INTERPRETING THE SOIL CONDITIONING INDEX

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ABSTRACT

The Soil Conditioning Index (SCI) is a tool for organic matter prediction used by the Natural Resources Conservation Service (NRCS) that utilizes the effects of climate, tillage, and erosion on organic matter decomposition at various geographic locations. The three components of the SCI include (1) the amount of organic material returned to the soil, (2) the effects of tillage and field operations on soil organic matter decomposition, and (3) the effect of predicted erosion associated with the management system. The SCI gives an overall rating based on these components. The original intent of this predictive tool assumed that a negative rating would indicate soil organic matter degradation, a zero would mean status quo, and a positive number would mean an increase in soil organic matter. The objectives of this study were to generate SCI ratings for plots in long-term carbon studies in several regions of the country and interpret the ratings compared to actual organic matter trends. Results show carbon gains correlated with positive SCIs and losses with negative SCIs. The accuracy of the predicted rate of change was better for the east (0.76) than the west (0.56). In both regions, further division on a state basis improved prediction of rate of change. The SCI may need regional calibration with additional research for differences in internal drainage. This study indicated favorable potential for the SCI to predict trends in organic matter content for conservation planning and carbon sequestration.

KEYWORDS

Soil erosion, soil quality, soil organic matter, regional assessment

INTRODUCTION

For much of its history, NRCS (formerly SCS) worked primarily with erosion on agricultural and other lands. Predictive tools such as the Universal Soil Loss Equation (USLE) and the Wind Erosion Equation (WEQ) enhanced conservation for erosion control. As the mission of the agency was broadening to include other resources – soil, water, air, plant, and animal – new planning tools were needed for the multi-resource concerns.

One area of concern is the degradation of soil quality as influenced by management. The Soil Conditioning Index (SCI) is an organic matter prediction tool used by the Natural Resources Conservation Service in conservation planning (NRCS, 2001) to ensure that organic matter is improving based on the application of conservation practices. Practices such as Conservation Crop Rotation (328) and Residue Management (Mulch Till – 329B, No-till – 329 A, and Ridge Till – 329 C) include standards that have criteria to maintain or improve soil organic matter content as predicted by the use of the SCI. With the potential for carbon-based programs in the upcoming farm bill and the interest in carbon sequestration, NRCS field offices need a simple, easy-to-use method to estimate trends of organic matter as influenced by management.

MATERIALS AND METHODS

The SCI estimates the combined effect of three components on trends of organic matter. Soil organic matter trends are assumed to be an indicator of improvement or degradation of soil quality. The formula for the SCI is SCI = OM + FO + ER where:

OM IS ORGANIC MATERIAL OR BIOMASS

This component accounts for the effect of biomass returned to the soil. Organic material from plant or animal sources may be grown and retained on the site or imported to the site.

FO IS FIELD OPERATIONS:

This component accounts for the effect of field operations that stimulate organic matter breakdown. Tillage, planting, fertilizer application, spraying, and harvesting crush and shatter plant residues, as well as aerating or compacting the soil all affect and increase the rate of residue decomposition and the placement of organic material in the soil profile.

