The Soil Conditioning Index Model Service

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The Soil Conditioning Index (SCI) estimates trends in soil organic matter, one of the soil quality resource concerns assessed by the USDA Natural Resources Conservation Service (NRCS) for conservation planning. The current SCI foundation rests primarily on the Blacklands Farming System studies conducted in 1949-59 at Renner north of Dallas, Texas, but also on studies in Iowa, Missouri, Montana, and other locations through the years. The first soil conditioning indices were published in 1964 for crops grown in the western U.S., followed by indices in 1987 for crops in the Southeast. Subsequent refinements to the SCI culminated in a spreadsheet application in 2002, published in the 2002 NRCS National Agronomy Manual, and integration with the desktop Revised Universal Soil Loss Equation version 2 (RUSLE2) application version deployed to NRCS county offices in 2006. SCI code from RULSE2 was converted and integrated into the desktop Wind Erosion Prediction System (WEPS) application in 2010, also deployed to NRCS county offices. See Kome et al. (2013), SWCS (2008), and Zobeck et al. (2007) for additional history and context. Both RUSLE2 and WEPS calculate SCI using the same computational algorithms, although RUSLE2 is written in C++ and WEPS in FORTRAN 95.

In 2012 both RUSLE2 and WEPS computational engines, including their SCI components, were wrapped as model web services deployable to cloud computing platforms and other data center infrastructures. These web services currently support RUSLE2 v2.5.11, the version released to NRCS offices in 2014, and WEPS v1.5.x, the version to be released to NRCS in 2016. Since both RUSLE2 and WEPS calculate a soil conditioning index value for the crop rotation being evaluated, a SCI web service consumes input from both models and computes a total index value. As the methods used to calculate SCI may continue to be refined, this brief paper describes the logic in the currently deployed RUSLE2, WEPS, and SCI web services.

The basic formula for the Soil Conditioning Index remains SCI = OM*0.4 + FO*0.4 + ER*0.2 where OM is the subfactor accounting for organic material returned to the soil, FO the subfactor for the effect of field operations on organic matter breakdown, and ER the subfactor accounting for sorting and removal of surface soil material by water and wind erosion.

For organic matter returned to the soil each year, OM = (RP – MA) / MA where RP is the total residue production returned to the soil, and MA is the maintenance amount of residue required to sustain the organic matter content of the soil. RP accounts for buried residue, dead roots, live roots, stranding biomass, and ground cover biomass. Both RUSLE2 and WEPS apply location and crop-based residue decomposition algorithms, eliminating the need for residue equivalent value (REV) tables previously used by the legacy SCI spreadsheet application and non-automated methods in the past. The base MA value comes from the Renner studies: 0.35155 kg/m^2/yr (3136.5 lbs/ac/yr). Both RUSLE2 and WEPS adjust MA using multipliers ranging from 1.0 – 1.6 for fine to coarse textured soils.

For field operation effects on organic matter breakdown, FO = (RennerSTIR –

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ScenarioSTIR) / RennerSTIR. ScenarioSTIR is the soil tillage intensity rating (STIR) for the scenario being assessed. Each field operation in the crop rotation has an assigned STIR value from the national Land Management Operations Data Warehouse (LMOD). Both RUSLE2 and WEPS compute a crop rotation STIR value. The RennerSTIR value is 101.0, reflecting the field operations of the crop rotations used to derive the base MA value at Renner, Texas.

For sorting and removal of surface soil material, ER = (RennerErosion – ScenarioErosion) / RennerErosion. ScenarioErosion is the sum of wind erosion computed by WEPS and water erosion computed by RUSLE2 for the farm field slope/region evaluated. The RennerErosion value is 0.56939 $kg/m^2/yr$ (2.54 t/ac/yr), the sum of water and wind erosion from the crop rotations used to derive the base MA value at Renner, Texas.

The SCI model web service computes a total SCI value applying the following logic: if wind erosion > water erosion, use WEPS OM and FO, else use RUSLE2 computed OM and FO. Then Total SCI = OM * 0.4 + FO * 0.4 + ER * 0.2. RULSE2 simulates water erosion daily through the crop rotation period, whereas WEPS simulates wind erosion daily through the crop rotation, for NRCS repeated through 50 years of generated climate and wind records. Therefore, RUSLE2 and WEPS may produce slightly different OM values, the reason for using OM and FO values from the model computing the higher erosion rate.

The SCI, RUSLE2, and WEPS model web services are HTTP-based RESTful services employing JavaScript Object Notation (JSON) request and result data payloads. Supporting data web services include LMOD (crops/operations by crop management zone), SSURGO (soils), CLIGEN (precipitation/temperature), RUSLE2 Climate (R factors), and WINDGEN (wind energy). SCI and associated web service descriptions and endpoints for these services can be accessed at https://alm.engr.colostate.edu/cb/project/csip.

References

Kome, C.E., S.S. Andrews, and A.J. Franzluebbers. 2013. Soil organic carbon assessment using the Carbon Management Evaluation Tool for Voluntary Reporting and the Soil Conditioning Index. JSWC 68(4): 296-305.

SWCS. 2008. Beyond T: guiding sustainable soil management. Soil and Water Conservation Society, Ankeny, Iowa. 16 pp.

Zobeck, T.M., J. Crownover, M. Dollar, R.S. Van Pelt, V. Acosta-Martinez, K.F. Bronson, and D.R. Upchurch. 2007. Investigation of Soil Conditioning Index values for Southern High Plains agroecosystems. JSWC 62(6): 433-442.