FIELD TO MARKET SUSTAINABILITY METRICS OVERVIEW DOCUMENTATION

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Next Up For Review:	Document will be revised when metric methodology changes are approved

FIELD TO MARKET VISION & MISSION

Our Vision: To champion solutions for tomorrow's safe, accessible, and nutritious food, fiber and fuel in thriving ecosystems.

Our Mission: To meet the agricultural challenge of the 21st century by providing collaborative leadership that is transparent; grounded in science; focused on outcomes; open to the full range of technology choices; and committed to creating opportunities across the agricultural supply chain for continuous improvements in productivity, environmental quality, and human well-being.

1.0 OVERVIEW

The Fieldprint® Platform utilizes eight metrics to assess the sustainability of commodity crop production. These metrics are each designed to measure a key environmental outcome using data input from individual farm field operations and environmental data on soils and weather. The metrics have been developed through Field to Market's multi-stakeholder, consensus-driven process to provide a common and comprehensive framework for measuring progress in improving environmental outcomes from commodity crop production in the United States. As part of the development process, special consideration is given to data input requirements to ensure all users can provide the necessary information to calculate the metrics. The measured outcomes provide important feedback to both farmers and the supply chain as indicators of sustainability and analyzing where additional improvement may be needed. This document provides an overview of the major characteristics and components of each of the eight metrics, and details where to find additional scientific documentation of the models and calculations that underpin the metrics in the Fieldprint Platform.

A metric is defined as a quantifiable sustainability outcome calculated by an equation or set of equations encoded as algorithms within the Fieldprint Platform. Metric calculations range from simple equations to complex environmental models and the results can be either quantitative (efficiency) or qualitative (risk) focused. Each metric is periodically reviewed by Field to Market's Metrics Committee, and when necessary, revisions are made to keep up to date with scientific advances, tool development and member needs, ensuring the metrics are scientifically robust. For more information, see the Metrics Standard Operating Procedure*.*

While users may choose to focus on specific aspects of sustainability, the Fieldprint Platform calculates all eight metrics simultaneously as agriculture's biological system requires an assessment that understands the interconnectedness between metrics. Users can view all metric outcomes together or view separate metric and sub-component scores for detailed planning purposes. User fact sheets to interpret metric scores are also available.

The eight metrics were selected through a multi-stakeholder process to identify key environmental outcomes important to all sectors of the supply chain—growers, agribusinesses, brand and retail companies, conservation organizations and the public sector. All stakeholders agreed that these eight indicators capture major environmental concerns related to agricultural production, and that it is important to track performance and pursue continuous improvement. The eight metrics are:

1. Biodiversity
2. Energy Use
3. Greenhouse Gas Emissions
4. Irrigation Water Use
5. Land Use
6. Soil Carbon
7. Soil Conservation
8. Water Quality

1.1 Benchmarks and Continuous Improvement

Where sufficient data are available, Field to Market provides state and national level Benchmark values for the Energy Use, Greenhouse Gas Emissions, Irrigation Water Use, Land Use and Soil Conservation metrics. Benchmarks are standard calculations of sustainability performance for a fixed period based on publicly available, statistically robust data of agricultural production systems. Benchmarks are reference points to enhance user experience with the Fieldprint Platform by providing a known value as context for Fieldprint results. Benchmarks are calculated based on USDA Survey and Census data for the period of 2008-2012 and thus represent a historical point of reference but do not provide a starting point for measuring continuous improvement. Note that Benchmarks are not available for three of the metrics – Biodiversity, Soil Carbon and Water Quality. These three metrics are represented by qualitative indices rather than quantitative measures and as such the results, while relevant for an individual field, cannot be aggregated or compared across multiple fields or regions. These Benchmarks are available to members and registered users through the Learning Center on the Member Portal.

Within a Fieldprint Project, a Project Administrator may also elect to calculate a set of Project Benchmarks, which represent the average performance across fields entered into that specific Project. Fieldprint Project Benchmarks calculated with three consecutive years of data can also be used as a Baseline to assess continuous improvement over time.

Individual Fieldprint Platform users may also elect to calculate their own user benchmark after several years of data entry. They may also compare their scores directly between years and across their own fields. These individual user scores and user benchmarks can also be used to assess individual continuous improvement over time.

Details and instructions for calculating and using project and user benchmarks are available through the Fieldprint Platform interface, user guides and API protocol documentation.

