Photo by Emily Brown, Allegan Conservation District

MICHIGAN SOIL HEALTH APPRAISAL METHODOLOGY OVERVIEW

FALL 2024

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EXECUTIVE SUMMARY

Michigan farmers may build soil health and improve water quality by adopting Soil Health Management Systems (SHMS), such as cover crops and no-till. However, prior stages of work by Delta Institute have shown that despite documented evidence which suggests improved soil health may create more profitable farming operations (American Farmland Trust, 2019; Soil Health Institute, 2019; American Farmland Trust, 2020; Soil Health Institute, 2021), Michigan farmers require greater financial incentives to adopt SHMS.

Farmers may be incentivized to adopt SHMS if building soil health can demonstrably increase the value of their land, helping to provide a clear value proposition to undertake soil health- and water quality- focused efforts. To do so, soil health must be valued as a property characteristic and a replicable process to incorporate soil health into commonly accepted appraisal practices must be created. However, in Michigan (and more broadly in the Midwest), no real estate appraisal approaches currently exist to empirically assess the value ($/acre) of soil health. Instead, land values are closely tied to National Commodity Crop Productivity Index scores (NCCPI) which are derived from measurements of inherent soil properties (e.g., texture and drainage class). In other words, the condition (or health) of the soil is not considered due to a lack of commonly accepted metrics by real estate professionals.

The appraisal process is critical to the functioning of the agricultural sector. Real estate market participants use appraisals to negotiate fair prices when buying or selling farm properties. Lenders use appraisals to assess the value of the farm property as collateral for operating loans or mortgages. Appraisals assist in estate planning by providing an accurate valuation of farm properties for inheritance and tax purposes. Investors utilize appraisals to evaluate potential returns and risks associated with investing in agricultural properties. Government authorities may employ appraisals to assess property taxes on farm properties based on their fair market value. Taken as a whole, if appraisers are able to value soil health as an asset or improvement on farmland, then soil health can be traded in the marketplace and building soil health by adopting SHMS may become an attractive business strategy for farmers.

Through generous support from the Fred and Barbara Erb Family Foundation, Delta Institute presents a modified “Sales Comparison” approach to factor measurements of soil health into Michigan farmland appraisals. This “proof-of-concept” approach was tested on several southeastern Michigan farms in 2024. To learn more about the Michigan Soil Health Appraisal Pilot Program, please visit https://delta-institute.org/project/michigan-soil-health/.

As an overview, the steps of the modified Sales Comparison appraisal approach are:

1. Collect foundational, widely recognized metrics of the subject property and comparable land sales in the defined market area.
2. Collect soil samples from the subject property and land management history from farm owner/tenant. Soil health data is analyzed to observe trends specific to soil health indicators. A ranking system will allow for comparisons among “peers.” Land management history data collected via farm owner/tenant interviews may be used for qualitative bracketing.
3. Use the simple “soil health index” described herein to create a score specific to each subject to determine the extent of any value influence and form an opinion as to how these ultimately influence property value.

4. Analyze the subject cohort for any trends specific to the soil health indicators (soil organic carbon percentage, potential carbon mineralization, and aggregate stability). The association between assessed value ($/acre) and soil health may be assessed by regression analysis or other statistical analysis depending on the dataset.
5. Finally, incorporate the soil health index specific to the subject to form an opinion as to how/whether these ultimately influence property value.

The novel approach outlined in this document has not been officially approved or adopted by any governing organizations or regulatory bodies within the appraisal industry. The effectiveness and reliability of this approach may vary depending on specific circumstances, local regulations, and market conditions. Therefore, it is recommended to consult with certified appraisers or relevant authorities for guidance on conducting farm real estate appraisals in compliance with established standards and best practices. This document is provided for informational purposes only and does not constitute professional appraisal advice or endorsement of the approach described herein.

About Delta Institute

Delta Institute collaborates with communities to solve complex environmental challenges throughout the Midwest. Delta exists because environmental, economic, and climate issues hit communities—urban and rural—through disinvestment, systemic inequity, and policy decisions. We collaborate at the community level to solve our home region's new and legacy issues, by focusing on the self-defined goals and needs of our partners.

Delta Institute improves the living conditions of more than five million Midwesterners by transitioning one million acres to more resilient, conservation-focused practices, and by improving water quality and reducing flooding by capturing 100 million stormwater gallons. By 2025 we will achieve these goals through our agriculture, climate, water, and community development projects.

This is what a more resilient, equitable, and innovative Midwest looks like. Visit us online at www.delta-institute.org.

Acknowledgements

This project was produced with generous support from the **Fred and Barbara Erb Family Foundation**, who envisions a flourishing, healthy, and resilient Great Lakes ecosystem and a culturally vibrant, sustainable Southeast Michigan. Toward this end, we strengthen the cultural and environmental organizations that share our vision to make this a reality for generations to come. Learn more at https://www.erbff.org/.

Douglas Hodge, ARA, MAI, has been involved in the valuation of agricultural assets since 1983 and has prepared appraisal reports and appraisal reviews globally. Doug graduated from Ferris State University in 1983 with a BS – Finance with a concentration in real estate. He formerly held the position of VP – Chief Appraiser at International Farming Corporation where he was responsible for valuation of farmland investments and appraisal review for the global agricultural assets held by IFC. He also held the position of VP of Appraisal Services for Nuveen Global Asset Management and Sr. Director for TIAA-CREF and was responsible for the appraisal

review of Nuveen/TIAA's global agricultural portfolio. Prior to joining Nuveen, he was the regional appraisal manager for the eastern US for Farmers National Co. Before joining FNC in 2007 he owned his own valuation firm in Lapeer, Michigan. He is currently a certified general appraiser in Michigan. Doug has served recently as the District III VP for the American Society of Farm Managers and Rural Appraisers (ASFMRA) and is the current immediate past president of ASFMRA and has held other positions with ASFMRA and the Great Lakes Chapter of the Appraisal Institute. Having grown up on a dairy farm in Sanilac County, Michigan he has a strong background in agriculture. In addition to his appraisal practice he and his wife, June, operate Stony Croft Farms, a producer and processor of heritage grains and flour.

Rob Malcolmnson holds a Bachelor's Degree in Resource Development from Michigan State University. He has managed Marsh Haven Farms, a diverse, organic/regenerative farm, for 30 years near Flint, MI. He has worked as the Urban Agriculture Technician for MSU Extension in Genesee County, and for the Lapeer Conservation District assisting landowners in earning verification in the Michigan Agriculture Environmental Assurance Program. He has served his region through various Boards of Directors and has taught classes through the local Community Education program. For 35 years, Rob has used and/or serviced residential alternative energy systems. Rob is a Certified Crop Advisor and has a 30-year history of mentoring/teaching farmers and homesteaders as an independent consultant.

