## Interpreting The Metric

# Soil Carbon

## Why It Matters

The importance of soil health cannot be emphasized enough. When a soil is healthy, it is able to fulfill the vital functions required of it by plants and other living organisms while staying resilient to climatic and environmental changes. The health of soil relies on the relationship between soil physical and chemical characteristics and the living organisms within the soil, and soil should be managed to protect and maintain these relationships. Part of building, improving, or maintaining these relationships is managing the soil's organic matter. Soil organic matter is made up of nutrient-rich, decomposing and/or weathered materials and is beneficial in soils because it:[1]

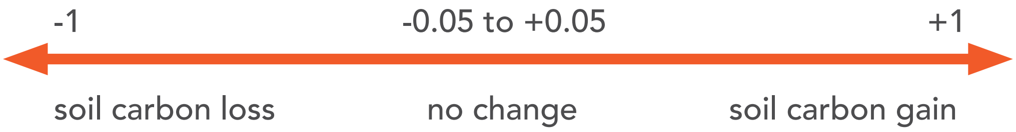
- Is a reservoir for plant nutrients that become gradually available over time, decreasing the amount of applied fertilizer needed to meet crop requirements. as a reservoir for plant nutrients that become gradually available over time, decreasing the amount of applied fertilizer needed to meet crop requirements;
- Stores water that is available to plant roots, reducing irrigation water requirements and improving resilience to drought; and
- Causes aggregates to form, thereby improving soil structure and water infiltration.

Soil organic matter also acts as a source and sink of carbon, and the amount of carbon in the soil is a good indicator of soil health. Investing in increasing soil carbon is a long-term investment in the productivity and ultimately, profitability of the land.

Carbon dioxide, a greenhouse gas, is removed from the atmosphere through photosynthesis and is sequestered in living organisms in the soil. By increasing the frequency that soils are covered with growing or decomposing plants and supporting the living microorganisms in soils, more carbon dioxide can be removed and sequestered from the atmosphere. Because plant and soil health support carbon removal, farmers play a crucial role in reducing greenhouse gases and reducing the impacts of climate change.

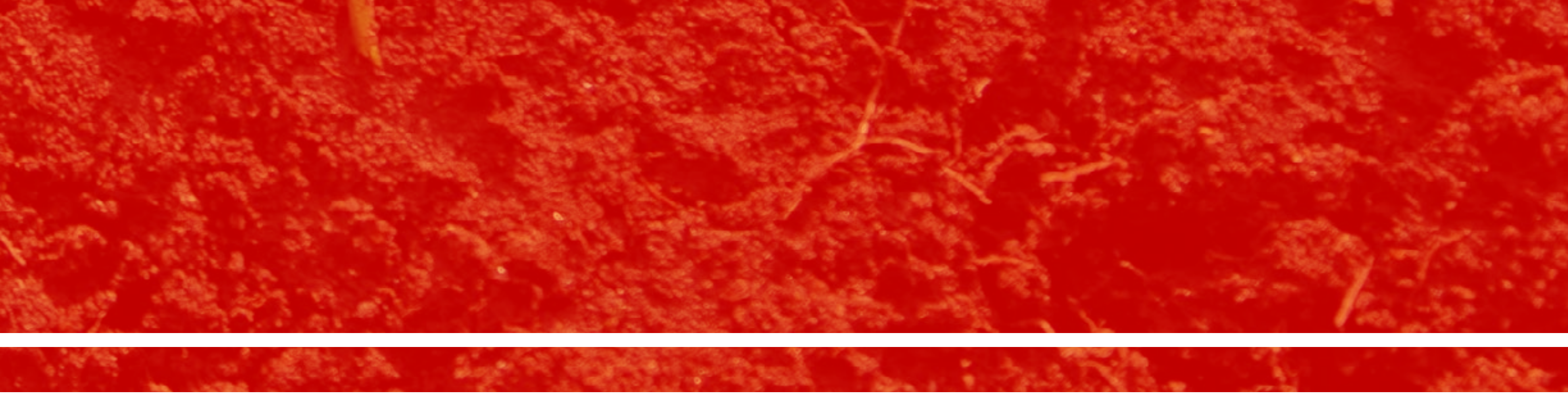
## How It Is Measured In The Fieldprint® Platform

The Soil Carbon metric in the Fieldprint Platform® is measured using the NRCS Soil Conditioning Index. Scores ranges from +1 to -1 and are unitless, relative, and crop specific.