1.3 Educational Materials

Field to Market has developed a set of practical guides for farmers and their trusted advisers that provide greater insight into the eight sustainability metrics within our program—biodiversity, energy use, greenhouse gas emissions, irrigation water use, land use, soil carbon, soil conservation, and water quality. Each guide explains the environmental, economic and community-level importance of the sustainability indicator; how it is measured by the Fieldprint Platform; the field characteristics and management practices used to calculate sustainability outcomes encapsulated in a Fieldprint Analysis; and the top ways that commodity crop farmers can improve their results.

1.4 Fieldprint Platform User Guide

An in-depth guide to help users navigate the Fieldprint Platform online interface is available. This provides additional detail on input data requirements and how to complete the process of running the metrics for a field. Additional written and video resources are available through the Fieldprint Calculator and through a dedicated support portal (https://support.fieldtomarket.org).

1.5 Qualified Data Management Partners (QDMPs)

Field to Market's sustainability metrics can also be accessed through accredited third-party software systems that embed the metrics through the Fieldprint Platform's Application Programming Interface (API). A current list of QDMPs can be viewed here.

2.0 BIODIVERSITY METRIC

Description: The Biodiversity metric is designed to measure the capacity of a farm to support a diverse community of plants and animals. It is measured by the Habitat Potential Index (HPI), a tool developed in 2014 by consultants to Field to Market. Initially available only as a separate spreadsheet tool, the Biodiversity metric was incorporated at the field level into the Fieldprint Platform Version 3.0 in 2018 and included as an optional calculation at the farm level in 2020. This is currently the only metric that considers all lands in a farm operation; all other metrics are specific to individual crop fields producing one of the 12 crops in the program. The Biodiversity metric is a qualitative index-based metric calculated by a series of algorithms and is intended to help encourage management decisions that maximize the potential habitat of the current land types on a farm.

Overview: The HPI measures how much potential capacity to support biodiversity is met on each land type on a user's farm. In brief, this capacity is determined by considering both the inherent properties of the land and ecoregion[1] where the farm is located (structural score) and the management of the land (management score) to determine an ecological quality score. This ecological quality score is then compared to the maximum achievable for the land type/eco-region combination and the fraction of the maximum achieved is interpreted as the potential for biodiversity that is realized.

Structural Score: The structural score is determined by the type of land, and whether any conversion of the land from another land type has occurred in the previous five years. Land types that can be selected by the user include cultivated fields; field edge features; pasture; managed and unmanaged grasslands; managed and unmanaged forests; and streams, wetlands and other water bodies. The ecological value of the land type is determined by the location of the farm with regard to the Bailey's ecoregion classification, developed by the US Forest Service.[2] Within this classification, certain land types have a greater inherent ability to support diverse ecosystems, with the highest values attributed to native ecosystems in a region (for example, native grasslands in the Great Plains region will have a higher ecoregion value than evergreen forest, where the reverse is true for grasslands in the New England Forest ecoregion).

Management Score: The management score is calculated based on user inputs regarding activities on the land, including such practices as tillage, cover crop and rotation for cultivated fields, and a diverse range of activities for other land types, including selective harvesting of woodlands or grazing of grasslands, the physical structure of stream banks, management to remove invasive species, etc. The management score comprises two-thirds of the eco-quality score, with the structural score comprising the remaining one-third. The final HPI score for each land type then accounts for the percentage of total potential realized with the eco-quality score for the field or farm.

Each land type entered will receive a separate HPI score from this methodology. The metric then calculates a full-farm HPI score that weighs

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[1] An ecoregion is a geographic definition of regions defined by their natural vegetation and ecological capacity

[2] Based on the Bailey's ecoregion classification

the land type scores according to the acreage present on the farm. This final full-farm score is the metric outcome; however, users should evaluate both the full farm score and separate land unit scores to understand what lands and practices represent opportunities for continuous improvement. The resulting units of the HPI are in percentage of potential habitat realized.

Linkages to Other Metrics: There are no direct linkages to other metrics.

Key Input Data: Land use types; management activities; land conversion history.