This document and the tools provided aim to be action oriented and to provide the most current, correct, and clear information possible, but some information may have changed since publication. We encourage practitioners to reach out to us at delta@delta-institute.org with questions, corrections, or to discuss implementation challenges.

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SOIL HEALTH CHARACTERISITICS RELEVANT TO MICHIGAN APPRAISERS

What is Soil Health?

Soil health is the capacity for soils to support life and provide crucial ecosystem services such as water filtration, nutrient cycling, decomposition and greenhouse gas storage. Healthy soils are also more resilient to extreme weather, erosion, and degradation. The soils of the subject property or parcel you assess will have both inherent and dynamic properties that are relevant to understanding their functionality (Figure 1).

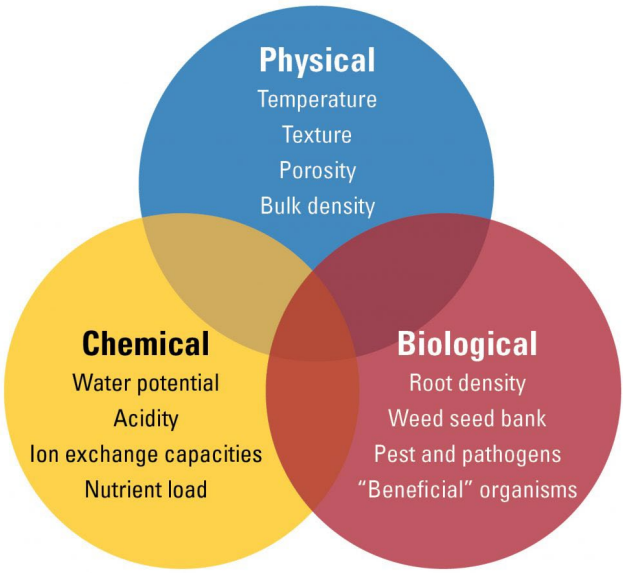

Figure 1: Soil Health characteristics. Source: https://maximumfarming.com/the-science/soil-health/

Inherent characteristics (e.g., mineralogy, texture, drainage class) determine a soil's "type" (e.g., sandy loam or silty clay loam) and offer insight into the soil's baseline agricultural productivity. Dynamic properties of soil are the characteristics that can change relatively rapidly under different land uses (e.g., organic matter, bulk density, plant-available nutrients, and microbial activity). These dynamic properties can be measured and monitored over time as valuable indicators of soil health.

How is Soil Health Measured?

Soil health is diagnosed by measuring **soil health indicators** – a standardized criterion of dynamic soil physical, chemical and biological properties (Stewart et al., 2018). There are dozens of indicators which can be measured to assess soil health.

Don't Panic, it's Simple!

In this modified approach, appraisers are only responsible for collecting soil samples from the subject property. Soil testing labs will test the samples and analyze the results for you. Just be sure that the lab will test for the **three soil health indicators** listed in this section!

In an effort to standardize and simplify the process of measuring soil health, the Soil Health Institute has identified a "minimum suite of widely applicable measurements for assessing soil health" that are "cost-effective, interpretable, and responsive to soil health promoting practices" following a 3-year study of over 100 long-term agricultural research sites. To quickly and simply assess the soil health of a farm field or subject property, the Soil Health Institute recommends measuring the following three soil health indicators:

- **Organic C Concentration:** Soil organic Carbon is an essential component of high–functioning soils, as it builds soil structure, thereby improving water and nutrient cycling and retention as well as sequestration of atmospheric carbon. Management that increases organic carbon content promotes greater soil structure, microbial activity, available water, and available nutrients. The Soil Health Institute's standard operating procedure for measuring Organic C concentration can be found here.
- **Carbon Mineralization Potential (Burst of CO2):** Soil nutrient cycling depends on a vibrant soil microbial community. Quantifying Carbon mineralization (e.g., the breakdown of organic matter by soil microbes) provides insight into the soil's microbial activity. This method measures the abundance of carbon dioxide (CO2) produced by soil microbes (metabolic activity/decomposition) following a 24-hour incubation period. The Soil Health Institute's standard operating procedure for this method can be found here.
- **Aggregate Stability:** Soil aggregates are formed through physical and chemical interactions between mineral particles and organic matter. Improved aggregation reduces erodibility, enhances water retention, and provides better habitat for microbes and larger soil organisms. Aggregates also play a role in carbon sequestration by physically protecting organic matter. Aggregate stability is measured by Image Quantification using a smartphone. The Soil Health Institute's standard operating procedure for this method can be found here.

To learn more about these recommended measurements of soil health, please see the Soil Health Institute's Soil Health Measurements Fact Sheet.

Please note: in Delta Institute's 2024 Michigan Soil Health Appraisal Pilot Program, the Project Team measured different soil health indicators than the three mentioned above to create "Soil Health Index" scores for each subject property. A Soil Health Index can be created using any number of soil health indicator values. Through our implementation, we found that simplifying the process and emphasizing the three above indicators met our soil health assessment needs and recommend this streamlined approach described in this document moving forward.

Can Farmers Build Soil Health?

Soil Health Management Systems (SHMS), also known as "soil conservation practices", are on-farm strategies that farmers can use to improve their soil health. Soil health may be restored to farmlands by reducing soil disturbance, promoting thriving and diverse soil biota, keeping living roots in the soil year-round and ensuring the soil is covered year-round. Research suggests that farmland managed using these strategies may have greater soil health (as measured by soil health indicators) than conventionally managed land (Kibblewhite et al., 2018).

To improve soil health on farmland, the USDA Natural Resource Conservation Service recommends the following four soil health management principles (Figure 2):

1. Maximize Presence of Living Roots
2. Minimize Disturbance
3. Maximize Soil Cover
4. Maximize Biodiversity

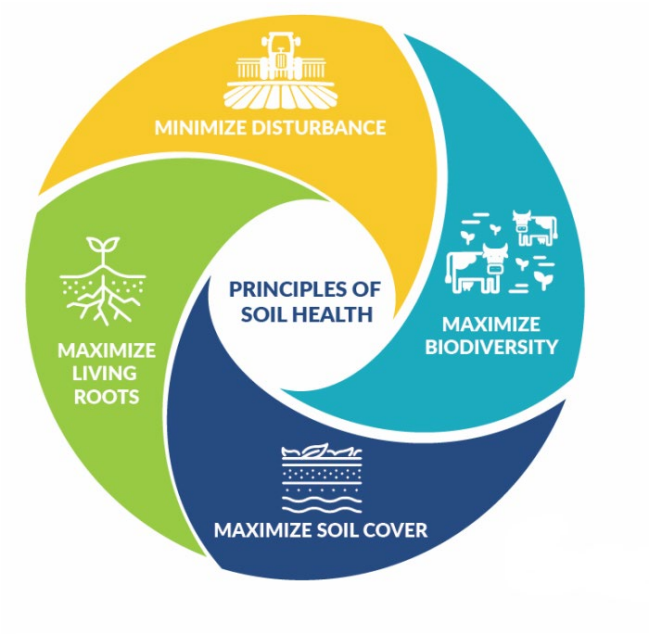

Figure 2: Principles of Soil Health. Source: https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health

To be sure, management strategies differ across cropping systems, soil types and climates – there is no "one size fits all" approach. For example, cropping systems in southeastern Michigan like corn and soybeans are managed differently than cotton in the South or nut tree orchards in California due to different tillage requirements and amount of living cover. While a subject property's soil health will ultimately be measured by its "Soil Health Index" score, appraisers should be familiar with the practices farmers adopt to build soil health and their associated costs and benefits. The conceptual framework for the modified appraisal approach described herein is built upon the logic of the Sales Comparison Approach – in that if building soil health does not provide returns on investment to the landowner or that no investment is required for farmers to build healthier soil, then there would be no value in buying land that already has these characteristics.