Positive values (>0.05) indicate that soil carbon is increasing. As the value approaches +1 the confidence that there is a gain in soil carbon increases. Inversely, as negative values (<-0.05) approach -1, the confidence increases that soil carbon is being lost. Positive numbers are desirable. An additional tool available in the Fieldprint Platform to quantify soil carbon is the COMET-Planner tool, which can be used by projects to estimate the soil carbon sequestration potential of practice interventions for corporate impact assessment and reporting needs.

Developed by USDA–NRCS and Colorado State University as a metamodel, COMET-Planner evaluates generalized impacts certain conservation practices have on reducing greenhouse gas emissions and increasing carbon sequestration. The tool uses conservation implementation scenarios to calculate potential emissions and carbon sequestration against a fixed baseline for typical management practices in a given region. Greenhouse gas emissions are calculated and expressed in their metric tons of $CO_2$ equivalent.



Positive results indicate a decrease in emissions and increase in carbon sequestration, while negative results indicate an increase in emissions and a loss in carbon sequestration. If multiple practices are implemented, results of potential reduction will be combined to calculate the field's total emissions potential. COMET-Planner is unique from the Soil Conditioning Index in its ability to not only quantify soil carbon sequestration but also factor in the co-benefits of estimated emissions reductions from various nutrient management scenarios. For a more in-depth and detailed examination of field specific emissions and sequestration potential, growers can assess their farm using the COMET-Farm tool, which evaluates conservation scenario analysis against a user-generated baseline based on historical management data for up to 20-years.

## Strategies to Increase Soil Carbon

While strategies to support a farmer in increasing soil carbon will vary by crop and region, there are several practices that can lead to improved outcomes across multiple cropping systems and geographies, including:

- Increasing soil organic matter by growing cash or cover crops with high residue that can be left on the soil or by adding animal manure and other organic material to the soil.
- Minimizing soil disturbance and implementing strip- or no-till to conserve soil carbon and prevent release of CO2 from organic matter decomposition.
- Keeping soil covered to prevent erosion and manage tillage, planting date, harvest timing, row spacing, crop residues and cover crops to maintain constant coverage.

## Other Factors For Farmers to Consider

Some factors that affect soil carbon are easily within the power of the farmer to manage, others are not. For example, a farmer can reduce soil disturbance, plant cover crops and improve crop residue retention to increase soil carbon. Field characteristics such as slope and soil texture affect soil erosion and therefore soil carbon. Other factors that affect the Soil Carbon metric include:

- **Wind barriers** - usually trees or shrubs planted to provide a break from prevailing winds, barriers reduce wind erosion and conserve soil and the carbon stored within.
- **The crop type and variety** - some produce more carbon-rich residues than others.
- **Field characteristics** - slope, slope length and surface soil texture are estimated from USDA soil surveyrotation be adjusted to increase the amount of vegetative cover on the fields each month?

Farmers face agronomic and financial risks when adopting new conservation practices. While some practices that reduce input and energy use can lead to immediate cost savings, many practices require up-front investment. An essential component to supporting farmers in building soil carbon is designing effective incentive strategies to support farmers and help share in the agronomic and financial risk inherent in transitioning to new practices. Please note more detailed strategies for increasing soil carbon by crop will be available Fall 2021.