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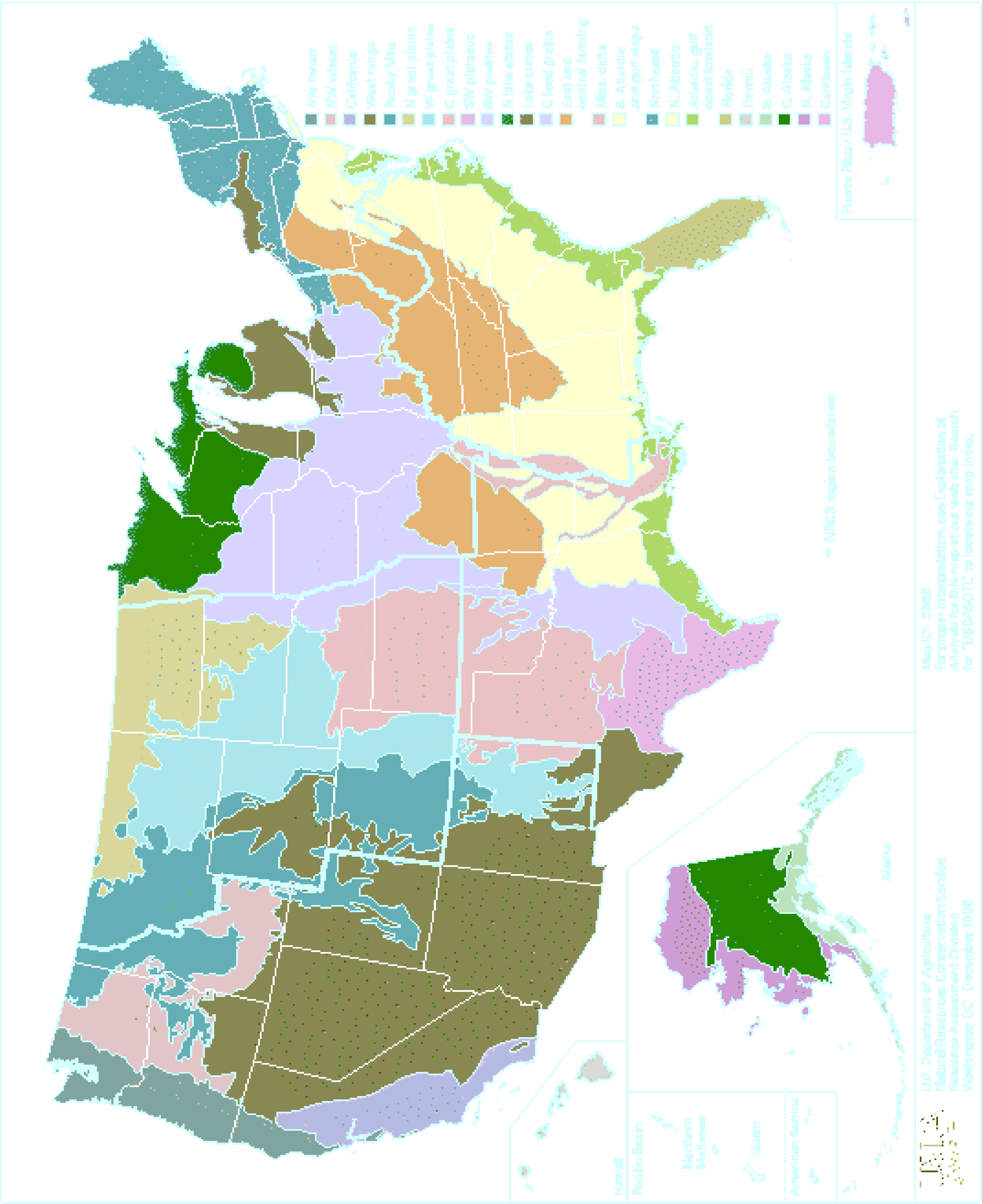
NW forest
NW wheat
California
West range
Rocky Mtn.
N great plains
W great plains
C great plains
SW plateaus
SW prairies
N lake states
Lake states
C feed grains
East and central farming
Miss. delta
S. Atlantic and gulf slope
Northeast
N. Atlantic
Atlantic, gulf coast lowland
Florida
Hawaii
S. Alaska
C. Alaska
N. Alaska
Caribbean
Puerto Rico / U.S. Virgin Islands
— NRCS region boundaries
Map ID: 3968
For proper interpretation, see Explanation of Analysis for this map at our web site. Search for "USDA SOTC" to locate our map index.
Alaska
U.S. Department of Agriculture
Natural Resources Conservation Service
Resource Assessment Division
Washington DC December 1998
Hawaii
Pacific Basin
Northern Mariana
Guam
American Samoa

ER IS EROSION:

This component accounts for the effect of removal or sorting, or both of surface soil material by sheet, rill, or wind erosion processes that are predicted by water and wind erosion models. It does not account for the effect of concentrated flow erosion such as ephemeral or classic gullies. Erosion contributes to loss of organic matter and decline in long-term productivity.