In the standard Sales Comparison Approach, appraisers identify 5-10 comparable properties sold in the vicinity and determine the value of the land based on those sales. Adjustments can be made by looking at pairs of properties to estimate the value of improvements or features of the property (e.g., dwelling, grain bin, tile drainage). This cyclical process creates an average of land values in the area. Currently, improvements typically considered are structural in nature. However, the modified approach described in this document will allow appraisers to create a database of comparable parcels and adjustments based on soil improvements related to conservation focused management. In doing so, appraisers can capture the increased value of the land resulting from sustainable management.

Indeed, recent partial budget analyses of Michigan corn and soybean farmers, which assessed changes in expenses and revenue associated with adopting a soil conservation practice (e.g., cover crops or no-till), have shown significant returns on investment from adopting soil conservation practices (Soil Health Institute, 2019; Soil Health Institute, 2021). The Figure below shows the results of one such study of Michigan corn and soybean farmers who reported, on average, net farm incomes increased by $24.74/acre for corn and $38.38/acre for soybean operations after adopting soil conservation practices (Figure 3).

	CORN		SOYBEAN	
	Benefits	Costs	Benefits	Costs
Expense Category	**Reduced Expense**	**Additional Expense**	**Reduced Expense**	**Additional Expense**
Seed	0.00	17.60	0.00	16.80
Fertilizer & Amendments	31.69	0.00	17.60	0.00
Pesticides	7.44	5.92	10.80	8.10
Fuel & Electricity	5.25	2.31	5.37	1.86
Labor & Services	11.72	10.06	11.67	9.75
Post-harvest Expenses	1.58	1.04	0.00	0.58
Equipment Ownership	22.57	13.54	23.36	11.33
Total Expense Change	**80.25**	**50.47**	**68.80**	**48.42**
	Additional Revenue	**Reduced Revenue**	**Additional Revenue**	**Reduced Revenue**
Yield, bu.	2.30	3.50	1.80	0.00
Price Received[2], $/bu.	4.20	4.20	10.00	10.00
Revenue Change	**9.66**	**14.70**	**18.00**	**0.00**
	Total Benefits	**Total Costs**	**Total Benefits**	**Total Costs**
Total Change	89.91	65.17	86.80	48.42
Change in Net Farm Income	**24.74**		**38.38**	

Figure 3: Partial budget analysis of 10 Michigan Corn and Soybean operations assessing changes in expenses and revenue associated with adopting a soil conservation practice. Source: Soil Health Institute. (2021). Economics of Soil Health Systems in Michigan. https://soilhealthinstitute.org/app/uploads/2022/01/Economics-of-Soil-Health-Michigan-04-27-2-Final.pdf

Soil Health Takeaways for Appraisers

To confidently utilize the modified approach described in this document, it is important for appraisers to recognize first that soil health is more than just yield. Second, landowners and farm managers can build their soil health by adopting Soil Health Management Systems (SHMS) such as cover crops or no-till. Third, investing in building soil health by adopting SHMS, while costly and time intensive, makes farming operations more profitable and resilient to erosion, droughts, and floods.

The soil health of a subject property can be easily and cost-efficiently measured using three soil health indicators:

1. Soil organic carbon concentration,
2. Potentially mineralizable carbon, and,
3. Aggregate stability.

By measuring these three indicators, the soil health of subject properties may be monitored over time and compared among their peers. Given that building soil health has been shown to make Michigan corn and soybean farms more profitable and requires some amount of investment

(e.g., time and costs of implementing SHMS), it follows that appraisers may opt to make valuation adjustments to Michigan farms with higher soil health using the Sales Comparison Approach. The sections that follow provide a step-by-step process for appraisers to incorporate measurements of soil health into the Sales Comparison Approach and factor soil health as a metric in the final valuation of a subject property.

MODIFIED APPROACH TO FACTOR SOIL HEALTH INTO MICHIGAN APPRAISALS

Step 1: Collect Foundational Metrics

Property Information

The first step of the modified appraisal approach is to define the extent to which the subject property is identified, including: the property's street address; legal description; plat of survey; deed plot survey; plat book; aerial map; soils map and soils analysis (Figure 4); county aerial map; deed; title commitment; assessor's parcel identification number (PIN #); County / Township zoning map; and Michigan real estate transfer declaration.

It is recommended to collect factual information regarding each subject property from a service such as Surety/AgriData Mapping, local County records, public courthouses, and interviews with the property owner and/or tenant.

Comparable Sales Data

Next, gather comparable sales data to provide an overview of economic trends in the market area. This data should be analyzed in a consistent format and stored in a Uniform Agricultural Appraisal Report (UAAR) to allow for the sales information to then be incorporated into the appraisal process.

Comparable sales data may be gathered via attendance at in-person and virtual public auctions, the county's equalization department, published data from the USDA National Agriculture Statistics Services (NASS) (USDA National Agriculture Statistics Services, 2022), as well as conversations with loan officers, appraisers, and other real estate professionals. Where possible, the appraiser should verify data via transfer documents filed at the county courthouse and conversations with buyer, seller, or knowledgeable parties close to the transaction with access to transfer records and a perspective on motivations of the parties, such as a sales agent, broker, or escrow agent. Sales should be selected for their reasonableness in representing a sound basis for value conclusions.

Cash rent data should also be collected from both the subject farms and the comparable sales data to determine what impact soil ratings may have on income levels. Cash rents offer a heuristic for net farm income and are valuable to collect as this eliminates the possibility of having management and/or marketing practices influence the profitability of a particular farm operation.

Agricultural production, or yield, data may be gathered during interviews with the property owners or tenants during soil and land management history data collection. However, with recently sold properties, there is no guarantee that the previous owners or tenants will be willing to share yield data. Yield data is dependent upon the accuracy of a yield monitor, harvest records, and is not typically marketed in the advertisement of a property.

A soils and topography map should be included in the analysis of each comparable sale to provide an indication of the National Commodity Crop Productivity Index (NCCPI) rating for each subject property.

