Integrating soil health into land valuation in Southeast Michigan: Final Report

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Executive Summary:

This report summarizes work completed by Michigan State University (MSU) that has ongoing funding from the Erb Foundation, through a subcontract with the Delta Institute. This sub-contract funds research and outreach aimed at understanding the role that soil health plays in the appraisal and valuation of agricultural land currently and the ways in which this role may expand in the future. Work commenced on this project in February 2021.

General Landscape of Michigan Farmland Soil Health

Michigan contains a wide variety of soil types, reflecting the diverse geography of the state. The National Commodity Crop Productivity Index (NCCPI) was developed by the United States Department of Agriculture (USDA) to classify locations by the productivity of their soils. The average NCCPI of Michigan farmland is 41. This average masks considerable variation across the state, with parts of the eastern Thumb region seeing values above 0.8 and much of the northern Lower Peninsula and Upper Peninsula with values close to 0.

Although some factors driving soil quality do not vary much over time, soil health can be improved over time through careful management. Adopting soil health practices can improve the physical, biological, and chemical characteristics of the soil (Kibblewhite et. al, 2018). The types of practices that may contribute to soil health are numerous and strategies that are effective for some crops and regions may be less effective for others. However, the USDA highlights four core principles of soil health: maximize presence of living roots, minimize disturbance, maximize cover, maximize biodiversity. Given these principles, practices such as planting cover crops, reducing tillage, and increasing crop rotation diversity can be considered to be soil health practices in most contexts. This report will survey recent trends in these practices.

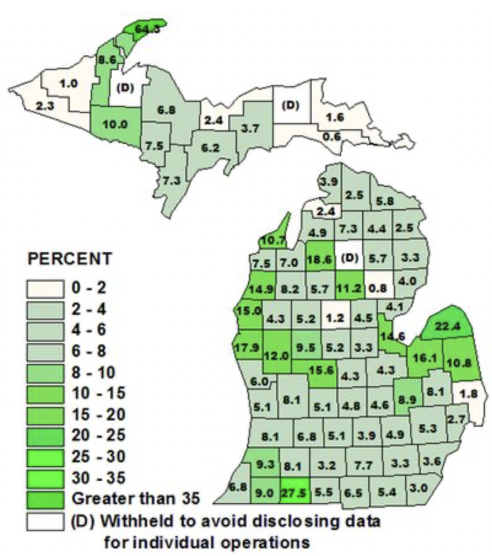
The share of US agricultural land that is cover cropped has increased over the past decade. According to the 2017 Census of Agriculture, cropland planted to a cover crop excluding land enrolled in the Conservation Reserve Program (CRP) was 15.4 million acres which demonstrated 5.1% of adoption rate. This is an increase of about 50% from 2012 when cropland with a cover crop was 10.3 million acres with the adoption rate of 3.4% (Wallender et al. 2021). Below table describes areas of cropland with a cover crop in 2012 and 2017 in Midwest states. In Michigan, farmers reported planting 0.67 million acres of cover crops in 2017, an increase of 54% from 2012. Among other states, Iowa and Illinois showed the highest growth rates of 156% and 122%, respectively in cover crop lands. On the other hand, the growth rate in Wisconsin was calculated only to be around 11%.

Table 1: Cropland Planted to a Cover Crop excluding CRP in Midwest

States	2017	2012	Change
	Acres		%
Michigan	673,205	437,200	54
Illinois	708,105	318,636	122
Indiana	936,118	596,062	57
Iowa	973,112	379,614	156
Wisconsin	611,231	553,005	11
US	15,390,674	10,280,793	50

Source: USDA. National Agricultural Statistics Service. April 2019.

Below Figure 1 displays the adoption rate of cover crops as a percent of agricultural land by county in Michigan. We can see that the adoption rates in counties in the Thumb part of the state stand out. Also, the southwest region and the central region show some higher adoption rates compared to other regions.



Source: Baas. April 2019.

Figure 1: Cover Crops as a Percent of Agricultural Land by County in Michigan

The Environmental Quality Incentives Program (EQIP) offered by USDA Natural Resources Conservation Service (NRCS) assists farmers to address natural resource concerns and delivers environmental benefits by implementing conservation practices with technical and financial support. NRCS offers about 200 unique practices for farmers, ranchers, and forest landowners (USDA NRCS 2020).