A soil texture correction factor was added to the original SCI based on findings from carbon measurements on different soil textures (Norfleet, unpublished). The Revised Universal Soil Loss Equation (RUSLE) decomposition functions are used in the model to estimate relative rates of plant residue decomposition at different locations. Climate at each location is expressed as average monthly precipitation and average monthly temperature.

Soil Conditioning Indices were generated and compared from long-term experiments that had been reported to gain or lose carbon. Certain Land Resource Region Groups, LRRs (Figure 1) were used for a representative sample of the country (Soil Conservation Service, 1981). We selected long-term carbon experiments of 10 or more years with the exception of Athens, GA (six years). Table 1 lists the location, years of duration at time of measurements, LRR Group, crops grown, tillage systems, and key references used to obtain data for the experiments.

We converted all carbon findings from the experiments to percent because of the inconsistencies found in the experimental data reported (i.e. bulk densities not reported at the end of experiments or not reported at all). Soil information and field operations described in the references were used to estimate soil losses using the revised soil loss equation (RUSLE).

RESULTS AND DISCUSSION

In the Western USA experiments (Figure 2), carbon gains began with a positive number as indicated by the intersect line at zero. The correlation between carbon gains and SCIs was not as solid for the west compared to the east (R^2 of 0.56 and 0.76, respectively, Figures 2 and 3). Although the correlation was lower, the SCIs in the west accurately predicted carbon trends and none of the systems estimated a loss where there was none. A negative SCI was always associated with a negative carbon trend. In the west region, further division on a state basis improved prediction. When the states were divided out independently, the R^2 improved (Figures 4, 5, and 6). Thus, to be useful in predicting rate of change, the SCI may need regional

Table 1. Crops, tillage and references from long-term carbon studies.

Location	Yrs	LRR	Crops	Tillage	References
Pendleton, OR	55	B	Wheat-fallow	Conventional	Ramussen and Parton, 1994
Akron, CO	10	G	Wheat-fallow	Conventional/ No-till	Halvorsen et al., 1997
Bushland, TX	30	H	Wheat fallow/ Continuous wheat	Sweep/One-Way sweep	Unger, 1982
Bushland, TX	10	H	Wheat/sorghum	Stubble mulch/No-till	Potter et al., 1998
Crossville, AL	10	N	Corn-wheat cover crop, soybean-wheat cover crop, corn wheat cover-soybean-wheat cover crop	Conventional/ No-till	Edwards et al., 1992
Lexington, KY	15	N	Corn-rye cover crop	Conventional/ No-till	Ismail et al., 1994
South Charleston, OH	28	M	Corn	Conventional/ No-till	Mahboubi et al., 1993
Athens, GA	6	P	Soybean/sorghum with rye or clover cover crop	Conventional/ No-till	Hendrix et al., 1997
Florence, SC	14	P	Corn/wheat-soybean and wheat/cotton	Conventional/ No-till	Hunt et al., 1996

calibration with additional research for differences in rainfall and decomposition in regions receiving less than 35 in (889 mm) annually. Although the current model of SCI accounts for texture, additional research may be necessary for differences in drainage.

The Eastern USA carbon studies showed more accuracy with the model as reflected by the R^2 (Figure 3). All of the studies in the east had cover crops or were double-cropped except the corn study in Ohio. The cover crops and double crops accounted for more organic material in the rotations along with the fact that most of the experiments were on level ground (low erosion), which resulted in mostly positive SCIs. By adding the soil texture correction, the SCI began to predict gains with a positive SCI, whereas before the SCI needed to be at 0.18 before OM gains were seen. The soil texture correction also improved the accuracy of predictions in conventional tillage when higher residues were produced and erosion rates were low.