Market Trends / Economic Indicators

Once comparable sales data has been collected, sales data should then be analyzed to determine the contributory value of different land classes (e.g., tillable cropland, irrigated cropland, woodlands) and a resulting price per acre, price per NCCPI rating point and if possible, land management practices. Qualitative factors (e.g., drainage and utility) may be included in the analysis at the discretion of the appraiser. By conducting this market survey, the appraiser will be able to identify regional and neighborhood market transactions that may quantify a market response to the subject property.

Social, economic, governmental, and environmental forces influencing land values in the market area may also surface and may be analyzed at the discretion of the appraiser. It is recommended that local market conditions be discussed with realtors, grantees and/or grantors and other knowledgeable individuals. Further insights into local market trends may be inferred using public tools/resources such as USDA NASS, AcreValue, the Michigan Department of Natural Resources, or MI Farm Link.

Step 2: Collect Soil Health & Land Management History Data

Lean on Local Networks.

Consider connecting with your local Soil and Water Conservation District office to identify area farmers that have adopted soil conservation practices or may be interested in learning about the health of their soil.

The next step of the modified appraisal approach is to collect soil samples from the subject property and land management history data from farm owner/tenant. Soil health data will be analyzed to observe trends specific to the three soil health indicators (soil organic carbon concentration, potentially mineralizable carbon, and aggregate stability). A ranking system will be created to allow for comparisons among “peers”. Land management history data collected via farm owner/tenant interviews, while not required as a part of this modified approach, may be useful for qualitative bracketing in the Sales Comparison Approach.

Collecting soil samples for the three aforementioned indicators of soil health requires a different kind of preparation and a few extra steps than traditional soil testing. The subsequent sections of this protocol walk through this process in a brief manner to be relevant to Michigan appraisers. More detailed information can be found in Delta Institute’s Soil Testing Guide or Soil Health Institute’s Soil Health Sampling – Standard Operating Procedure.

Before You Sample

Planning activities prior to conducting soil health sampling can streamline the sampling process, align with your client's needs, and make future testing easier. Planning activities may vary depending on the appraisal scenario, but overall appraisers should consider the goals and constraints they have, choose testing sites and a testing lab, create a testing timeline and organize parcel information. The planning process for soil health testing can be an iterative process, as the insights from some steps inform others and may reveal additional considerations for testing. For example, an appraiser may have a list of testing sites in mind before collecting additional data about each site and learn that several of its parcels have multiple soil textures. As each distinct soil texture on a site should be tested separately, the appraiser may have to revisit its budget and testing capacity to see if these additional tests are possible and adjust its site list if necessary.

Consider Your Timing

It is important to consider your timeline for soil sampling. The Soil Health Institute recommends sampling in Spring, "prior to field activities at the beginning of the cropping cycle to minimize the chances that changes in soil measurements are impacted by field operations. For most row-crops in temperate climates, this preferred sample period is in spring prior to planting or preplant field operations (e.g., seedbed preparation, pre-plant fertilizer application, planting, etc.). A second preferred window is about 3 to 4 weeks after planting." (Soil Health Institute, 2024). If you collect samples during the growing season, be careful not to damage crops and be aware of recent fertilizer/pesticide applications. However, the testing window in the spring may be very narrow for collecting samples, waiting for results, and sharing with farmers and inclement weather may affect an appraisers ability to collect samples. In Spring, appraisers should plan on waiting several days up to three weeks for soil health test results, depending on the lab.

Fall testing, while most useful for soil fertility, can be used to help the landowner inform decision making for the upcoming spring growing season, allow for the application of treatments like lime that take several months to affect soil health, and potentially receive discounts on items like fertilizer. Labs are generally less busy in the fall, meaning there may be a quicker turnaround in results. Timing may also depend on organizational factors such as budget and staff bandwidth.

Build Parcel Profiles

Document Soil Types and Textures

Soil type and its physical, chemical and biological characteristics capture the inherent properties that influence soil health. One of the most foundational inherent soil characteristics to know for each parcel is surface soil texture. Soil textures vary and are determined by soil particle size, ranging from fine clays and silts to coarser sand. Soil texture affects other properties of soil like water retention. Because the National Commodity Crop Productivity Index (NCCPI) score on a parcel largely reflects the soil's inherent characteristics (and neglects the more dynamic soil properties that reflect soil health), it is recommended to do multiple soil health tests on parcels with different crops, management units and textures to capture this variation. Most labs will also ask for this information. Data is available through a web-based tool developed by the US Department of Agriculture - Natural Resource Conservation Service (USDA-NRCS) called Web Soil Survey.

Collect Land Management History

At the start of the soil sampling process, farm managers should compile data on the land and management systems they have implemented in prior years. Management practices, such as the tillage and crop rotations, capture current ways the parcel is taxed and restored, explaining differences in soil health results and may point to opportunities for improving soil health in the future.

Qualitative, local knowledge of parcels can also be helpful in informing soil testing decisions and later understanding test results. It is recommended to compile this information in a spreadsheet format, as it can clearly organize the data and be connected to spatial outputs. Land managers may already have much of this information on hand as part of other land management projects.

It is recommended to collect the following land management history data for up to 10 years, if possible, from the landowner or farm manager by asking them if they have implemented the following Soil Health Management Systems. If yes, please ask the landowner or farm manager to describe the practice and which years it was applied.

Take time for a conversation at the farm gate.

Your clients (e.g., landowner/ tenant farmers) can help you identify an adjacent site for reference sampling, provide insights into their management history, and set up a long-term partnership for future appraisals and soil health monitoring.

- Cover Crops: Unharvested grasses, legumes, and/or forbs planted for seasonal vegetative cover as part of the planned crop rotation. Cover crops protect soil from erosion and enhance plant-available nutrients in the soil.
- Vegetative Buffers: Planting areas along ditches, streams, and rivers with perennial vegetation, which act as a buffer to erosion and collect nutrient run-off from fields.
- No-Till/ Strip-Till: Growing crops without disturbing the soil with tillage. Plant residue remains on the soil surface year around.
- Reducing Soil Compaction: Includes reducing axle load and ensuring proper inflation and size of tires on farm vehicles. Inflating tires to the proper air pressure will reduce surface compaction, while reducing axle loads will reduce depth of compaction.
- Avoiding Winter Fertilizer Application: Application of fertilizer to frozen impermeable soils can increase the risk of manure nutrients and contaminants running off of fields during spring thaw.
- Crop Rotation: Growing a diverse number of crops in a planned sequence in order to increase and maintain soil organic matter and biodiversity in the soil.
- Integrated Pest Management: Managing pests by promoting the growth of healthy plants with strong defenses, while increasing stress on pests and enhancing the habitat for beneficial organisms.
- Incorporating long-living, woody plants such as trees, shrubs or perennial crops. May include crops which are low water users, high carbon crops and legumes. Keeping roots in the ground all-year long will protect soil from erosion and enhance the soil's water storage capacity.
- Livestock Integration: Inclusion of cows, horses, sheep, pigs, goats and/or chickens to graze

on crop residues, cover crops, rotational grazing of pasturelands, grazing in lieu of herbicide, and silvopasture. Proper management of livestock manure—while avoiding saturation—on soils enhances soil fertility and promotes beneficial soil organisms like arbuscular mycorrhizal fungi and N-fixing bacteria.