Additional References:
Field to Market Consultant Report: Habitat Potential Index Documentation

3.0 ENERGY USE METRIC

Description: The Energy Use Metric calculates all energy used in the production of one crop in one year from pre-planting activities to the first point of sale. It is an efficiency metric, calculated using a series of algorithms and designed to provide feedback on the energy used per unit of crop production. The metric has seven specific subcomponents that may contribute to the total score, based on the crop and activities entered. Energy use is calculated for each component based on energy source used, and component scores are converted into a common unit—British Thermal Units (BTU)—before being aggregated to a total score. Users will receive their score on both a per unit of crop production and a per acre basis, to help evaluate opportunities for improved efficiency in energy use, which can help to reduce costs of operations.
The Energy Use metric was first developed for Field to Market by consultants in 2009 and was updated in 2017. The seven subcomponents are described as follows:

Management Energy

One component that every user will receive is a Management Energy score that includes the energy used in field operations, including any tillage, planting, harvesting, and passes across the field to apply nutrients and chemicals. The data entered describing the rotation and individual activities each growing season are passed to the NRCS Integrated Erosion Tool

(IET) (see Soil Conservation metric description). In addition to calculating soil erosion, these models will use information on soil characteristics to estimate the energy required for each field operation. For example, tillage operations that break into the soil, or no-till planting operations that must break through residue cover, will be impacted by soil characteristics. Energy from other operations that do not disturb soil are also included in the calculation. These models return the total management energy required for field operations to be used as this component of the metric.

The Fieldprint Platform cross-checks the user input data that are passed to the NRCS IET against the rotation information and applications of fertilizers and chemicals to ensure that all activities are captured. In some instances, additional applications that are not impacting the soil may be added separately based on standard assumptions of fuel usage per acre.

Application Energy

An additional energy component for commercial fertilizer and crop protectant products is the energy embedded in the products applied to the field, that is, the energy required to mine and/or manufacture the products applied.

Energy required to produce commercial fertilizer products is derived from the GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) model[3] developed for use in life cycle analysis of transportation fuels. As this includes biofuels, the GREET model includes the energy and greenhouse gas contribution of fertilizers used in crop production. The GREET model is the main data source, with adjustments made to account for fertilizer blends not provided directly in the GREET databases. The amount of energy is then calculated based on the quantity of product applied, so both the type of fertilizer and the amount applied will impact the Energy Use metric score.

Energy required to produce crop protection products is derived from two main sources of data. The USDA Chemical Use Survey[4] provides background information on the most common active ingredients by crop and region of the country. The energy used to produce active ingredients is

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[3] GREET ver. 1.3.0.13130, 2016;

[4] USDA ARMS survey

provided by a research study published in the scientific literature.[5] Combining these two sources of data provides an estimate for each crop of how much energy is embedded in a single application of a crop chemical of each class (herbicide, insecticide, fungicide, growth regulator, and fumigant). As such, the Fieldprint Platform requires information on the chemical class and number of times each class is applied. It does not require data on the amount of chemical applied or the specific active ingredients used.

Manure Loading Energy

For applications of manure, the metric accounts for the energy required for loading and spreading of manure. This component is only calculated if a user has applied manure, and it requires data to be entered on the rate as well as the type (liquid, slurry, semi-solid or solid). If the manure type selected is liquid or slurry, then it is first adjusted by a water density factor. This component is then calculated based on the total weight of the manure applied and a constant value of the amount of fuel required to load and spread the product.

Seed Energy

The metric also accounts for the energy required to produce the seed used for the crop. This component is based on industry and expert judgement regarding the more intensive level of management and use of inputs to produce seed than to produce a commercial crop. The energy use value for each crop from the Field to Market National Indicators Report is therefore multiplied by a factor of 1.5 and used as the assumption for energy embedded in seed applied. For this component, user input of seeding rate is multiplied by this energy value.

Irrigation Energy

For irrigated producers, energy required to run irrigation pumps can be a significant proportion of total energy use. The irrigation energy component is only included for irrigated crops and is calculated in one of several ways based on the user input available.

The most direct calculation is if a user inputs how much energy was used to run the pump in a given growing season—based on either an electric

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[5] Audsley, E., K. Stacey, D.J. Parsons, and A.G. Williams. 2009. Estimation of the Greenhouse Gas Emissions from Agricultural Pesticide Manufacture and Use. Rep. Cranfield: Cranfield U, 2009.

meter reading or on the diesel fuel usage. In this case, the energy amount is divided by the field area and converted to BTUs to provide an energy estimate per acre and per unit of crop production.

If a user does not input this direct energy use information, the metric uses engineering equations to calculate the energy use based on the pumping system and the amount of water applied. For this calculation, the user must enter information on the pump pressure and pumping depth of their irrigation system, as well as the annual water applied in acre-inches. If a field draws from more than one water source, the metric will calculate the energy requirement separately for each and require the specific data entries as well.

