# **Nutrient Sensitive Areas Analysis - Soil Sensitivity (Nutrient Runoff) for CART/CD**

## Document Version: 09/19/2022

## Model Version: 1.0

## About

* Identify inherent vulnerability of cropland for nutrient runoff

## Why

* Nutrient management is an important part of climate-smart agriculture. Excess nutrients on the land can lead to nitrogen losses to the atmosphere. Nutrient management maximizes crop-nitrogen uptake and has a compelling and cost-effective role to play in mitigating greenhouse gas emissions from agriculture.
* Reduce nutrient loading in receiving waterbodies such as the Gulf of Mexico
* Help conservation planners identify vulnerable areas with customers to target reductions in nutrient runoff
* Assist producers with using less fertilizers and more cover crops on soils that are more sensitive.

Purpose:

To support the NRCS SMART Nutrient Management initiative, a soil sensitivity index (interpretation) was developed to rate soils based on their sensitivity for nutrient runoff. The index can be used in conservation planning to assist in identifying soils and areas with greater vulnerability to nutrient runoff. The most sensitive soils are those that are most vulnerable, or highly susceptible to nutrient runoff.

Nutrient Sensitive Areas Analysis – The Soil Sensitivity (Nutrient Runoff) model provides a science-based methodology, a tool and visualization for the conservationists to use with clients in Conservation Desktop. Conservationists can use this pre-planning tool and map to assist clients with a plan to reduce nutrient runoff from their operations.   Conservation planners will be able to select practices and fields to run the sensitivity analysis to help with planning alternatives. Results of the sensitivity analysis will be stored for future use within the CART assessment and ranking process.  The Conservation Products module will retrieve the results and develop a map and report and to provide to the client with information for planning practices on their operation.

Develop a science-based tool to for pre-planning work with clients so that conservation planners can view a map with clear ratings that show fields with different potential for nutrient runoff.  Conservation Planners will be able to select practices and land units to run the sensitivity analysis.  Results of the sensitivity analysis will be stored for future use within the CART assessment and ranking process.  The Conservation Products module will be able retrieve the results and provide the planner and client a map and related information for planning practices.

## How Soil Data is Used:

The Soil Sensitivity Interpretation uses soils data along with spatial datasets to develop modeled results for the planner. Tapping soil data and supporting data in this way allows the model to go beyond the map unit down to the individual soil polygon level (Dynamic Soil Survey). This will allow the conservation planners to easily communicate with the producers what their recommendations are, for which fields, and why.

## Background - Summary:

A soil sensitivity soil index interpretation was developed to rate soils based on their sensitivity for nutrient runoff. The index can be used in conservation planning to assist in identifying soils and areas with greater vulnerability to nutrient runoff. Soils can be rated in an interpretation based on their properties susceptibility to nutrient runoff. The most sensitive soils are those that are most vulnerable, or highly susceptible to nutrient runoff.

Soil Sensitivity also reflects the potential for pesticides to be transported by surface runoff beyond the field boundary where the nutrients were applied. Nutrients are transported by surface runoff as either nutrients in solution or nutrients adsorbed to sediments suspended in runoff. Nutrients that are surface transported have a potential to contaminate surface waters, such as lakes, ponds, streams, and rivers.

Soil Sensitivity also indicates some site-related conditions that makes soils more vulnerable to runoff. Site conditions such as sloping ground and high rainfall create higher erosion risks.

The soil properties and conditions considered in the Soil Sensitivity are those that affect rates of runoff and erosion. These soil properties and conditions are:

* Soil texture
* Organic matter content
* Soil structure
* Soil particle-size distribution
* Permeability
* Restricting layers
* Depth
* Drainage
* Depth to a water table
* Slope
* Shrink-swell potential

Runoff is represented by slope and the saturated hydrologic conductivity, which considers soil texture, permeability, restrictive layers, depth, drainage, and shrink-swell potential. Soil erodibility is represented by the K factor, which is estimated from soil particle-size distribution, organic matter content, structure, and permeability. Flooding has the potential of catastrophic surface nutrient loss. It may remove large quantities of nutrients, either those in solution or those adsorbed to sediments, in a single event. Ponding can concentrate nutrients that are surface transported, and draining ponded areas adversely affects the receiving surface waters.

Soils are placed into interpretive classes based on their index rating. Interpretative classes are:

|  |  |  |
| --- | --- | --- |
| Rating Class | Description | Values |
| Low | These soils have a low potential for nutrient runoff. Slopes are nearly level flat, shorter slope length (LS factor), lower soil erodibility factor (Kf factor), rainfall not as intense, soils more permeable, generally sand textures soils with less clay. | index rating > 0 and <= 5.99 |
| Moderately Low | These soils have a moderately low potential for nutrient runoff, generally sandy to loamy soils, nearly level to gently sloping. | index rating > 5.99 and <= 28.67 |
| Moderate | These soils have a moderately potential for nutrient runoff. Generally loamy soils, rolling slopes, gently sloping. | rating index > 28.67 and <= 114.51 |
| Moderately High | These soils have a moderately high potential for nutrient runoff. Generally loamy to clayey soils, moderately steep. | rating index > 114.51 and <= 439.46 |
| High | These soils have a high potential for nutrient runoff. Strongly sloping with steep and very slopes, high erodibility factor (Kf factor), intense rainfall, potentially soils with less permeable, generally soils with high clay (Soil Texture Clay). | rating index > 439.46 and <= 1669.59 |