A printable Land Management History Data Collection Template is available in Appendix I.

Essential Soil Sampling Supplies & Equipment

Below is a recommended list of supplies to conduct soil health testing for this modified appraisal approach:

- GPS unit to document where samples were collected.
- Pen, field notebook, and hardboard clipboard for field notes.
- Soil sampling probe to collect ten, 6" bulk, composite samples
    - The probe will be used to collect samples for Organic C Concentration and Carbon Mineralization Potential.
- Resealable Plastic Bags (Gallon Sized) for storage of bulk, composite samples.
- Spade to collect Aggregate Stability samples from the site of probe sampling.
- Sieve to help identify soil aggregates (optional)
- 50mL centrifuge tubes for storage of soil aggregate samples
- Permanent marker to label both composite and soil aggregate samples
- Cooler for both bulk, composite and soil aggregate sample storage with cold ice packs
- Land Management History Data Collection Template (optional)

Lab Selection

Soil health testing labs offer different and specified services. Choosing a lab to work with depends on multiple criteria, including but not limited to cost, parameters tested, timing, and accessibility of results. This decision can be made by setting goals and identifying constraints early in the planning process. Many labs are willing to work with clients, both prior to testing (by providing sample reports and cost estimates) and afterward (by addressing any questions or concerns and providing data in a usable way). If your appraisal organization has an ongoing relationship with a lab, inquire about their soil health testing offerings. As labs use different procedures and test for different metrics, it is important to use the same lab and testing protocols if you or your appraisal organization plans to test over multiple years--hence why it is important to choose a lab that meets both current and future testing needs. Information on the specific labs and tests reviewed while writing this protocol is available in Appendix II.

When selecting a soil testing lab, it is recommended to ask the following questions:

- What soil health indicators, if any, do your facility test for?
- Does your facility interpret the results for clients?
- What is the average cost per test?
- What is the average turnaround time for results?

Soil Sampling Methodology

1. Site Selection: Subject Properties vs. Reference Sites

If possible, the appraiser should collect soil samples from both the subject property (Figure 5) and from an adjacent "**reference site**" (Figure 6). Ideally, the reference sites are paired with each farm site, but this is dependent on the availability and location of available reference sites. Reference sites must have the same underlying soils as the subject property and have not been farmed for at least 10 years. A reference site can be a nearby fence row, idle field, or yard. In other words, one sample from long-term idle land should be taken for comparison to the farmed fields.

Because the reference site has not been disturbed for several years, it is assumed to have higher soil health than a worked field. Therefore, the reference site provides a "highest possible soil health" benchmark against the subject property.

Once the subject property and reference site have been selected, a field representing the average conditions for the farm should be identified. When selecting locations within a parcel to collect samples, it is good practice to sample in a consistent landscape position as different parts of a hillslope may have very different properties. It is also good practice to mark the location of your selected sites with GPS.

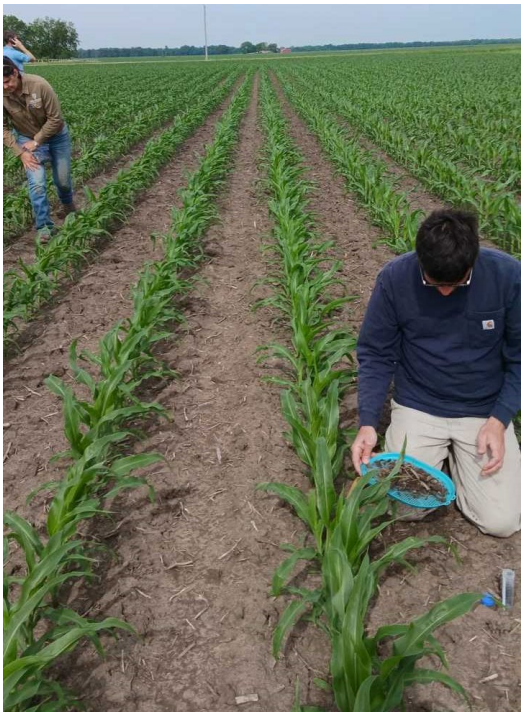

Figure 5: Soil sampling of a subject property. Source: Delta Institute

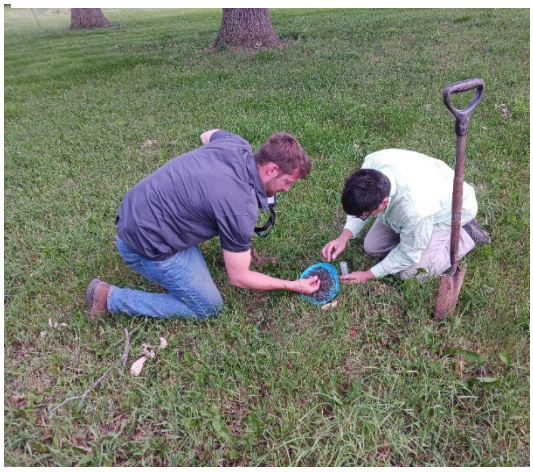

Figure 6: Soil sampling of a reference site – a grassed yard that has not been farmed in over 10 years that shares identical underlying soils as the subject property. Source: Delta Institute

2. Collect Soil Samples

Soil samples from both the subject property and reference site should be collected within 30 ft. of a GPS-marked location. As a reminder, the appraiser will be collecting soil samples to test for the three following soil health indicators:

- **Organic C Concentration:** Soil organic Carbon is an essential component of high–functioning soils, as it builds soil structure, thereby improving water and nutrient cycling and retention as well as sequestration of atmospheric carbon. Management that increases organic carbon content promotes greater soil structure, microbial activity, available water, and available nutrients. The Soil Health Institute's standard operating procedure for measuring Organic C concentration can be found here.

- **Carbon Mineralization Potential (Burst of CO2):** Soil nutrient cycling depends on a vibrant soil microbial community. Quantifying Carbon mineralization (e.g., the breakdown of organic matter by soil microbes) provides insight into the soil's microbial activity. This method measures the abundance of carbon dioxide (CO2) produced by soil microbes (metabolic activity/decomposition) following a 24-hour incubation period. The Soil Health Institute's standard operating procedure for this method can be found here.
- **Aggregate Stability:** Soil aggregates are formed through physical and chemical interactions between mineral particles and organic matter. Improved aggregation reduces erodibility, enhances water retention, and provides better habitat for microbes and larger soil organisms. Aggregates also play a role in carbon sequestration by physically protecting organic matter. Aggregate stability is measured by Image Quantification using a smartphone. The Soil Health Institute's standard operating procedure for this method can be found here.