Post-Harvest Treatment Energy

This category applies to energy required for any activity (except transportation) after harvest and prior to the first point of sale. For many crops, this is primarily crop drying, which is calculated based on crop specific estimates of energy requirement for removal of a point of moisture from the University of Wisconsin.[6] Users are required to indicate the points of moisture removed in drying (defined as the difference between the moisture level at harvest and the moisture level at sale) as well as indicate the drying system they use. The efficiency of the selected system and the amount of water removed is then used in engineering equations to calculate the energy requirement.

In the case of cotton, where lint drying occurs at the gin and is considered before sale but not in direct control of the grower, industry estimates of drying energy required based on the qualitative moisture level of lint at the point of delivery to the gin is used to estimate energy used.

For peanuts, drying energy is calculated using a set of equations developed by staff at USDA ARS in Georgia, which are based on empirical data. The peanut drying energy considers energy for electric fans blowing air past a gas burner.

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[6] Sanford, 2005. Reduce Grain Drying Costs this Fall. University of Wisconsin, Biological Systems Engineering publication. September 2005.

Transportation Energy

This accounts for the hauling of the crop harvest from the field on on-farm storage bin to the first point of sale. This was revised in 2017 (link) and uses standard assumptions regarding the fuel efficiency and truck capacity of semi-trailer trucks. This component then considers the total field production, and the distance the user indicates that the crop is transported to sale. The energy of the return trip to the farm is included, with adjustment for higher fuel efficiency with an empty truck.

A user may indicate if the return trip to the farm is used to “backhaul” materials for use. For example, the energy included in a return trip of feed or products for use in the farm operation is not included in the calculation. In some cases, for feed crops such as corn silage or hay that are used on-farm, a user may not have transportation energy as part of their metric calculation.

Linkages to Other Metrics: The Energy Use metric is dependent on results from the IET model of the Soil Conservation metric to calculate Management Energy. Energy Use is a key input into the Greenhouse Gas Emissions metric.

Key Input Data: The Energy Use metric shares many data input points with other metrics; it requires detailed information on field operations as well as details on fertilizer and crop protectant applications, details of irrigation systems and crop drying, and details on transportation distances. Additional key inputs are reference tables of the energy (BTU) content of different fuel types, including electricity.

Additional References

Field to Market Documentation: 2016 National Indicators report
Field to Market Documentation: 2017 Energy Use Metric Revision Documentation

4.0 GREENHOUSE GAS EMISSIONS METRIC

Description: The Greenhouse Gas (GHG) Emissions metric calculates the total emissions from four main sources: energy use, nitrous oxide emissions from soils, methane emissions (from flooded rice fields) and emissions from residue burning. It is an efficiency metric calculated using a series of complex algorithms to determine the total GHG emissions per unit of crop production. All users will have emissions resulting from energy and soil; methane emissions from flooded fields are included only for rice; and residue burning emissions are calculated only in those cases where the user indicates that the prior crop residue was burned. Emissions are calculated in units of pounds of carbon dioxide equivalent (lbs CO_2e) per unit of crop production. Units of CO_2e are a way to express emissions of all greenhouse gases based on their global warming potential. Thus, the methane and nitrous oxide emissions are multiplied by standard factors (1 lb N_2O = 296 lb CO_2e; 1 lb CH_4 = 23 lbs CO_2e) to convert to CO_2e for this metric. While the final metric units are pounds of CO_2e per unit of production for all components combined, results are presented to the user for each of the four components both per unit of crop production and per acre.

The Greenhouse Gas Emissions metric was initially developed for Field to Market by consultants in 2009; several components of the energy emissions, nitrous oxide emissions from soils and methane emissions from rice were updated in 2016 and 2017 by scientific experts convened by Field to Market member organizations and the Metrics Committee (see links under Additional References). In 2020, an optional feature to capture the impact of 4R Nutrient Management practices on nitrous oxide emissions was released for corn and wheat farmers in certain regions of the country. The four subcomponents are described as follows:

Emissions from Energy Use

The Energy Use metric is calculated in British Thermal Units (BTUs) per unit of crop production. This energy is converted into greenhouse gas emissions separately for each component of the energy use described above. The components of management energy, manure loading energy, and transportation energy are converted directly from BTUs to the equivalent unit of energy in gallons of diesel, and from there to carbon dioxide equivalent values. User-provided data on the type of fuel used as input to the energy metric, which then converts each into BTUs; thus, fuel type selection does factor into greenhouse gas emissions, with data on both the BTU and CO_2e for each fuel option determined from the US EPA.[7]

