cements soil particles into aggregates which can both improve infiltration and water holding capacity. A large portion of OM adheres to mineral particles, so the soil's capacity to store OM is based on soil texture. When soil is not disturbed, more OM builds up both within aggregates and free-floating in the soil matrix.

Soil Organic Matter



Error bars represent 1 standard deviation from the mean. Black points and text labels are the mean of measurements in that category. Smaller colored points represent individual sample measurements.

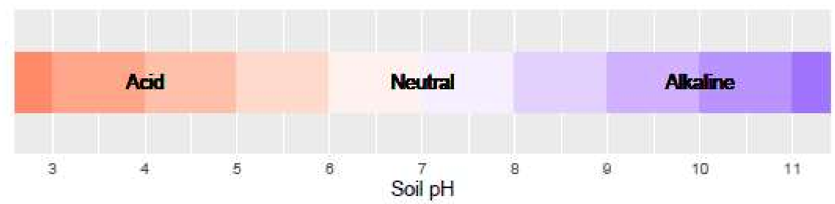
What is organic matter?

Total soil organic matter (OM) consists of both living and dead material in the soil, including well decomposed, more stabilized materials. The percent organic matter is determined by loss on ignition, based on the change in mass after a soil is exposed to high temperature (500 °C or 932°F) in a furnace. At these temperatures, carbon-rich materials are burned off (oxidized to CO_2), while other materials (such as minerals) remain.

How organic matter relates to soil function

Soil organic matter is where soil carbon is stored, and is directly derived from biomass of microbial communities in the soil (bacterial, fungal, and protozoan), as well as from plant roots and detritus, and biomass-containing amendments like manure, green manures, mulches, composts, and crop residues. OM acts as a long-term carbon sink, and as a slow-release pool for nutrients, providing energy to the plant and soil microbial communities. It cements soil particles into aggregates which can both improve infiltration and water holding capacity. A large portion of OM adheres to mineral particles, so the soil's capacity to store OM is based on soil texture. When soil is not disturbed, more OM builds up both within aggregates and free-floating in the soil matrix.

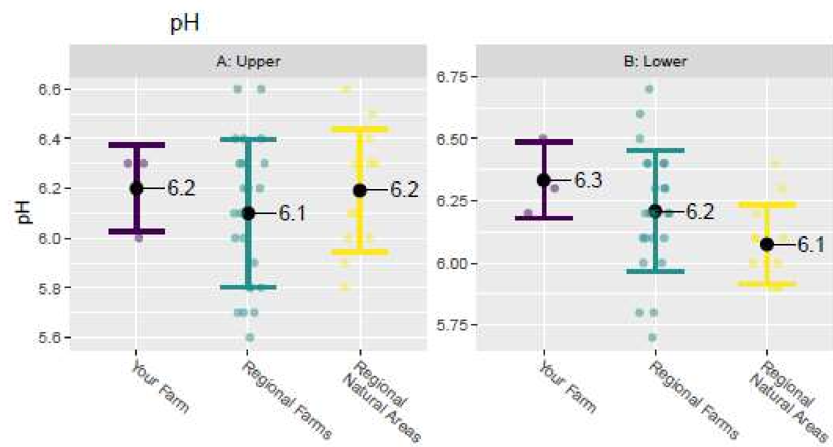
Soil pH



Soil pH is a measure of whether the soil is acid, neutral, or alkaline. Soil pH controls how available nutrients are to crops. It is affected by both natural factors and management factors. Natural factors include the parent material your soil developed from, historical precipitation levels, and the infiltration rate of your soil. Management factors that impact pH include the application of lime, fertilizer type and quantity, and others.