More detailed information about these soil health indicators and how to interpret their values can be found in Delta Institute's Soil Testing Guide as well as the Soil Health Institute's Soil Health Measurements Fact Sheet.

Collect Organic C Concentration & Carbon Mineralization Potential

Soil testing labs only require bulk soil samples (e.g., loose soil in a plastic bag) to test for both their Organic C Concentration & Carbon Mineralization Potential. Therefore, in order to collect soil samples to test for these two indicators, follow these steps:

- Insert a standard soil probe to 6" depth randomly about the field (Figure 7).
- Release the 6" sample into a Resealable Plastic Bag (Gallon Sized). Be sure the Plastic Bag is labeled with the site ID and date (Figure 8).
- Repeat this process 10 times until you have 10, 6" samples in one Plastic Bag.
- Lightly shake or mix the 10 samples together so they become one composite sample to represent the soil of the subject property.
- Place the Plastic Bag in a cooler on ice.
- Repeat this process for the reference site.

Important Reminder - Both Organic C Concentration and Carbon Mineralization Potential samples are collected as composites of ten samples with a push probe at 0-6" depth.

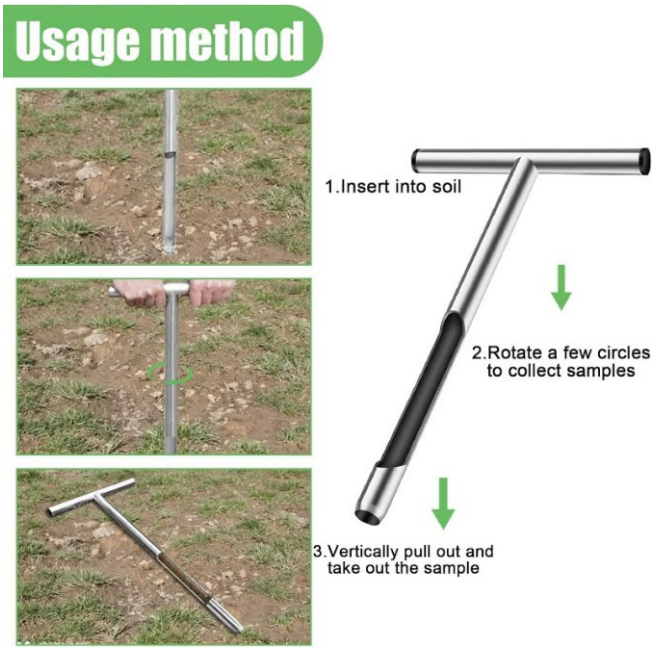

Figure 7: Soil probe usage method. Source: https://www.amazon.com/Sampler-Handle-Stainless-Sampling-Sample/dp/B0CQRGFJS9

Collect Aggregate Stability Samples

Next, collect soil samples for the third and final soil health indicator: Aggregate Stability. To do so, follow these steps:

- At the locations where the 10 bulk samples were collected using the push probe (as outlined in the previous step), insert a shovel or trowel, perpendicular to the ground, approximately 15 cm deep and pull back out.
    - Optional: pour the contents of the shovel or trowel over a sieve to separate the large soil aggregates from sand or silt (Figure 9).

Figure 9: Pea-sized soil aggregates selected for sampling. Source: Delta Institute.

- Collect Aggregate Stability samples by hand selecting pea-sized aggregates and gently placing them in 50mL conical tube until 1/3 of the tube is filled, taking care not to compress the aggregates.
- Label the 50mL conical tube with the site ID and date.
- Close the lid of the 50mL conical tube and be careful not to destroy the soil aggregates inside.
- Place the 50mL conical tube in the cooler with ice.
- Repeat this process for the reference site.

3. Select a Testing Lab and Ship Samples

Both bulk, composite soil and 50 mL conical tube samples should be kept on ice until they can be shipped to a soil testing lab. As mentioned in the "Preparation" section of this documents, when selecting a soil testing lab, it is crucial to verify that the lab measures the soil health indicators you are interested in before soliciting their services.

To better understand the landscape of soil health analysis capabilities among Midwestern testing facilities, Delta Institute surveyed 33 soil testing facilities across the greater Midwest in Fall 2024. Only 17 labs confirmed that they had testing capabilities for at least one of the above recommended soil health indicators (Figure 10).

The contact information and location of those 17 Midwestern soil testing facilities are available in Appendix I alongside each of the 17 labs' offered services, turnaround time, and price per sample.

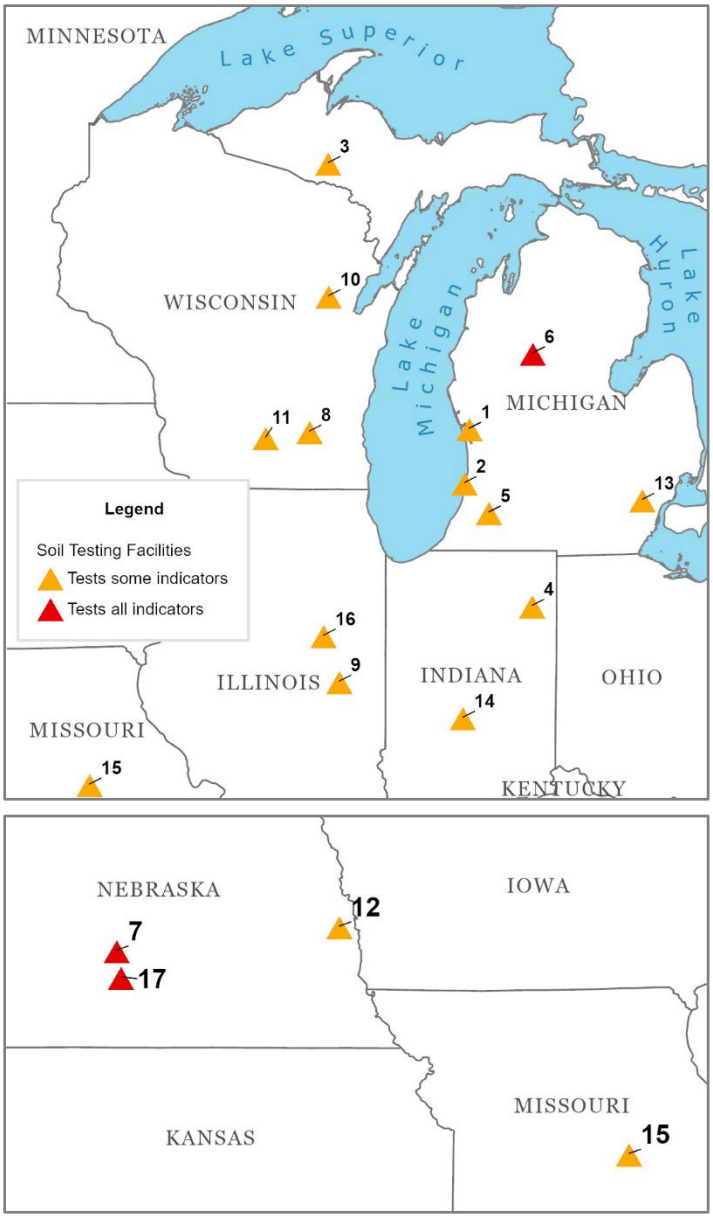

Figure 10: Surveyed Midwestern soil testing labs with confirmed capacity to measure at least one of the recommended 3 soil health indicators (Organic C Concentration, Mineralizable C Potential, and Aggregate Stability). Source: Delta Institute.