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[7] https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

For two of the energy use components—irrigation and post-harvest treatment—greenhouse gas emissions are dependent on the form of energy used. If diesel is used, the same conversion as described above is applied. If electricity is used, then emissions are based on the amount of electricity in kilowatt hours (kWh) and regional estimates of electricity emissions based on the US EPA Emissions Generation Resource Integrated Database (EGRID).[8] Alternatively, a user has the option to select electricity from renewable sources— solar or wind—for these two components; in these instances, the energy used would not be converted to greenhouse gas emissions. These two options can be selected whether the user is generating the electricity on-farm or purchasing renewable energy from their electricity supplier.

For application energy and seed energy components, the greenhouse gas emissions are calculated separately based on emissions associated with the manufacture or production of the fertilizers, crop protectants and seed. The same data sources that were used to determine the embedded energy—the GREET model databases and the 2016 National Indicators Report—are used to determine the embedded GHG emissions associated with the amount and type of fertilizer, the number and category of crop protectants, and the seeding rate for the crop.

Emissions from Soils

Agriculture is a major contributor of nitrous oxide emissions (N_2O) to the atmosphere. Emissions of N_2O result from soil biological processes and are affected by geographic factors including climate conditions and soil properties. They are also impacted by the amount and type of organic matter on the field, the amount and type of organic and inorganic nitrogen fertilizer amendments, the timing of application, and the source of fertilizer. N_2O emissions are highly variable according to background soil characteristics, weather, historical land use and current land management. Field to Market worked with a group of scientific experts in 2016 and 2017 to devise a method that would capture the major sources of variability as well as allow users to provide information on their nitrogen management practices and receive feedback about how their practices influence nitrous oxide emissions. Based on the findings of the science group, Field to Market revised the N_2O component of the GHG emissions metric in 2017, and detailed documentation is available.

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[8] https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

In the first phase, a meta-model approach is used to estimate N_2O emissions based on the field location, predominant soil texture, crop type grown, and amount of nitrogen applied in fertilizer and manure. Based on a database of published simulations from the USDA hybrid DayCent/DNDC model as used in the annual national inventory of emissions,[9] field specific emissions are calculated using an approach to scale the actual field-applied N to the average N rate used by USDA in the simulation modeling. This meta-model approach provides the benefit of considering geographic and environmental conditions without the computational and data entry burden of incorporating the full model into the Fieldprint Platform. This approach also accounts for the indirect N_2O emissions from a field, using a standard factor of 0.35% of N applied.

Note that for three crops—barley, peanuts and sugar beets—results are not available from the USDA hybrid model. For these crops, we continue to use the Tier 1 approach recommended by the Intergovernmental Panel on Climate Change,[10] which uses a standard factor of 1.4% of N applied lost as N_2O through a combination of direct and indirect pathways.

The second phase incorporates the option to detail adoption of 4R nutrient stewardship fertilizer management practices for corn and wheat production. Users are presented with a set of questions to determine the source, timing and placement of N fertilizers, and determine whether the user qualifies for an associated reduction in nitrous oxide emissions. The 4R practices are crop and region specific and are included in the metric revision documentation from 2017. They are based on a combination of expert judgement of a group of scientists as well as additional research on attribution of emissions reductions to practices.[11]

Emissions from Flooded Rice Fields

Flooded rice production creates anaerobic conditions that result in emissions of methane (CH_4). These emissions are impacted by the duration of time that a field is flooded, as well as the amount of organic material and residue on the field and other management factors. For a 2018 update to the GHG Emissions metric, a meta-analysis of methane

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[9] US EPA Inventory

[10] IPCC GHG Guidelines 2006

[11] Vyn, T.J., A.D. Halvorson, and R.A. Omonode. 2016. Relationships of nitrous oxide emissions to fertilizer nitrogen recovery efficiencies in rain-fed and irrigated corn production systems: data review.

measurements from rice fields in the US was conducted.[12] The results were used to determine a specific set of factors that influence methane emissions.