Table 2, shown below, represents total acres on active and completed EQIP contracts. In 2020, among Midwest states contiguous to Michigan, we find comparable total acres in Michigan, Indiana, and Wisconsin where they amount to around 150,000 acres. On the other hand, the area under EQIP contracts in Illinois falls below the numbers in comparing states.

Table 2: Total Acres on Active and Completed EQIP Contracts

State	2016	2017	2018	2019	2020
	Acre				
Michigan	111,644	86,750	89,895	304,695	156,085
Wisconsin	113,245	108,262	142,323	178,678	153,097
Illinois	25,563	31,033	40,990	44,322	41,238
Indiana	124,132	172,272	135,509	227,996	146,607
Ohio	80,827	94,358	154,139	183,572	115,834
US	10,578,295	11,639,193	16,664,093	12,911,989	10,517,713

Source: EQIP data page.

The following Table 3 shows conservation practices related to “Cropland Soil Health & Sustainability” category, which includes conservation crop rotation, cover crop, mulch till, and no till / strip till / direct seed. Across the U.S. in 2020, we find that each cover crop practice and no-till / strip till / direct seed practice accounts for 43.2% and 31.3%, respectively. Acres under conservation crop rotation and mulch till practice are around 70,000 acres.

Table 3: Land Unit Acres under Conservation Practices related to Cropland Soil Health & Sustainability

Practice	2016	2017	2018	2019	2020
	Acre				
Conservation Crop Rotation	79,227	89,591	96,660	60,791	70,121
Cover Crop	128,827	163,673	205,450	187,801	236,304
Mulch Till	40,804	47,876	66,571	62,175	69,667
No-Till / Strip Till / Direct Seed	98,930	112,906	148,600	126,171	171,459

Source: EQIP data page.

Soil Health as a Missing Market

The value of agricultural land depends on how much value the market expects the land to generate in the future. This can be estimated by the sum of present values of all future cash flows. The future cash flows depend on diverse factors including agricultural sales, input costs, and agricultural subsidies. We focus on the role of soil health that might play in these cash flows and how this may affect farmland valuation.

Soil productivity or fertility can be defined as a capacity of a soil to support agricultural yield. While the soil productivity is centered on agricultural production, the concept of soil health focuses on its function as a vital ecosystem that supports plants, animals, and humans (Bowman et al., 2016). Despite this distinction, the concepts are linked, with improved soil health contributing to both improved production and decreased input requirements over time (Stevens, 2019).

As the definition of soil health is rather abstract, it is more intuitive to see what indices represent the soil health. Table 4 lists the indices and divides them into three categories. While some of the factors might take longer time to make a change, it is a dynamic process that farmers can affect the levels of these elements through different farm practices such as cover cropping and reduced tillage. It has been tried to explain soil health with one single index by researchers, but it is limited in the sense that it can oversimplify the diverse elements of soil health.

Table 4: Conceptual Framework of Defining Soil Health

Category	Element
Physical	Aggregate stability
	Soil compaction
	Available water capacity
Biological	Organic matter
	Carbon content
	Nitrogen cycle
	Microbial ecosystem
Chemical	Soil pH
	Nitrogen, Phosphorus, and Potassium levels
	Electrical conductivity, salinity

Source: Stevens (2018).

The benefits of soil health can be categorized into two groups; private and social. Stevens (2018) summarizes different benefits of healthy soil as shown in Table 5. Our work focuses on the relationship between these benefits and land valuation. For there to be any connection between them, benefits from healthy soil need to have an effect on future cash flows. For instance, having healthier soil may reduce fertilizer expenditure and boost yields, and this can have a positive impact on land valuation through increased expected future net cash inflows. Assuming that social benefits are not traded in the market, we narrow down our focus on private benefits that can increase the net cash flows.

Table 5: Benefits of Healthy Soil

Category	Ecological/Environmental	Agronomic
Private	Erosion control	Increased yields
	Local biodiversity	Pest control
	Natural beauty	Reduced fertilizer expenditure
	Flood control	Less necessary irrigation
External	Erosion control	Lower risk of pest outbreaks
	Cleaner water	Lower risk of disease outbreaks
	Flood control	Fewer unwanted nitrates runoff
	Carbon sequestration	-

Source: Stevens (2018).

While it is established in theory that soil health can affect land valuation through the private benefits listed above, soil health does not seem to play much role in actual valuation and transactions according to our interviews with appraisers in Michigan. Appraisals are typically made based on comparables that do not include any explicit soil health information.