## Interpretation Description:

Soil Sensitivity defines how vulnerable a soil is to nutrient runoff. When used in soil survey the index assesses the inherent soil condition. Depending on a soils’ inherent characteristics and the climate, soils can vary from highly resistant, or stable, to those that are vulnerable and extremely sensitive to nutrient runoff. A soils sensitivity can change over time due to climate change and changes in site characteristics, and thus soil sensitivity will change. Under stress, soil sensitive soils can degrade to a new altered state which may be less or unfavorable to nutrient runoff. To assess the soil sensitivity of the soil, vulnerability indicators to sensitivity processes (mostly erosion) are used. The minimum dataset of indicators of soil sensitivity are as follows:

1. ***Kw Factor***: An erodibility factor which quantifies the susceptibility of soil particles to detachment and movement by water. This factor is adjusted for the effect of rock fragments.
2. ***Rainfall Factor***: Spatial layer intersecting map unit polygon layer. The energy of moving water detaches and transports soil materials. The energy intensity parameter Erosion Index (EI) measures total raindrop energy of a storm and its relation to the maximum 30-minute intensity1/. Soil losses are linearly proportional to the number of EI units. Storm EI values are summed to obtain an annual rainfall erosivity index for a given location.
3. ***Slope Length***: The distance from the point of origin of overland flow to the point where either the slope gradient decreases enough that deposition begins, or the runoff water enters a well-defined channel that may be part of a drainage network or a constructed channel. (Predicting Rainfall Erosion Losses, a Guide to Conservation Planning, Agr. Handbook #537, USDA, 1978).
4. ***Texture***: An expression, based on the USDA system of particle sizes, for the relative portions of the various size groups of individual mineral grains less than 2mm equivalent diameter in a mass of soil.
5. ***Organic Matter****: The amount by weight of decomposed plant and animal residue expressed as a weight percentage of the less than 2 mm soil material.*
6. ***KSAT****: The amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient.*
7. ***Total Sand****: Mineral particles 0.05mm to 2.0mm in equivalent diameter as a weight percentage of the less than 2 mm fraction.*
8. ***Total Silt****: Mineral particles 0.002 to 0.05mm in equivalent diameter as a weight percentage of the less than 2.0mm fraction.*
9. ***Total Clay****:* *Mineral particles less than 0.002mm in equivalent diameter as a weight percentage of the less than 2.0mm fraction.*
10. ***Very Find Sand****: Mineral particles 0.05 to 0.10mm in equivalent diameter as a weight percentage of the less than 2 mm fraction.*
11. ***Bulk Density 1/3 Bar****:* *The oven dried weight of the less than 2 mm soil material per unit volume of soil at a water tension of 1/3 bar.*
12. ***Horizon Top Depth****: The distance from the top of the soil to the upper boundary of the soil horizon*
13. ***Horizon Bottom Depth****: The distance from the top of the soil to the base of the soil horizon.*
14. ***Slope****: The difference in elevation between two points, expressed as a percentage of the distance between those points. (Soil Survey Manual)*

## Equations:

1. *sine\_theta*: SIN( ATAN (CAST(slope\_r AS decimal(6, 2))/100))
2. *Length Factor*: slope\_r < 1 THEN (slope\_length/72.6) \*0.2; slope\_r >=1 AND slope\_r < 3 THEN (slope\_length/72.6)\*0.3 ; slope\_r >=3 AND slope\_r < 4.5 THEN (slope\_length/72.6)\*0.4 ; slope\_r >= 4.5 THEN (slope\_length/72.6)\*0.5
3. *LS factor*: (length\_fact)\*(steep\_fact)
4. *Soil Sensitivity Index*: ((r\_factor)\*(kwfact)\*(ls\_factor)) water\_sensitive

## Appendix:

|  |  |
| --- | --- |
| Parameter | Value |
| Version | 1.0 |
| Date effective | 10/24/2022 |
| Frequency of update | Yearly |
| Purpose/Design/intent/scope of interpretation | Nutrient Management |
| Scale of appropriate use | Soil survey data seldom contain detailed, site-specific information. They are not intended for use as primary regulatory tools in site-specific permitting decisions. They are, however, useful for broad regulatory planning and application. |
| Limitations on use | Soil survey information cannot replace site-specific details, which require onsite investigation. It is a valuable tool where acquiring onsite data is not feasible or is cost prohibitive. It is most useful as a tool for planning onsite investigation. Understanding the capability and limitations of the different types of soil data is essential for making the best conservation-planning decisions. |

|  |  |  |
| --- | --- | --- |
| Methodology Scope | Data Stewardship | Point of Contact |
| Soil interpretations methodology | SPSD-Soil Services and Information | Bob Dobos |
| CD/CART process integration | CPTAD | Travis Rome |
| Soil data information integration | SPSD-Soil Services and Information | Jason Nemecek |
| Contributors |  | Steve Campbell |
|  |  | Cathy Seybold |
|  |  | Richard Reid |
|  |  | Laura Morton |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |