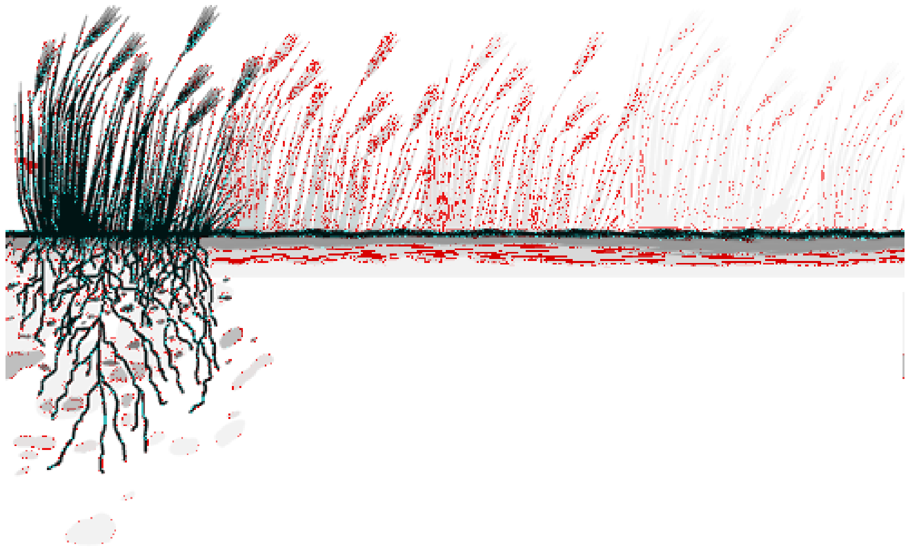

Background

The USDA–Natural Resources Conservation Service (formerly Soil Conservation Service) focused through much of its history on combating erosion on agricultural and other private lands. Conservation efforts were supported by predictive tools, such as the Universal Soil Loss Equation (USLE) and the Wind Erosion Equation (WEQ). As the mission of the agency broadened to include other resources—soil, water, air, plants, and animals—new planning tools were needed for multi-resource concerns.

One important resource concern is the degradation of soil quality as influenced by land management. Of the numerous components of soil quality, soil organic matter deserves special attention because it impacts several critical soil functions and is strongly affected by management practices. Enhancing soil organic matter can improve a soil's capacity for productivity, nutrient cycling, filtering and buffering of potential pollutants, and partitioning water. Organic matter can improve the soil's resistance to compaction and erosion.

The Soil Conditioning Index in conservation planning

The Soil Conditioning Index (SCI) is a prediction tool used by the NRCS in conservation planning to estimate whether applied conservation practices will result in maintae8oondinrea uselevels of s Soiorganic (a)Tj10.98 0 0 10.98 2

Components of the SCI

The SCI estimates trends in soil organic matter, which are assumed to be an indicator of soil quality trends. The index was developed from Revised Universal Soil Loss Equation (RUSLE) technology. Like RUSLE, SCI models the top 4 inches of the soil. Although 4 inches does not account for all soil organic matter, most soil quality improvements result from changes in the surface layer. The SCI combines the effect of three determinants of organic matter as follows. SCI = OM + FO + ER where:

OM is the organic material or biomass factor. This component accounts for the effect of biomass returned to the soil, including material from plant or animal sources, and material either imported to the site or grown and retained on the site.

FO is the field operations factor. This component accounts for the effect of field operations that stimulate organic matter breakdown. Tillage, planting, fertilizer application, spraying, harvesting, and other operations crush and shatter plant residues and aerate or compact the soil. These effects increase the rate of residue decomposition and affect the placement of organic material in the soil profile.

ER is the erosion factor. This component accounts for the effect of removal and sorting of surface soil organic matter by sheet, rill, or wind erosion processes as predicted by water and wind erosion models. It does not account for the effects of concentrated flow erosion, such as ephemeral or classic gullies.

Other considerations. A soil texture correction factor added to the original SCI increased the accuracy of the model by requiring more biomass production to maintain the level of organic matter in the coarser textured soils. The Revised Universal Soil Loss Equation decomposition functions are used in the model to estimate relative rates of plant residue decomposition at different locations. Climate is one of the most important factors determining decomposition rates. The effect of residue quality or C:N ratio on decomposition is also considered.

Linking SCI and RUSLE2

NRCS is working with developers of RUSLE2 to incorporate the SCI within the erosion control model. When the two models are linked, users will automatically receive an SCI value after entering data into RUSLE2 to predict water erosion. Any additional wind erosion or irrigation-induced erosion would need to be added. A stand-alone worksheet will remain available for those who do not use RUSLE2.

Using the SCI

The latest version of the Soil Conditioning Index is available at the Soil Quality Institute Web site (http://soils.usda.gov/sqi) or the following site: ftp://ftp.nssc.nrcs.usda.gov/pub/agronomy/SCIfiles/latest_revisions. Download the file named <sciver25.xls> or the latest version with a higher number. Running the file requires Microsoft Excel 5.0 or a later version. The User's Guide (available at the same locations) provides a full explanation of how to use the program.

Users must provide seven types of information about the field to be evaluated:

- Location (to determine climate data)
- Soil texture
- All crops in the crop rotation
- Typical yield for each crop
- Applications of additional organic matter, such as manure or compost
- All field operations including tillage, applications of fertilizer and manure, and harvesting
- Rate of wind and water erosion

The spreadsheet returns values for each component—OM, FO, and ER—as well as the overall SCI.

Interpreting SCI results

If the calculated index is a negative value, the level of soil organic matter is predicted to decline under the production system. If the index is a positive value, the level is predicted to increase under the system. Values near zero (i.e., 0 ± 0.05) suggest that organic matter will be maintained near the current level.