CONCLUSION

As NRCS and other conservation planners begin using the SCI as an organic matter maintenance tool, it is important that they consider the entire system that the three sub-factors of the SCI represent, and how they combine to form an overall SCI. Since this comparison was done from experimental plots, erosion was not a determining factor to the SCI since they tend to be on more gentle slopes. This was reflected in the higher scores (higher = less erosion) for the erosion sub-factor in the SCIs (not shown). Most of the problems seen in this study were with conventional tillage systems that generated positive SCIs but had negative carbon trends. We expect better correlations on land with slopes greater than 2% where the lower erosion scores will contribute to a lower SCI. However, if conservationists are seeing positive SCIs that are near zero, but soil degra-

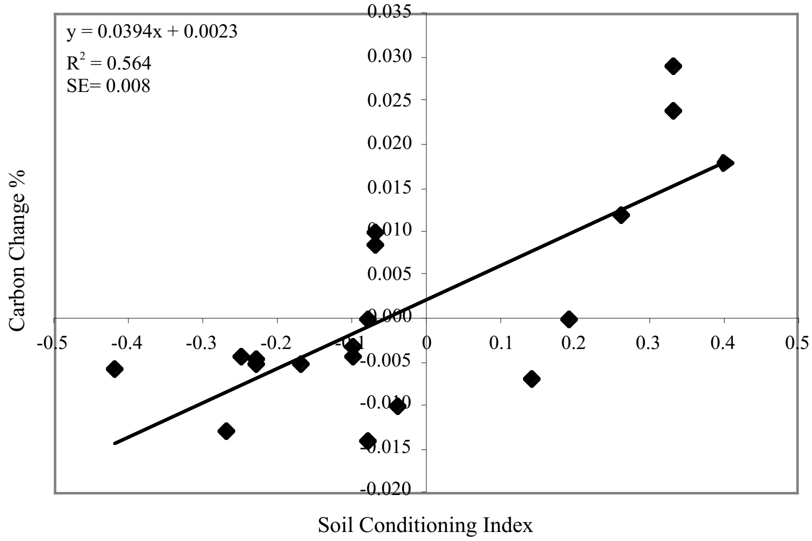

Fig. 2. Soil Conditioning Index vs % Carbon Change for the Western USA.

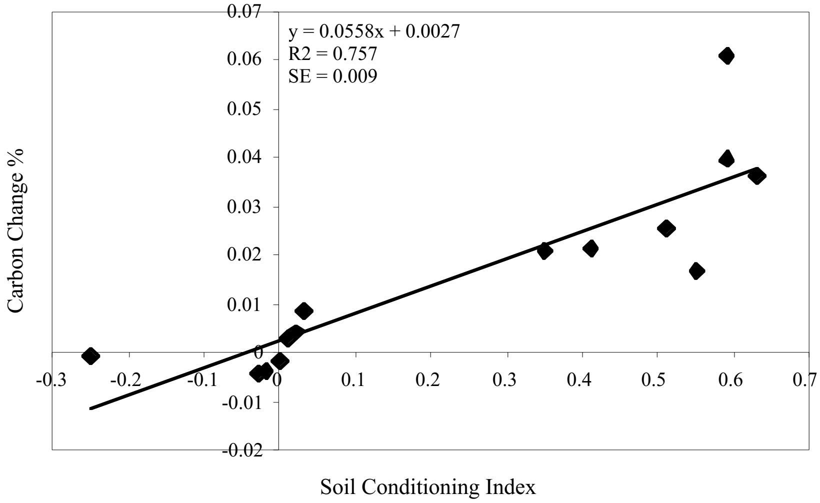

Fig. 3. Soil Conditioning Index vs % Carbon Change for the Eastern USA.