For this calculation, rice fields are assigned a standard seasonal emissions factor based on their region (southern US or California) and the clay content of the soil. This emission factor is then modified by specific practices: alternate wetting and drying of the soil during the growing season; amount of crop residue on the field at planting; sulfur and organic fertilizer (manure, compost) amendments; cultivar type (south only); seeding method (CA only). An additional factor is included for producers in the southern region who practice ratoon cropping; ratoon refers to the practice of allowing regrowth after the first harvest, resulting in a second harvest of the same crop. This requires leaving the field flooded for a longer period, and commonly includes an additional fertilizer application. This results in additional methane emissions, represented in the metric by an additional per-acre methane addition to the field score. In instances of ratooning, the ratoon yield is also added to the first harvest yield for the total annual yield from one rice crop.

Emissions from Residue Burning

In cases where a prior crop residue is burned by prescribed fire before planting, the combustion of the residue releases greenhouse gas emissions into the atmosphere. If a user indicates residue was burned, they will be asked to specify the prior crop type and yield. The emissions are then determined by the IPCC standard factors of residue composition and combustion, resulting in nitrous oxide and methane emissions that are converted to CO_2e.[13]

Linkages to Other Metrics: The Greenhouse Gas Emissions metric relies on the results of the Energy Use metric.

Key Input Data: In addition to the data required for the Energy Use metric, the N content of manure fertilizer and details on residue burning and flooded rice management are required.

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[12] Linquist, BA, M Marcos, A Adviento-Borbe, M Anders, D Harrell, S Linscombe, ML Reba, BRK Runkle, L Tarpley, A Thomson. 2018. Greenhouse gas emissions and management practices that impact emissions in US rice production systems. J. Environ. Qual. doi:10.2134/jeq2017.11.0445

[13] IPCC GHG Guidelines 2006

Additional References
Field to Market Documentation: N_2O Metric Revision documentation
Field to Market Documentation: CH_4 Metric Revision documentation
Field to Market Documentation: Energy Use Metric Revision documentation

5.0 IRRIGATION WATER USE METRIC

The Irrigation Water Use metric is an efficiency metric that uses a simple equation to account for the amount of water used to achieve an incremental increase in crop yield. This metric was developed and adopted in 2009. The Irrigation Water Use metric requires a user to enter their actual, irrigated yield as well as an estimate of non-irrigated yield. The non-irrigated yield is intended to represent the production that would have been achieved on the same field but without irrigation. Note that for many users, the non-irrigated yield may be 0 if the crop would not be grown on that field without irrigation.

Users also specify the amount of water applied to the field in terms of acre-inches over the entire growing season. If irrigation water is applied prior to planting for the benefit of the crop, that water should be included in the irrigation water estimate. For users who do not have direct measurement of water applied from a water meter, they are directed to estimate the amount using resources such as crop water requirement and rainfall estimates; water rights or water district allocations; or engineering calculations based on pump capacity and energy used or hours run. In 2019 a feature was added to the Platform to provide a standardized estimation of irrigation water applied based on user input detailing irrigation equipment and practices and standard engineering equations. This is an optional feature that improves data entry quality by using standard methodology when estimating this important data input value.

The Irrigation Water Use metric is then calculated as the amount of applied water divided by the difference between the irrigated yield and the non-irrigated yield. The metric will implicitly account for implementation of water-saving management practices and technologies that reduce the total amount of water applied, assuming yields are maintained. The metric is reported to the user in terms of amount of water applied per unit of incremental increase of crop yield (e.g., acre-in / bu).

Linkages to Other Metrics: The irrigation amount is used in the calculation of the Energy Use and Greenhouse Gas Emissions metric, and the identification of a field as irrigated is important in the Biodiversity and Water Quality metrics.

Key Input Data: Amount of irrigation water applied and the estimate of non-irrigated yield are the critical inputs.

6.0 LAND USE METRIC

The Land Use metric is an efficiency metric that uses a simple equation to account for the planted area used to produce a crop. The metric was initially developed and adopted in 2009.

Operationally, it is calculated as the simple inverse of user-supplied crop yield. Outcomes are in units of planted land area per unit of production. The standard units of yield for the Fieldprint Platform are provided in Table 1.