[1] Funderburg, E. 2001. What Does Organic Matter Do In Soil? Available from www.noble.org/news/publications/

## Interpreting The Metric

# Water Quality

## Why It Matters

When water leaves the farm field it takes the soil and residual crop inputs with it resulting in lost investments, reduced yields and negative impacts on water quality. Protecting water quality is beneficial for the economic health of the farm and the health of the local and downstream communities and industries that rely on clean water.

Crop protectants and nutrients can runoff directly into surface waters, leach through the soil profile and enter either tile lines that discharge to surface water or leach into groundwater. This is especially true when the quantity, type, time, and placement of the inputs are not in-line with what the crops need. Groundwater supplies approximately 95% of people living in agricultural communities with drinking water1. Agricultural chemicals can give drinking water a foul odor and flavor. More importantly, there are known negative health effects of nitrates in drinking water, particularly for infants and children2. Excess nutrients from fertilizer and manure that run off of fields into surface water are also known to stimulate rapid expansion of algae populations. The massive algal "blooms" cause hypoxic, or oxygen-scarce zones in ecologically and economically important bodies of water. Wildlife and fishing industries have been negatively impacted by hypoxia.

To reduce the amount of crop nutrients in watersheds, some states have created laws regulating nutrient application and manure management. These states may require nutrient plans to be filed by growers with their state department of agriculture.

Field management practice that can enhance the aggregate stability, water holding capacity, or microbiological life in the soil may prevent or decrease the chances of runoff by increasing the soil's ability to hold water and nutrients. Using cover crops, installing water buffers and greenways, maintaining crop residue on the soil surface, or reducing tillage are practices that may work on some fields to reduce runoff potential.

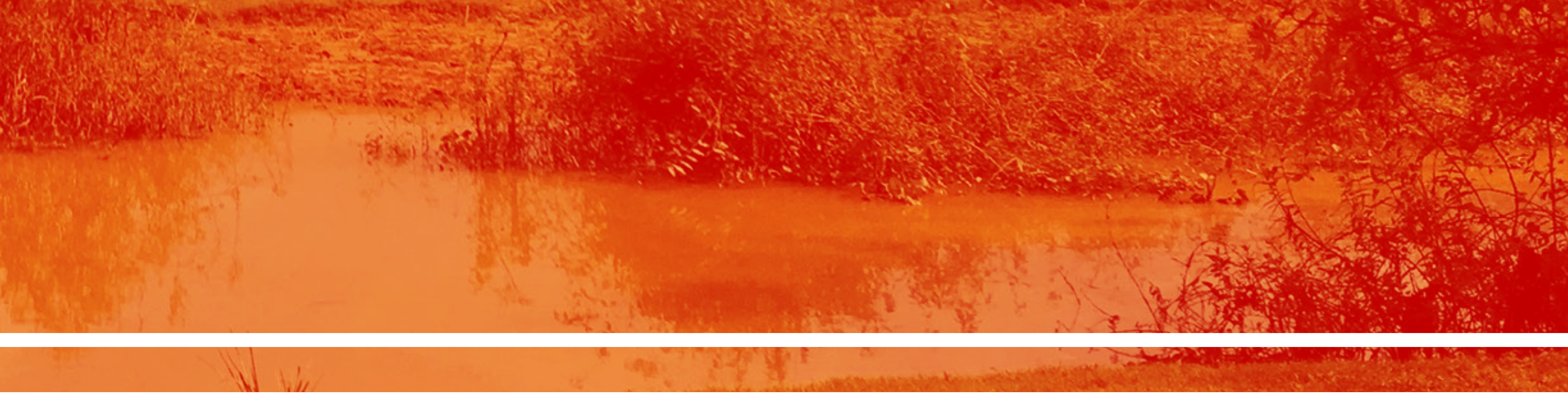
## How It Is Measured In The Fieldprint® Platform

The Water Quality Metric uses the Stewardship Tool for Environmental Performance (STEP), developed by NRCS to assess how likely a field is to lose nutrients to waterways. Based on soil properties and local climate characteristics, STEP assigns a Field Sensitivity Score (FSS) to each field that represents the potential for nutrient losses, either by runoff beyond the edge of the field (surface loss) or leaching below the rootzone (subsurface loss), for each of four loss pathways: Surface P (Phosphorus), Subsurface P, Surface N (Nitrogen), and Subsurface N. STEP then assigns mitigation points, the Risk Mitigation Score (RMS), for management practices that impact nutrient loss.