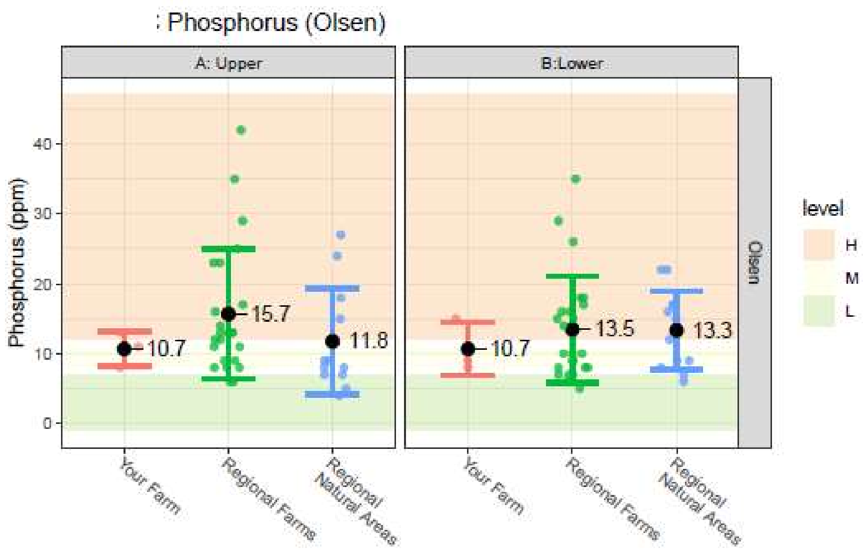
Soil pH is measured by mixing two parts water to one part soil and measuring the solution with a pH electrode probe. Optimum pH is around 6.2-6.8 for most crops (exceptions include potatoes and blueberries, which grow best in more acidic soil). If pH is too high, nutrients such as phosphorus, iron, manganese, copper and boron become unavailable to the crop. If pH is too low, calcium, magnesium, phosphorus, potassium and molybdenum become unavailable. Lack of nutrient availability will limit crop yields and quality. Aluminum toxicity can also be a concern in low pH soils, which can severely decrease root growth and yield, and in some cases lead to accumulation of aluminum and other metals in crop tissue. In general, as soil organic matter increases, crops can tolerate lower soil pH. Soil pH also influences the ability of certain pathogens to thrive, and of beneficial organisms to effectively colonize roots.

As a general rule, in the state of Minnesota we expect to observe somewhat higher (more basic) pH in the western parts of the state.



Error bars represent 1 standard deviation from the mean. Black points and text labels are the mean of measurements in that category. Smaller colored points represent individual sample measurements.

Phosphorus

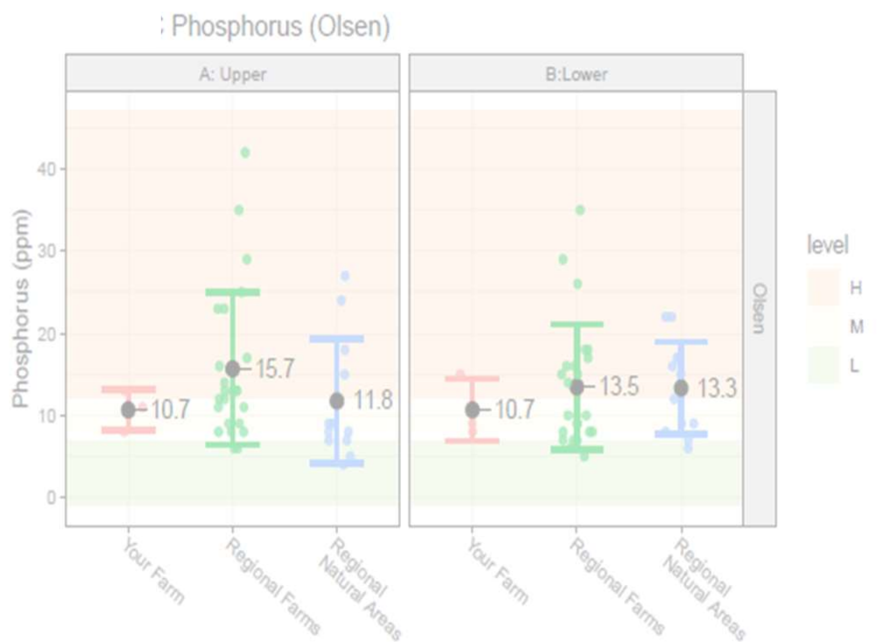


Error bars represent 1 standard deviation from the mean. Black points and text labels are the mean measurements in that category. Smaller colored points represent individual sample measurements.

Extractable phosphorus is a measure of phosphorus (P) availability to a crop. The type of P test (Bray or Olsen) appropriate for your soil depends on pH. Following University of Minnesota guidance, we have reported Bray P results for farms with soil pH > 7.5 and Olsen P results for farms with soil pH < 7.5.

P is an essential plant macronutrient, as it plays a role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement, and several other process in plants. Its availability varies with soil pH and mineral composition. Low P values indicate poor P availability to plants. Excessively high P values indicate a risk of adverse environmental impact. P can be considered a contaminant and runoff of P into fresh surface water will cause damage through eutrophication. For this reason, over-application is strongly discouraged, especially close to surface water, on slopes, and on large scales. For a general understanding of what constitutes a "Low" or "High" value, see the next page for more information from the University of Minnesota's calibrations.