Table 1: Standard units of crop yield used in the Fieldprint Platform

Crop	Yield Unit of Production	Description
Alfalfa	ton	Total tons of hay harvested per year
Barley	bu.	Bushel, 48 lbs. of barley grain per bushel
Corn (grain)	bu.	Bushel, 56 lbs. of corn grain per bushel
Corn (silage)	ton	2000 pounds (lbs)
Cotton	lb.	Pounds (lbs)
Peanuts	lb.	Pounds (lbs)
Potatoes	cwt	Hundred weight, (100 lbs.)
Rice	cwt	Hundred weight, (100 lbs.)
Sorghum	Bu.	Bushel, 56 lbs. of sorghum grain per bushel
Soybeans	bu.	Bushel, 60 lbs. of soybean per bushel
Sugar beets	Ton of sugar	2000 pounds (lbs) of sugar
Wheat	bu.	Bushel, 60 lbs. of wheat grain per bushel

Linkages to Other Metrics: Crop yield is an important component of the Energy Use, Greenhouse Gas Emissions, Irrigation Water Use and Soil Conservation metrics.

Key Input data: Crop yield

7.0 SOIL CARBON METRIC

Soil carbon is important in supporting water infiltration, water and nutrient holding, crop productivity, and carbon storage. Due to the difficulty in quantifying the amount of change in soil carbon in a single year, the Fieldprint Platform utilizes a qualitative and directional measure of soil carbon. The Soil Carbon metric is represented by a USDA NRCS tool, the Soil Conditioning Index (SCI),[14] adopted into the Fieldprint Platform in 2012. SCI model calculations are performed on NRCS computer servers and connected to the Fieldprint Platform via Application Programming Interface services. SCI is based on USDA field research sites across the country and has been continuously developed since 1964 as a user-friendly annual snapshot indicator of soil carbon for use in farmer education and conservation planning.

The SCI accounts for three major components that impact soil carbon: organic matter and crop residue returned to the soil (including root material and above and below ground residue biomass); soil erosion from water and wind; and the soil-impacting characteristics of field operations (represented by a soil tillage intensity rating). It is calculated internally to the USDA model (IET) used in the Soil Conservation metric and thus shares the same key input data with that metric. The SCI calculation accounts for regional differences in organic matter and residue decomposition rates based on climate conditions at the field location as well as soil texture determined from the USDA SSURGO soils database.[15]

The SCI returns a value between -1 and 1 for each field. A positive value indicates increasing soil carbon, a neutral value (between -0.05 and 0.05) indicates maintaining soil carbon and a negative value indicates losses of soil carbon. The magnitude of the index reflects confidence in the directionality, and does not indicate a higher or lower quantity of carbon in the soil.

In addition to the Soil Carbon metric, the Fieldprint Calculator includes an optional scenario tool for users to explore the potential quantitative impact of any changes in management practices on soil carbon. The COMET-Planner tool, developed by USDA, has been integrated into the farm level section of the Calculator as part of the Version 4.0 release in 2021. Users

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[14] Carlson et al. 2016

[15] https://websoilsurvey.nrcs.usda.gov/

select a field for which they have run a Fieldprint analysis and indicate what practices have recently changed (or what practice they are considering changing) and COMET-Planner will return the annual expected soil carbon sequestration associated with that practice change.

Linkages to Other Metrics: The Soil Carbon metric is closely tied to the Soil Conservation Metric and is calculated in the same USDA model services. While not directly linked in calculations, the Soil Carbon and GHG Emissions metrics are frequently linked in interpretation, as increasing the soil carbon content of a field can help to offset emissions from the components calculated in the GHG Emissions metric

Key Input Data: Both the Soil Carbon and Soil Conservation metrics require details of field operations that impact the soil, such as tillage, as well as treatment of crop residue and crop rotation. While soil properties are determined by the USDA SSURGO database, the user has the option to override certain inputs such as organic matter content, from field specific soil tests.

Additional Resources:
USDA Publication: SSURGO Soils Database Documentation
USDA Publication: Agronomy Technical Note # 16

8.0 SOIL CONSERVATION METRIC

The Soil Conservation metric is a measure of soil lost to erosion from water and wind, and is calculated using USDA NRCS models and reported to the user as tons of soil lost per acre. It is an efficiency metric that uses a complex biophysical model to simulate crop growth, water flow across the field, and sediment runoff. The metric is calculated by the USDA NRCS Integrated Erosion Tool (IET), which is comprised of two models—WEPP (Water Erosion Prediction Program) and WEPS (Wind Erosion Prediction Service). The IET is the product of decades of field research and model development at USDA and is currently the most complex model used in calculation of the Fieldprint Platform metrics. IET model calculations are performed on NRCS computer servers and connected to the Fieldprint Platform via Application Programming Interface services.