The goal is to mitigate all four nutrient loss pathways. A pathway is considered to be mitigated if the pathway ratio, assessing overall risk mitigation against a given field's potential for nutrient loss is equal to or greater than 1. Higher pathway ratios are desirable as scores less than 1 indicate risk of nutrient loss.

## Factors That Affect The Fieldprint Score

- STEP calculations are dependent on the crop being grown.
- The Field Sensitivity Score is assessed using the location of the field, the soil type, rainfall amounts, tile drainage and the amount of irrigation water applied (if relevant).
- The Risk Mitigation Score is determined by nutrient management techniques, such as the use of nitrification inhibitors and precision application, presence of a cover crop, tillage type, 4R nutrient management techniques and the implementation of NRCS conservation practices.



## Strategies to Improve Water Quality Outcomes

Farmers should work with trusted advisers to develop the right combination of practices that work best for their cropping system and location. In-stream water quality measurement can be time- and cost- restrictive. Farmers may need support to access the tools and equipment needed to implement management practices that reduce potential water and nutrient runoff. The right practice(s) for a farmer to adopt will be unique to the farmer and their field, but there are several practices generally recommended to improve water quality such as:

- Adopting NRCS edge of field conservation practices like installing bioreactors, riparian buffers or grassed waterways ( see Edge of Field Roadmap).
- Keeping water and soil on the field with low-output irrigation delivery. If tile drainage is used, implementing in-field drainage water management or end of pipe treatment practices. Reduce soil erosion (see Interpreting the Metric: Soil Conservation) by minimizing soil disturbance using the least aggressive tillage tools available and keeping soil covered with vegetation throughout the year.
- Optimize fertilizer and crop protection applications using 4R Nutrient Stewardship (right time, right rate, rate source, right place) and integrated pest management to maximize plant uptake and keep inputs on the field.

Farmers face agronomic and financial risks when adopting new conservation practices. While some practices that reduce input and energy use can lead to immediate cost savings, many practices require up-front investment. An essential component to driving improvements in water quality is designing effective incentive strategies to support farmers and help share in the agronomic and financial risk inherent in transitioning to new practices. Please note more detailed strategies for improving water quality outcomes by crop will be available Fall 2021.

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[1] *Pesticides in Groundwater, https://water.usgs.gov/edu/pesticidesgw.html*

[2] *Nitrates in Drinking Water, https://extension.psu.edu/nitrates-in-drinking-water*

## Interpreting The Metric

# Greenhouse Gas Emissions

## Why It Matters

Greenhouse gases hold heat inside the Earth's atmosphere, causing the atmosphere to warm and weather patterns to become more volatile. Warmer temperatures extend pest and disease pressure and increase plant heat stress and irrigation requirements. Extreme weather events like prolonged drought and severe flooding can cause catastrophic crop losses.

The primary approach to reducing greenhouse gas emissions for many projects is avoided emissions. This includes implementing practices that can lead to reductions in three important greenhouse gases: carbon dioxide ($CO_2$) when soil organic matter is oxidized by aerobic respiration; nitrous oxide ($N_2O$) from nitrate in fertilizer, manure, or other organic matter; and methane ($CH_4$) released from water-saturated rice fields. Key practices that reduce greenhouse gas emission include reducing soil disturbance, keeping the soil covered and following nutrient management techniques.

## How It Is Measured In The Fieldprint® Platform

Greenhouse gas emissions are reported in the Fieldprint® Platform as pounds of carbon dioxide equivalent ($CO_2e$) per crop unit produced (e.g. bushels or pounds). "$CO_2e$" simply means the N2O and CH4 emissions are converted to the equivalent amount of $CO_2$ to provide a common unit of all emissions in one measure, which is comparable over time and influenced by all the actions a farmer takes.