Phosphorus

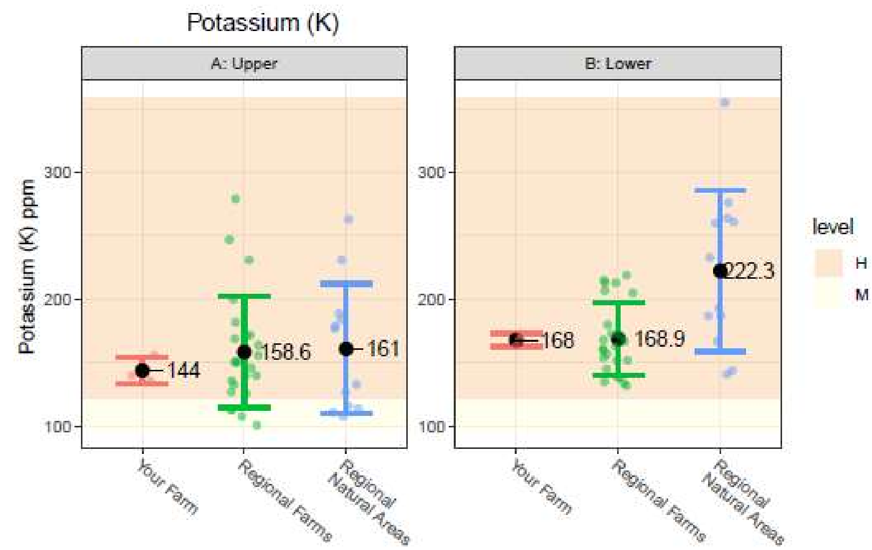


Error bars represent 1 standard deviation from the mean. Black points and text labels are the mean measurements in that category. Smaller colored points represent individual sample measurements.

Extractable phosphorus is a measure of phosphorus (P) availability to a crop. The type of P test (Bray or Olsen) appropriate for your soil depends on pH. Following University of Minnesota guidance, we have reported Bray P results for farms with soil pH > 7.5 and Olsen P results for farms with soil pH < 7.5.

P is an essential plant macronutrient, as it plays a role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement, and several other process in plants. Its availability varies with soil pH and mineral composition. Low P values indicate poor P availability to plants. Excessively high P values indicate a risk of adverse environmental impact. P can be considered a contaminant and runoff of P into fresh surface water will cause damage through eutrophication. For this reason, over-application is strongly discouraged, especially close to surface water, on slopes, and on large scales. For a general understanding of what constitutes a "Low" or "High" value, see the next page for more information from the University of Minnesota's calibrations.

Potassium



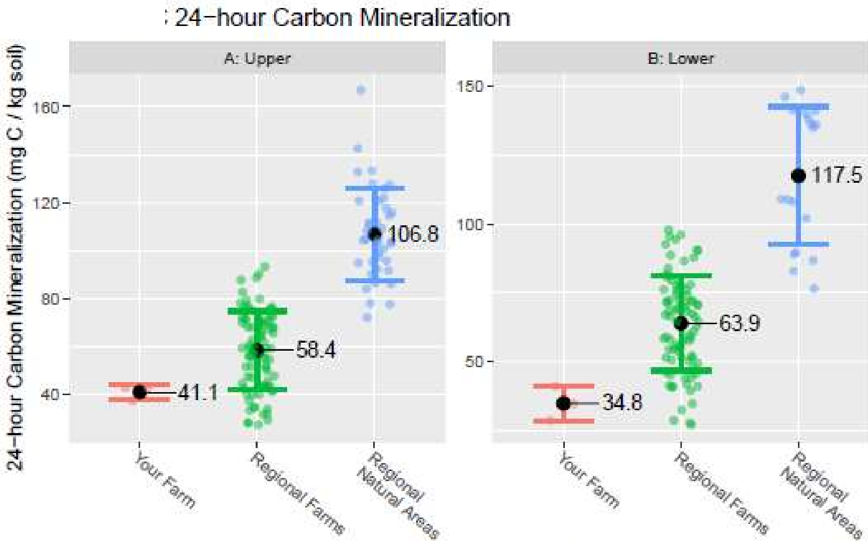
Error bars represent 1 standard deviation from the mean. Black points and text labels are the mean of measurements in that category. Smaller colored points represent individual sample measurements.