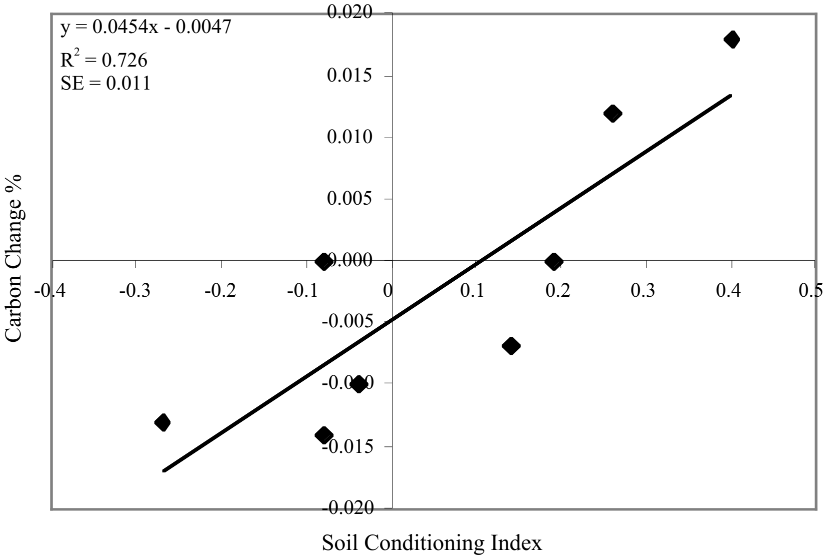

Fig. 4. Soil Conditioning Index vs % Carbon Change for Texas

dation is still evident, then further inventory of the resources may be needed. Based on comparison of SCIs with these long-term carbon studies, we found the following: (1) In the Western and Eastern USA, positive trends of carbon follow positive SCIs; (2) negative SCIs were associated with negative carbon trends in both the west and the east; (3) The R^2 in the west improved when we separated the data by states; and (4) problems with the model associated with conventional tillage on flatter slopes were corrected by adding texture to the model. The SCI may need calibration for certain regions especially in the west. More studies from different regions are needed.

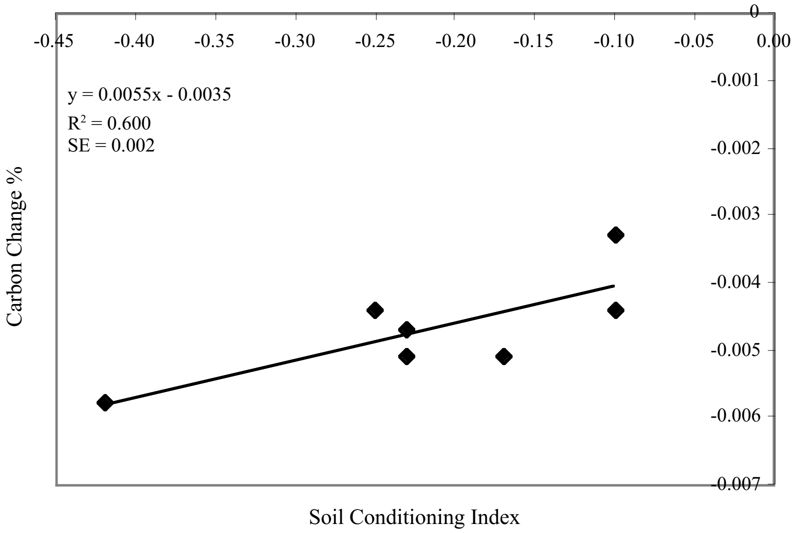

Fig. 5. Soil Conditioning Index vs % Carbon Change for Oregon.

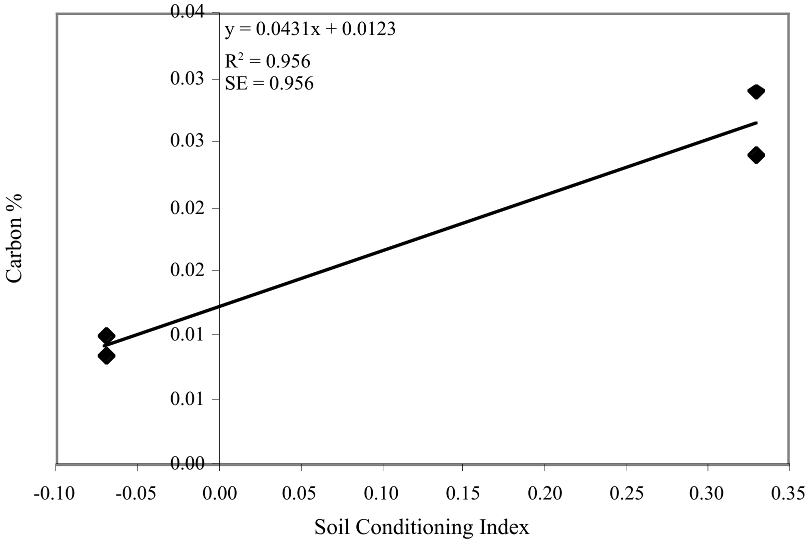

Fig. 6. Soil Conditioning Index vs % Carbon Change for Colorado.

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