The Fieldprint® Platform uses standard U.S. government assumptions regarding fuel use, such as the 22.3 pounds of $CO_2$ that are emitted per gallon of diesel combusted. Emissions also result from electricity and fuel usage as well as from burning crop residues.

Nitrous oxide emissions from a field are determined using a look-up table from detailed crop modeling performed for the annual U.S. government inventory of emissions. The Fieldprint Platform uses data on crop type, region of the country, and soil texture to determine the "emissions factor", which means how much $N_2O$ results from additions of nitrogen (N). This factor is used to convert N from fertilizer and manure additions into $N_2O$.

For some corn and wheat producers, there is an option to respond to questions about adoption of advanced nutrient management practices relevant to their system to reduce agricultural $N_2O$ emissions. Determining the right time, rate, place as well as the right source of N inputs is known as the "4R's of nutrient stewardship" and can be adopted at either beginning, intermediate or advanced levels to reduce emissions.

As noted above, methane is only calculated for rice. Methane is the byproduct of the anaerobic fermentation of soil organic matter that occurs when atmospheric oxygen is cut off from the soil and soil airspace is filled with water. Field flooding of wetland rice production creates the anaerobic environment required for methane production. The degree and timing of methane production depends on the soil and environmental conditions during flooding. Methane emissions from wetland rice fields are therefore based on region- and country-specific data. Water management, organic matter and fertilizer amendments, and other management practices are key to decreasing $CH_4$ emissions.

Low scores are desirable and indicate less greenhouse gas emitted per unit of crop produced.

## Management Factors

- Greenhouse gas emissions are directly related to energy use. Energy-intensive practices that produce $CO_2$ as a by-product are:
  - Manufacturing crop seed, protectants and fertilizers
  - Grain drying
  - Irrigation pumping
  - Transportation to first point of sale
  - Field equipment passes
- Practices that produce other greenhouse gas emissions ($N_2O$ and $CH_4$) are:
  - Burning crop residues to prepare a field
  - Nutrient management practices and the amount of applied nitrogen in fertilizer or manure
  - Water management, inputs and other management practices for rice fields

## Strategies to Reduce Greenhouse Gas Emissions

While strategies to support a farmer in reducing greenhouse gas emissions will vary by crop and region, there are several practices that can lead to improved outcomes across multiple cropping systems and geographies, including:

- Following the principles of 4R nutrient stewardship to ensure optimal uptake of fertilizers and reduce embedded energy use.
- Minimizing soil disturbance by reducing or eliminating tillage.
- Reducing on-farm and embedded energy use.
- For irrigated crops, use of irrigation scheduling technology to improve water use efficiency and reduce the amount pumped, thereby reducing energy use.

## Other Factors for Farmers to Consider

- Reducing on-farm and embedded energy use
- For rice producers, consider region-specific alternative irrigation and management options available to manage field flooding, organic matter content, and fertilizer
- Manage crop residues without burning.

The Greenhouse Gas Emissions Metric in the Fieldprint Platform offers Continuous Improvement Projects the ability to document and demonstrate progress in emissions reductions. If your project wishes to estimate carbon removals from specific practice interventions, two pathways are available to evaluate the extent to which certain farming practices remove CO2 from the atmosphere and sequester it in soil.

Farmers face agronomic and financial risks when adopting new conservation practices. While some practices that reduce input and energy use can lead to immediate cost savings, many practices require up-front investment. An essential component to supporting farmers in reducing greenhouse gas emissions is designing effective incentive strategies to support farmers and help share in the agronomic and financial risk inherent in transitioning to new practices. Please note detailed strategies for emissions reductions by crop will be available Fall 2021.

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[1] *IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. R.K. Pachauri and L.A. Meyer (eds.) IPCC, Geneva, Switzerland, 151 pp. Available at http://www.ipcc.ch/report/ar5/syr*