Extractable potassium is a measure of potassium (K) availability to the crop. K is an essential plant macronutrient that plays a role in photosynthesis, respiration, energy storage and transfer, regulation of water uptake and loss, protein synthesis, activation of growth related enzymes, and other processes. Plants with higher potassium tend to be more tolerant of frost and cold. Thus, good potassium levels may help with season extension. While soil pH only marginally affects K availability, K is easily leached from sandy soils and is only weakly held by increased OM, so that applications of the amount removed by the specific crop being grown are generally necessary in such soils.

Relative Nutrient Levels for Phosphorus and Potassium

Level	Phosphorus (P)	Phosphrous	Potassium (K)
	Bray/Mehlich III	Olsen	
	ppm	ppm	ppm
Very low (VL)	0–5	0–3	0–40
Low (L)	6–11	4–7	41–80
Medium (M)	12–15	8–11	81–120
High (H)	16–20	12–15	121–160
Very High (VH)	21+	16+	161+

24-Hour Carbon Mineralization (Soil Respiration)



Error bars represent 1 standard deviation from the mean. Black points and text labels are the mean of measurements in that category. Smaller colored points represent individual sample measurements.

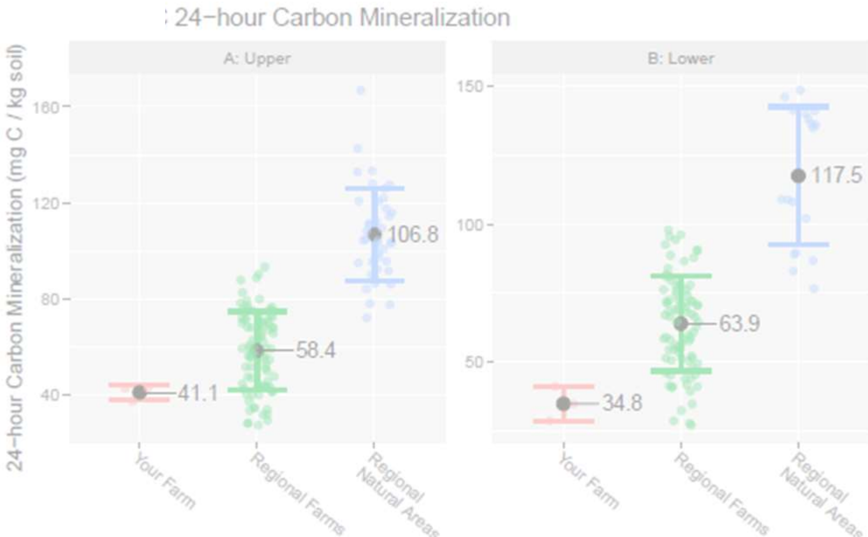
24-Hour Carbon Mineralization

24-hour C mineralization is a measure of the metabolic activity of the soil microbial community. It is measured by capturing and quantifying carbon dioxide (CO_2) released from a re-wetted sample of air dried soil held in an airtight jar for 24 hours. Greater CO_2 release is indicative of a larger, more active soil microbial community with more available food. A similar test is sometimes called Solvita, CO_2 Burst, or potentially mineralizable carbon (PMC).

How 24-hour Carbon mineralization relates to soil function

Respiration is a direct biological activity measurement, integrating abundance and activity of microbial life. Thus it is an indicator of the ability of the soil's microbial community to accept and use residues or amendments, to mineralize and make nutrients available to plants and other organisms, to store nutrients and buffer their availability over time, and to develop good soil structure, among other important functions. Soil biological activity influences key physical, biological, and chemical soil processes, and is also influenced by constraints in physical and chemical soil functioning.

24-Hour Carbon Mineralization (Soil Respiration)



Error bars represent 1 standard deviation from the mean. Black points and text labels are the mean of measurements in that category. Smaller colored points represent individual sample measurements.