The results cannot be used to predict the amount of organic matter or the rate of change. Higher values only indicate more confidence that a trend in soil organic matter will be significant. For example, consider a cropping scenario with an SCI value of 0.4 compared to a second scenario with an SCI of 0.2. Carbon and organic matter levels will increase under both systems, and a significant increase is more likely under the first scenario. It is inappropriate to say the first will store twice as much soil organic matter or store it twice as fast as the second. Furthermore, the SCI does not indicate a desirable or target level of soil organic matter. For example, a near-zero SCI value indicates that the level of soil organic matter is being maintained, but soil health may still be poor if the organic matter is maintained at a low level.

If the SCI value is negative, it is helpful to focus on the subfactor(s) that has the most influence on the index. The conservation planner should develop alternative combinations of crops and field operations for the producer to consider. Erosion values must be adjusted for each alternative as a new SCI is generated.

If a farmer decides to change practices to improve the level of soil organic matter, the planner should explain what changes to expect and how to monitor the changes so adjustments can be made if needed. It may take several years to measure an increase in total soil organic matter, but related soil properties, such as aggregation, infiltration, and biological activity, are likely to improve more quickly.

The SCI may produce misleading results when one of the components is near zero. For example, tillage losses of organic matter (FO factor) may be balanced by a low ER factor because of flat slopes or a high OM factor because of extremely high yields. The result may be a positive SCI even though organic matter quality and soil quality are poor. Overall, SCI values near zero suggest the need for practices that generate a higher positive SCI value and thus inspire more confidence that organic matter is not degrading.

The relationship of SCI to soil quality

The SCI should not be used as the sole assessment of soil quality or conservation planning. As with any model or assessment tool, the SCI should be used in combination with other observations and evaluations. If the planner sees problems with infiltration, runoff, poor aggregation, or other soil quality concerns, the field evaluation should take precedence over the model and conservation practices should be planned to address the soil quality problem.

In addition to the level of organic matter, other important aspects of soil quality are the quality of the organic matter, compaction, crop diversity, salinity, sodicity, sedimentation, soil biota, nutrient management, contaminants, and the effects of irrigation management. These are related to the level of organic matter but are not directly reflected in the SCI.

For example, crop diversity is not directly considered in the SCI estimates. Crop diversity has important impacts on organic matter quality and soil quality generally (NRCS 1996). In addition to examining total biomass production of a rotation as indicated by the SCI, planners should look at the diversity of the rotation by using a worksheet like the one available for the Northern Plains from the Dakota Lakes Research Farm (see references).

Validating the SCI model with long-term soil organic matter experiments

Comparisons of SCI outcomes with long-term carbon experiments showed good correlations (Hubbs et al. 2002). Table 1 lists the long-term carbon experiments used to validate the model. Soil Conditioning Indices were generated for each management system at various sites and then were compared to the measured changes in soil carbon at the same sites. Soil information and field operations described in the references were used to estimate soil losses using RUSLE. The SCI predicted the correct trend in about 90 percent of the assessed systems. The few erroneous predictions occurred in western states at sites with high inputs from manure or legumes. Further investigation is needed to adjust organic matter decomposition rates to accommodate these situations.

The conclusion of this study was that the SCI predicted the direction but not the magnitude of changes in soil organic matter accurately enough to inform land management decision-making. The SCI may be able to predict magnitude in the future if the model is adjusted for regional variations in organic matter decomposition rates as affected by soil drainage properties and rainfall.

Table 1: Long-term carbon studies used to validate the SCI.

Location and duration of study	Crop rotations grown	Tillage systems	References used to obtain data
Pendleton, OR 55 years	Wheat–fallow	Conventional	Ramussen and Parton 1994
Akron, CO 10 years	Wheat–fallow	Conventional/ No-till	Halvorsen et al. 1997
Bushland, TX 30 years	Wheat–fallow; Continuous wheat	Sweep/ One-way sweep	Unger 1982
Bushland, TX 10 years	Wheat; Sorghum	Stubble mulch/ No-till	Potter et al. 1998
Crossville, AL 10 years	Corn–wheat cover crop; Soybean–wheat cover crop; Corn–wheat cover–soy–wheat cover	Conventional/ No-till	Edwards et al. 1992
Lexington, KY 15 years	Corn–rye cover crop	Conventional/ No-till	Ismail et al. 1994
South Charleston, OH 28 years	Corn	Conventional/ No-till	Mahboubi et al. 1993
Athens, GA 6 years	Soybean; Sorghum–rye or clover cover crop	Conventional/ No-till	Hendrix ,1997
Florence, SC 14 years	Corn–wheat/soybean; Corn–wheat/cotton	Conventional/ No-till	Hunt et al. 1996

Summary

The Soil Conditioning Index can be used to:

- Predict a positive or negative trend in soil organic matter on agricultural land,
- Predict how modifications of a management system will affect the level of soil organic matter,
- Evaluate conservation management systems, when used along with other assessment methods.

The SCI cannot:

- Indicate the desirable or potential level of soil organic matter for the site.
- Predict the rate or magnitude of changes in soil organic matter. This kind of prediction may be possible in the future after the model is adjusted for regional differences.

The SCI may be less reliable when:

- SCI is near zero (i.e., –0.05 to 0.05).
- Conventional tillage is combined with very low erosion rates or very high residue yields. In these cases the SCI may indicate a better trend in soil organic matter than the actual rate of soil carbon change.
- Manure or legumes provide high nitrogen inputs. Further investigation is needed to adjust decomposition rates.

The SCI is a simple tool that accurately predicts trends in organic matter through consideration of biomass production, field operations, and erosion rates. Organic matter is the most important single indicator of soil quality, but it is not the only indicator. Crop diversity, salinity, and other factors must also be considered.

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