This can be considered a missing market. A “missing market” occurs when there is an opportunity for a mutually beneficial trade, but no market exists to enable that trade. These barriers typically result from high transaction costs or limited information. In the case of the farmland market, a market for soil health does not seem to exist, meaning that healthier soil does not result in higher farmland valuation.

We believe that some prerequisites are needed for soil health elements to actually affect the land values. For one, it should be well agreed upon among key players in the farmland market including sellers, buyers, and appraisers that healthier soil leads to higher future cash flows. Additionally, it is important to have at least a general idea about the increase in cash flows and timing of those cash flows that result from healthier soil.

In order to have common knowledge regarding the health of a particular piece of land, soil tests would need to be widely available to provide information on soil health. Soil health is difficult to observe without testing and can differ by parcels and time. Hence, accurate testing would need to be available at relatively low costs in order to bridge the gap in information between buyers and sellers.

Lastly, for soil health to affect farmland values, it must be costly to build soil health. The costs can include time taken to enhance soil health, lower yields or profit loss in the short run, and additional costs to adopt different farm practices. If it is not costly for farmers to produce healthier soil, then there would be no value in buying land that already has these characteristics. Given the long time scales it can take to build soil biomass, this condition is easily met.

In the next section, we build on the idea of a missing soil health market through a more formalized model.

Conceptual Model

In this section, we establish a conceptual model connecting the land valuation and soil health. We characterize the value of farmland V as depending on on soil health H as shown in (1) where X represents other factors that can affect the valuation. The level of soil health is a function of expenditure E related to activities to improve soil health which include time and additional costs to adopt new practices.

$$V = f(H, X) \quad (1)$$

$$H = g(E) \quad (2)$$

Regarding the soil testing which fills the information gaps, we assume that the tests have some noises (ε) to accurately measure the true soil health as in (3) and the price to have a test equals P.

$$T = H + \varepsilon \quad (3)$$

From buyers' perspectives, if healthier soil does not affect farmland values ($\frac{\partial V}{\partial H}$ is small), soil health would not be considered in transactions and they would not ask for soil test results. If it does affect the farmland values, buyers would consider how much it costs to increase the level of soil health. If the marginal costs to improve soil health ($\frac{\partial H}{\partial E}$) is small, buyers would just buy the farmlands and improve soil health for themselves if necessary. In this case also, the market for soil health would be thin or may not even exist.

When both marginal effects of soil health and marginal costs to produce healthy soil are large enough, there exists some demand for healthy soil in the market. Since soil health is not observable, sellers need to get tests for their farmlands and share them. If the costs of testing (P) is too high so that the marginal benefits from getting a test and selling at higher prices is insignificant, sellers would forgo getting a test and let buyers guess the level of the soil health. In this scenario, the market for soil health collapses as it fails to remedy the information gap.

Another case where the information gap causes a problem is that the accuracy of tests is too low (ε is too large) to measure the true soil health, even when the costs to get a test is low enough. In this case, test results may be available, but buyers still have to make a guess about the true soil health.

When all these conditions are met, the soil health is traded in the market and farmland owners have market incentives to change their practices to enhance the soil health and to expect appreciation of their farmlands.

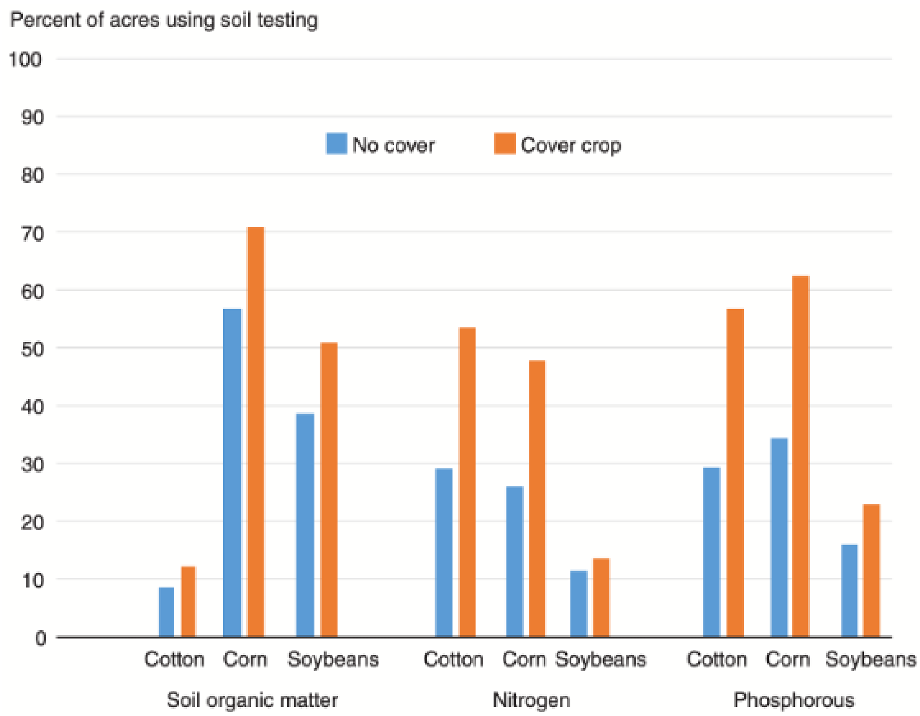
In conclusion, three conditions must be met for there to be a market for soil health in Michigan. These are: (1) soil health must increase future profits and individuals must be aware of the role soil health plays in profits, (2) soil health must be observable to market players through testing or other mechanisms, and (3) soil health must be costly to build. In the next section we will explore whether these conditions are currently being met in Michigan.

Practical Questions

The natural follow-up questions are whether these theoretical conditions are being met in actual markets. As shown, the size of effects of each element as well as the directions are crucial in that the incentives for farmers are large enough to engage in improving soil health of their parcels. For instance, how much productivity healthier soil can raise and how costly it is to build soil health in reality are important to know to derive the relationship between soil health and land value.

However, we do not have estimates for marginal effects of healthier soil on profits or the costs incurred to improve a unit of soil health. We expect that it is highly difficult to generalize the effects as they are to be affected by different sources such as weather, soil type, primary crops, and so on. On the other hand, soil testing is available in the market and can provide estimates of this information. Figure 2 shows the percentage of acres using soil testing according to Agricultural Resource Management Survey(ARMS) data. This indicates that the soil testing is widely available and farmers have a tendency to receive it depending on their farm practices and crops.

Figure 2: Use of Soil Testing



Source: Wallander et al. (2021).

The proportion of farmers performing soil testing may depend on different factors including crop types, types of soil testing, and farm practices like planting cover crops. According to ARMS data, depending on their main crop, the types of soil testing that farmers were more likely to have widely varied. For instance, corn and cotton farmers were prone to receive soil tests on Nitrogen and Phosphorus within two years comparably. On the other hand, soybean farmers' propensity to have soil testing on them was far lower than that of corn and cotton farmers.

Also, farm practices can affect farmers' inclination towards performing a soil test. In general, farmers who planted a fall cover crop tended to have performed a soil test more than other farmers. Corn farmers who planted a fall cover crop were 22% more likely than other corn farmers to have performed a soil test on Nitrogen within two years, 27% more likely to conduct a soil test on Phosphorus within two years, and 13% more likely to conduct a soil organic matter test within ten years. In the case of cotton, the differences in the tendency to have soil testing between cover crop and non cover crop fields were noticeable for both nitrogen and phosphorus by 25% and 27%, respectively. For soybean farmers, fields with cover crops tended to be tested more than others for soil organic matter by 13% and phosphorus by 7%.

One way to estimate the magnitude of $\frac{\partial V}{\partial H}$, the effect of soil health on land values, is to look at the market premium for enrolling land in programs that are generally associated with soil health. The 2021 Michigan Land Values survey asked respondents to report on the land value premium for land that is certified organic, transitional, or enrolled in the Michigan Agriculture Environmental Assurance Program (MAEAP). All of these certifications require practices that are typically associated with improved soil health, such as cover cropping, limited tilling, and crop rotation. Respondents were asked to report a “typical” premium value, as well as a “high” and “low” value. Table 6 shows median response values for the typical, high, and low premiums of each of these programs. The median is used (rather than the mean) as some responses reported unrealistically high outlier premium values.

While typical premium values of certified organic farmland is reported to be $25/acre, responses varied considerably. Most respondents reported no premium for transitional or MAEAP land. For the high premium category, the median response was $175/acre for organic, $150/acre for transitional, and $25/acre for MAEAP.

Table 6: Premium Values for Organic, Transitional, and MAEAP

Program	Typical Premium	High Premium	Low Premium
	$/acre	$/acre	$/acre
Organic	25	175	50
Transitional	0	150	0
MAEAP	0	25	0

An alternative method to learn about the role of soil health in land values is to directly ask stakeholders about the importance of various soil characteristics and soil health practices. As shown below in Table 7, across the state, topography factors including terrain and continuity of parcels and yield history were considered the most important factors to affect the farmland value. At the same time, tileage, crop rotation, and soil testing were also shown to be important factors. On the other hand, no-till practices were not identified as a crucial factor for farmland valuation.

Table 7: Importance of Agronomic Factors

Region	Tile-age	Irriga-tion	Soil		Topography		Production Practices			
			NRCS PI	Soil Testing	Terrain	Continuity	Cover Crop	No till	Crop Rotation	Yield History
	Average Score									
Michigan	3.7	3.0	3.1	3.4	3.8	4.1	3.3	2.9	3.6	3.9
District 1-4	4.1	2.4	2.6	3.9	4.3	4.5	3.5	3.0	3.8	3.5
District 5-6	3.3	2.6	3.1	3.4	3.7	4.2	3.5	2.9	3.6	3.8
District 7-9	3.9	3.6	3.2	3.3	3.7	3.9	3.0	2.8	3.5	4.0

Note1: Response scale was 1=not important, 2=somewhat unimportant, 3=neutral, 4=somewhat important, 5=very important.
Note2: NRCS PI indicates Productivity Index provided by the Natural Resources Conservation Service.
Note3: District indicates Agricultural Statistics Districts defined by USDA.

Appraisal process

Delta Institute and MSU conducted an interview with appraisers based in Michigan and agricultural extension experts at MSU on the general appraisal process and how soil quality is being incorporated in the current farmland appraisal process. Appraised value of farmland factors in a wide range of variables including productivity of the parcel, topography, location, proximity to a consumer market, comparable sales records, and so on. In this report, we focus on how farmland characteristics are reflected in the appraisal process.

First of all, productive soil types are valued higher in the market and to incorporate this productivity the NCCPI is commonly used in the appraisal process. When the NCCPI is considered to be outdated, local factors or judgment of regional appraisers can also be taken into account. In addition, soil composition and topography are considered crucial factors in the appraisal process.

On the other hand, except for certain cases, soil testing is hardly used in the appraisal process mainly for two reasons. For one, in most of the cases, the soil testing data is not available in the market and there does not exist much information to take into account. Furthermore, as there is not enough demand to reflect soil testing results from clients, appraisers generally do not feel a need to change the process to incorporate it.

For the other reason, even if soil testing results were at hand, appraisers believe that their impact on appraised value to be generally limited, which hinders the potential use of soil testing.

If soil testing is to be reflected in the appraisal process, it would most likely be due to the demand from institutional investors. Since they tend to lend their farmlands, they would be interested in soil quality information to ensure their renters are maintaining a certain level of soil health to retain the properties' value. Also, for specific cases, certain soil quality information may be demanded in farmland transactions. For instance, blueberry farms tend to care about the level of pH for its production and the soil testing on pH may be requested for potential transactions.

Conclusion

Surveying Michigan appraisers and other stakeholders, we explored the role that soil health measures play in current valuations. Despite the general interest in the role of soil health to enhance farmland values, soil health does not seem to play a major part in actual farmland transactions. As in our conceptual model, this limited role of soil health could be due to the limited effect of soil health on farmland's cash flows or a lack of availability of high quality soil testing.

The soil health of Michigan farmland is an important factor for the state's long-term agricultural productivity. This report has reviewed current efforts and trends in soil health practices that contribute to improved soil health. One potential mechanism to incentive soil health is to enable the farmland market to incorporate health into valuations. We outline a conceptual framework of how soil health may contribute to increased land values. Our framework demonstrates that for soil health to affect the market for land: (1) soil health must increase future profits and individuals must be aware of the role soil health plays in profits, (2) soil health must be observable to market players through testing or other mechanisms, and (3) soil health must be costly to build. Our partnership with Delta Institute has enabled us to bring these questions to data through our 2021 Michigan Land Values Survey and conversations with Michigan appraisers. Based on this investigation we believe that currently a lack of knowledge about the role of soil health in long-term profitability and limited information on soil health has prevented the emergence of soil health as a land valuation metric. Through increased understanding of the role of soil health in profitability and access to improved soil testing, we believe in the future we may see the role of soil health in farmland appraisal grow.

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