Step 3: Soil Health Index Creation

Using the results from the soil testing lab, merge the values of each of the soil health indicators to create a Soil Health Index score for each subject property. To do so, divide each subject property's soil health indicator value by the reference site's value. Then, average the subject property's values to reach a final index score between 0 and 1. The subject property's final Soil Health Index score demonstrates the subject property's relative soil health to the reference site (assumed to be the highest soil health in the area) and its peers. Therefore, in comparison to the subject properties, the reference site will always have a Soil Health Index score of 1.

The Table below demonstrates how to create a Soil Health Index score for three properties. From this, we can infer that Subject 1 has the highest Soil Health Index score of its peers.

It is recommended that the appraiser include these metrics on the appraisal report either as an addendum or in the methodology section. For example, include a "Soils Map;" "Soils Analysis;" & "Soil Health Summary".

Table 1: The soil health indicator values of three subject properties being averaged against one reference site to create each property's "soil health index" score.

Property ID	Organic Carbon	% of Reference Value	Carbon Mineralization Potential	% of Reference Value	Aggregate Stability	% of Reference Value	Average of 3 Indicators	Soil Health Index (0:1)
Subject 1	2.25	56%	31.52	64%	0.34	72%	64%	0.64
Subject 2	1.66	42%	33.6	68%	0.28	60%	57%	0.57
Subject 3	1.69	43%	26.92	54%	0.3	64%	54%	0.54
Reference	3.98	N/A	49.52	N/A	0.47	N/A	N/A	1.0

Step 4: Analyze Subject Cohort

After creating a soil health index score for each subject property, the appraiser should utilize the following steps of the Sales Comparison Approach:

- Determine the parcel's price per acre based on the typical price/average rental rate within the applicable land class (productivity range), gross and net income, tax liability, local and general market conditions and capitalization rate.
- Adjust the sales price per acre according to comparable sales and additional factors such drainage conditions, existing or needed improvements and existing conservation practices. It is recommended to use property owner interviews for qualitative bracketing.
- Rank soil health of each property among its peers as the ratio of each property's measured value to its paired reference site (or to the mean of the reference sites when obtaining paired sites for each farm is not feasible).
- Analyze subject cohort and observe any trends specific to Organic C Concentration, Carbon Mineralization Potential, and Aggregate Stability.

- The association between assessed value ($/acre) and soil health can then be assessed by regression analysis, non-parametric statistics, or other statistical methods depending on the nature of the dataset.

Step 5: Final Valuation

The final value estimate involves the exercise of judgment, not simply applying qualitative or quantitative techniques. An appraisal produces a meaningful, defensible value estimate by fulfilling three important criteria - appropriateness, accuracy, and quantity of evidence. The independent approaches to value are market derived and provide a range of value for the subject property. This methodology to incorporate soil health into the valuation process recommends use of the Sales Comparison Approach in determining the final value opinion.

Therefore, the final step of this modified approach is the reconciliation or correlation of the value indications. To do so, the appraiser should first compare both the individual soil health indicator values and soil health index scores of recently sold farms to traditional appraisal metrics (e.g., Cropland Class, $/Acre, $/NCCPI Point, and $/Tillable Acre.) If conclusive market data exists to suggest that a farm's soil health impacts the value of that property, incorporate the soil health metrics specific to the subject and form an opinion as to how these ultimately influence value.

CONCLUSIONS

Soil health is measurable, comparable among parcels, and farmers may build soil health by adopting soil conservation practices. Appraisers can measure and monitor the soil health of their clients' fields by collecting soil and land management history data. In doing so, appraisers may create and incorporate a simple "soil health index" into the valuation approaches. The soil health index scores of a cohort of properties may be compared and analyzed using the Sales Comparison Approach. If conclusive market data exists to suggest that a farm's soil health impacts the value of that property, incorporate the soil health metrics specific to the subject and form an opinion as to how these ultimately influence property value.

An appraisal produces a meaningful, defensible value estimate by fulfilling three important criteria - appropriateness, accuracy, and quantity of evidence. The independent approaches to value are market derived and provide a range of value for the subject property. The final value estimate involves the exercise of judgment by appraisers, not simply applying qualitative or quantitative techniques. Integration of a novel soil health index into the advertisement of agricultural properties that are available for sale and further education of auctioneers, brokers, buyers, and other market participants of agricultural real estate will be necessary to monitor and capture soil health's influence on market value.

The agricultural real estate market is becoming more quality oriented with growing interest in soil health. Therefore, appraisers may advance this modified approach by helping buyers and sellers recognize the economic benefits of healthy soils. Additionally, integration of soil health metrics into the advertisement of agricultural properties that are available for sale and further education of auctioneers brokers, buyers, and other market participants of agricultural real estate will be necessary to monitor and capture soil health's influence on market value.

REFERENCES

American Farmland Trust. (2019). Soil Health Case Study: Thorndyke Farms, IL. https://farmlandinfo.org/wp-content/uploads/sites/2/2024/05/thorndyke-farms-soil-health-case-study.pdf

American Farmland Trust. (2020). Soil Health Case Study: Ifft Yorkshire Farms, IL. https://farmlandinfo.org/wp-content/uploads/sites/2/2024/05/ifft-yorkshire-farm-soil-health-case-study.pdf

Soil Health Institute. (2019). Economics of Soil Health Systems: Stony Creek-River Raisin Watersheds of Michigan. https://soilhealthinstitute.org/app/uploads/2023/06/SHINACDNRCS_factsheet_Farm21.pdf

Soil Health Institute. (2021). Economics of Soil Health Systems in Michigan. https://soilhealthinstitute.org/app/uploads/2022/01/Economics-of-Soil-Health-Michigan-04-27-2-Final.pdf

Soil Health Institute. (2021). Economics of Soil Health Systems on 100 Farms. https://soilhealthinstitute.org/app/uploads/2022/01/100-Farm-Fact-Sheet_9-23-2021.pdf

Soil Health Institute. (2022). Soil Health Measurements Fact Sheet. https://soilhealthinstitute.org/app/uploads/2022/10/SHI_SoilHealthMeasurements_factsheet.pdf