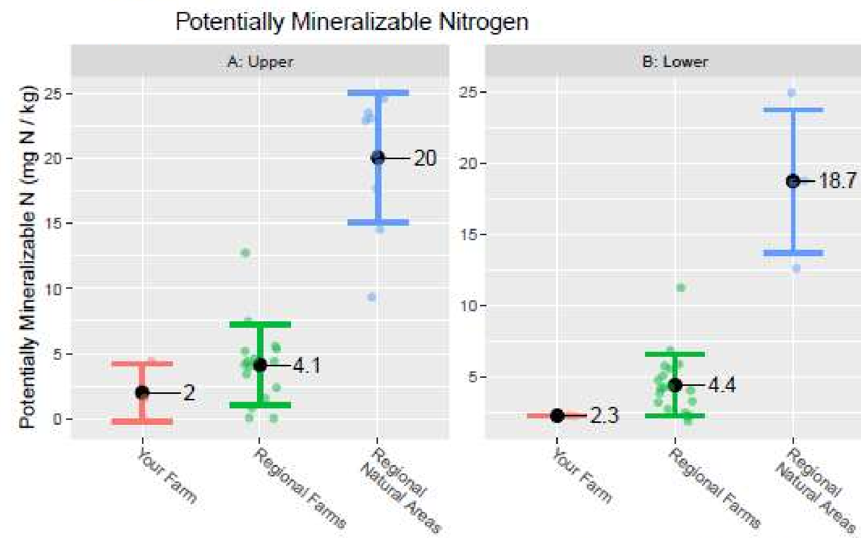
24-Hour Carbon Mineralization

24-hour C mineralization is a measure of the metabolic activity of the soil microbial community. It is measured by capturing and quantifying carbon dioxide (CO_2) released from a re-wetted sample of air dried soil held in an airtight jar for 24 hours. Greater CO_2 release is indicative of a larger, more active soil microbial community with more available food. A similar test is sometimes called Solvita, CO_2 Burst, or potentially mineralizable carbon (PMC).

How 24-hour Carbon mineralization relates to soil function

Respiration is a direct biological activity measurement, integrating abundance and activity of microbial life. Thus it is an indicator of the ability of the soil's microbial community to accept and use residues or amendments, to mineralize and make nutrients available to plants and other organisms, to store nutrients and buffer their availability over time, and to develop good soil structure, among other important functions. Soil biological activity influences key physical, biological, and chemical soil processes, and is also influenced by constraints in physical and chemical soil functioning.

Potentially Mineralizable Nitrogen (PMN)



Error bars represent 1 standard deviation from the mean. Black points and text labels are the mean of measurements in that category. Smaller colored points represent individual sample measurements.

Potentially Mineralizable Nitrogen

Potentially Mineralizable Nitrogen is an indicator of the capacity of the soil microbial community to convert (mineralize) nitrogen tied up in organic residues into the plant available form of ammonium. To measure PMN, soil samples are anaerobically incubated for 7 days, and the amount of ammonium produced in that period is measured as an indicator of the soil microbes' capacity to transform organic N into plant-available N.

How PMN relates to soil function

Nitrogen is the most limiting nutrient for plant growth and yield in most agricultural situations. Almost all of the nitrogen stored in crop residues, soil organic matter, manures and composts is in the form of organic molecules (such as proteins) that are not directly available to plants. We rely on several microbial species in the soil to convert this organic nitrogen into the ammonium and nitrate forms that plant roots can utilize. The PMN test doesn't predict how much plant-available N will be released over the season. It's like a fitness test for microbes, showing the capacity of the soil biota to recycle organic nitrogen into plant available forms. Since plant-available N is water-soluble and leaves the profile rapidly, we can't rely on storing it for the long term. Still, high PMN indicates you have plenty of organic N, and microbes with

Contact with questions:

University of Minnesota

Hava Blair, Graduate Student
blair304@umn.edu or (612) 513-4301

Dr. Anna Cates, State Soil Health Specialist - Minnesota Office of Soil Health
catesa@umn.edu or (612) 625-3135

Mower County

Steve Lawler, Mower County Soil and Water Conservation District
steve@mowerdistrict.org or (507) 434-2603

Red River Valley, Redwood County, & Renville County

Kent Solberg, Sustainable Farming Association
kent@sfa-mn.org or (844) 922-5573 ext 701

Stearns County

Mark Lefebvre, Stearns County Soil and Water Conservation District
mark.lefebvre@mn.nacdnet.net or (320) 345-6488

Acknowledgements:

Portions of the explanatory text in this report were modified from:

Moebius-Clune, B.N. et al. (2016). Comprehensive Assessment of Soil Health - The Cornell Framework, Edition 3.2, Cornell University, Geneva, NY.

This research is funded by a Conservation Innovation Grant from the Natural Resources Conservation Service (NRCS) to the University of Minnesota Office for Soil Health, in partnership with University Extension and the Department of Soil Water and Climate.

Closing Thoughts

- How do we think about interpreting soil health indicator results for farmers and stakeholders?

- Is a “high”, “medium” and “low” approach appropriate for soil health indicators? We have this information for standard nutrient tests. What’s different?

- What is the value of comparison
  - Between farms
  - Between management practices
  - In reference to a “natural” area

Thank you!

- Hava Blair - blair304@umn.edu - havablair.github.io
- Dr. Anna Cates - catesa@umn.edu