The Soil Conservation metric was initially adopted in 2010 and updated in 2012 to include the WEPS model for wind erosion. It was updated again in

2018 to incorporate the WEPP model for water erosion in place of the RUSLE2 (Revised Universal Soil Loss Equation) model. As of the 2021 release of Fieldprint Platform 4.0, the wind erosion model (WEPS) is now being run in calibration mode; this means that the model uses the crop yield from the data entry to check and ensure the crop growth simulated by the model is accurate. This results in more accurate estimates of wind erosion for the metric.

The IET models require information on field characteristics—including slope, slope length and soil properties—and crop management practices that impact the soil such as tillage and rotation as well as soil profile characteristics and climate data. Much of the required information is obtained from background databases including soil profile properties from the USDA SSURGO[16] data and climate normal data from the PRISM[17] dataset. Users are required to select field characteristics, confirm the existence of any subsurface drainage, surface drainage, water recapture systems, and wind barriers, and enter management information for the field using the rotation builder.

Linkages to Other Metrics: The IET models also provide the SCI results for the Soil Carbon metric, and provide the management energy information used in the Energy Use and Greenhouse Gas Emissions metrics. The erosion results are also a key input to the Water Quality metric.

Key Input Data: Both the Soil Carbon and Soil Conservation metrics require details of field operations that impact the soil, such as tillage, as well as treatment of crop residue and overall crop rotation system and field physical features such as tile drains, terraces and wind barriers.

Additional resources:
USDA Publication: History of WEPP Model
Field to Market Documentation: Soil Conservation metric revision documentation

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[16] https://websoilsurvey.nrcs.usda.gov/

[17] http://www.prism.oregonstate.edu/

9.0 WATER QUALITY METRIC

The Water Quality metric is a measure of nutrient lost from a farm field to adjacent waterways and is measured through four nutrient loss pathways: Surface Nitrogen, Subsurface Nitrogen, Surface Phosphorous and Subsurface Phosphorous. For each of those four pathways, a field receives two numerical scores, one indicating how sensitive the field is to nutrient loss along that pathway (FSS- Field Sensitivity Score), and the second indicating how much mitigation has been done to prevent loss (RMS – Risk Mitigation Score). The FSS is determined based on field location, climate zone, soil properties and topography while the RMS is determined by management practices on the field.

The final metric score is presented in four parts, indicating for each pathway whether the mitigation score exceed the sensitivity score. When a mitigation score exceeds the sensitivity for a loss pathway, it means that the management practices are adequate for avoiding excessive nutrient loss; if a mitigation score is lower than the sensitivity score for a pathway, that indicates adjustments to field management are necessary to reduce the risk of excess nutrient loss.

The NRCS Stewardship Tool for Environmental Performance (STEP) as developed for the Resource Stewardship Evaluation Tool (RSET) program provides the calculations for the Water Quality metric. An overview of the scientific basis for STEP is available in NRCS documentation (see “STEP within RSET”) and the calculations and scoring in STEP have been developed from the series of national modeling exercises USDA conducts as part of the Conservation Effects Assessment Project (CEAP) cropland reports. CEAP is an ongoing assessment of water quality and conservation practice adoption that applies complex biophysically based crop and water quality models (APEX and SWAT) to detailed survey results from the National Resources Inventory. STEP utilizes these detailed quantitative results to characterize the relative potential for nutrient loss and effectiveness of different conservation practices on water quality based on a field’s specific soil and topographic characteristics and climate conditions.

Similar to the Soil Conservation and Soil Carbon metrics, to calculate STEP scoring the Fieldprint Platform accesses USDA model and data services through a backend API integration to the Cloud Services Integration Platform (CSIP), a model-as-a-Service framework hosted by the Object Modeling System (OMS) Lab at Colorado State University (CSU). STEP was adopted as the Water Quality Metric in 2021, replacing the USDA Water Quality Index.

Linkages to Other Metrics: Water Quality is not directly linked to other metrics but shares many common data inputs with Biodiversity, Irrigation Water Use, Energy Use and Soil Conservation.

Key Input Data: Conservation practices, soil nutrient testing and data captured on field operations, irrigation, and nutrient applications.

Additional Resources:
USDA Publication: STEP within RSET
Field to Market Metric Update Documentation: STEP-Implementation-for-Field-to-Market-06.10.2020.pdf (fieldtomarket.org)

10.0 VERSION HISTORY

Version/Date	Change	Link
1.0	Initial Publication	
2.0	Update to include all changes in the Fieldprint Platform Version 4.0 release	
2.1	Updated contact information	Current