Stewart, R.D., J. Jian, A.J. Gyawali, W.E. Thomason, B.D. Badgley, M.S. Reiter, and M.S. Strickland. (2018). What We Talk about When We Talk about Soil Health. Agricultural and Environmental Letters. 3(1). https://doi.org/10.2134/ael2018.06.0033

USDA NRCS. (n.d.). What is Soil Health? https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health

USDA NASS. (n.d.). Charts and Maps – Land Values. https://www.nass.usda.gov/Charts_and_Maps/Land_Values/index.php

Soil Health Institute. (2024). Soil Health Sampling – Standard Operating Procedure. https://soilhealthinstitute.org/app/uploads/2023/05/SOP_SoilSampling-v1.2.pdf

USDA NRCS. (n.d.). Web Soil Survey. https://websoilsurvey.nrcs.usda.gov/app/

APPENDIX I: SURVEYED MIDWESTERN SOIL TESTING FACILITIES

Key agricultural real estate market participants (e.g., agricultural banks, lenders, buyers and sellers) may be hesitant to adopt a Soil Health Index if testing is not easily accessible or reliable. To better understand the landscape of soil health analysis capabilities among testing facilities, Delta Institute surveyed 33 soil testing facilities across the greater Midwest in Fall 2024.

Only 17 labs confirmed that they had testing capabilities for at least one of the above recommended soil health indicators (Table 2). This represents a major barrier to the widespread adoption of a standardized methodology to create a Soil Health Index as appraisers may struggle to find labs that offer comprehensive soil health testing, leading to inconsistent or incomplete assessments. Limited availability often drives up testing costs, making routine soil health monitoring for appraisal purposes financially burdensome. Without widespread lab capabilities, different regions may rely on varying methods, preventing the creation of a uniform Soil Health Index. Finally, a lack of standardized testing infrastructure can result in inconsistent or incompatible data, weakening the credibility and usefulness of the Soil Health Index for decision-making. This may be also problematic for appraisers looking to obtain soil health measurements quickly, as they may have to sort through pages of facilities to find one that can offer acceptable services.

In addition to the time taken to search for an applicable facility, pricing for these soil testing services varies widely. Survey results showed that tests can range from $18 to $150 per sample depending on the lab. To further complicate matters, some testing facilities charge clients by the sample, others will charge for bulk measurements, and some do not advertise their pricing at all.

We also found that the turnaround times can range from 1-3 days to 3 weeks depending on the lab. This may make testing more difficult for appraisers as the timeline for testing and analysis may not align with appraisal timelines. Testing soil health indicators is ideally performed in Spring – creating a small window of opportunity for appraisers and farmers.

Finally, less than half of labs surveyed confirmed that they provide an interpretation of results. If farmers or appraisers receive raw soil health data without guidance on how to apply or interpret it, the results are less actionable. Clients unfamiliar with soil science may struggle to understand this often-complex data, discouraging them from using soil health testing altogether. Additionally, without expert interpretation, users might overlook key soil health issues or misapply management strategies, reducing the effectiveness of conservation and improvement efforts.

Table 2: Surveyed Midwestern Soil Testing Facilities with Confirmed Soil Health Indicator Testing Capabilities.

#	Facility Name	Address/Contact	Test Organic Carbon?	Test Carbon Mineralization?	Test Aggregate Stability?	Interpret Results?	Average turnaround time?	Average cost
1	Trace Analytical Laboratories, Inc.	2241 Black Creek Rd., Muskegon, MI 49444 800-733-5998	Yes	Yes	Unknown	No	Standard 10 business days, rushes available	Unknown
2	NEWAGE Laboratories	160 Veterans Blvd., South Haven, MI 49090 (269) 637-5658	Yes	Yes	Unknown	No	3-5 days, depending on time of year	Unknown
3	White Water Associates, Inc.	429 River Lane, Amasa, MI 49903 (906) 822-7889; bette.premo@white-water-associates.com	Yes	No	Yes	Yes	10-15 business days	$60
4	A&L Great Lakes Laboratories	3505 Conestoga Dr., Fort Wayne, IN 46808 (260) 483-4759; lab@algreatlakes.com	Yes	No	No	No	Unknown	$30
5	Crop Services International	29246 Lake St., Marcellus, MI 49067 (800) 260-7933; team@cropservicesintl.com	Yes	Yes	No	Yes	7-10 days	Avg. $60
6	Morgan Composting, Inc.	4353 US 10, Sears, MI 49679 (231) 734-2451; theo@dairydoo.com	Yes	Yes	Yes	Unknown	7-14 days, depending on time of year	$40
7	Regen Ag Lab	31740 Hwy 10, Pleasanton, NE 68866 (308) 627-0065 ; customerservice@regenaglab.com	Yes	Yes	Yes	Yes	3-5 days, depending on time of year	Avg $55
8	Rock River Labs	710 Commerce Dr., Watertown, WI 53094 (920) 261-0446; office@rockriverlab.com	Yes	No	No	No	5-7 days	$10 per sample
9	Agricultural Soil Management	2106 County Road 1000, East Champaign, IL 61822 (217) 356-5756; abean@asmlabs.net	Yes	Yes	Unknown	No	2-3 weeks	$30-$150
10	AgSource Cooperative Services	106 North Cecil St., Bonduel, WI 54107 (715) 758-2178; bonduel@agsource.com	Yes	Yes	No	Unknown	Unknown	Unknown

11	UW-Madison Soil and Forage Lab	4702 University Ave., Madison, WI 53705 (608) 262-4364; soil-lab@mailplus.wisc.edu	Yes	No	No	Unknown	Unknown	Unknown
12	Midwest Labs	13611 B St., Omaha, NE 68144 (402) 334-7770; contactus@midwestlabs.com	Yes	Yes	No	Yes	3-5 business days	$ 55 - $65 per sample
13	Paragon Laboratories, Inc.	12649 Richfield Ct., Livonia, MI 48150 (734) 462-3900; richm@paragonlaboratories.com	No	No	No	No	5 business days	Varies
14	Sure-Tech Labs	7501 Miles Dr., Indianapolis, IN 46231 (317) 243-1502; jmjaynes@landolakes.com	Yes	No	No	Yes	Unknown	$13.75 per sample
15	U of Missouri Soil and Plant Testing Laboratory	1100 University Ave., Columbia, MO 65211 (573) 882-0623; soiltestingservices@missouri.edu	Yes	No	No	Unknown	Unknown	$18 per sample
16	United Soils Inc	108 South Crystal Ln., Fairbury, IL 61739 (815) 692-2626; info@unitedsoilsinc.com	Yes	Unknown	No	Yes	Unknown	$27.83 per sample
17	Ward Laboratories	4007 Cherry Ave., Kearney, NE 68847 (308) 234-2418; customerservice@wardlab.com	Yes	Yes	Yes	Yes	1-3 business days	$81.71 per sample