Simulating Crop Rotations in the Piedmont with Revised Universal Soil Loss Equation 2

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Research shows the benefits of using conservation practices such as conservation tillage, vegetated waterways, adding organic soil amendments and reducing tillage operations. The USDA-NRCS (USDA Natural Resource Conservation Service) provides financial assistance and technical support to help farmers establish these conservation practices on their operations through conservation planning efforts. One of the computer-based conservation planning tools typically used to develop a conservation plan is the RUSLE2 program. RUSLE2 is used by NRCS personnel to estimate soil erosion and other data that is useful to the conservation planning effort.

What is RUSLE2?

RUSLE2 is an acronym for the 2nd version of the **R**evised **U**niversal **S**oil **L**oss **E**quation – a computer model that predicts long-term, average-annual sheet and rill erosion by water. The program is useful for broad-based farming operations and other activities such as conservation practice planning, mining, construction and forestry. NRCS personnel use RUSLE2 as guidance on the farm for:

· Conservation planning
· Inventory of erosion, and
· Estimating sediment delivery.

In addition to sheet and rill erosion losses, the RUSLE2 program estimates: 1) Soil Conditioning Index (**SCI**), 2) Soil Tillage Intensity Rating (**STIR**), 3) Soil Loss and 4) Fuel Costs. These outputs are used together to evaluate the impact of existing farming operations on soil loss and soil organic carbon. The output values also can be useful in helping decide which conservation practice(s) will provide the most benefit for reducing soil losses and increasing soil carbon. The impact of the SCI and STIR

outputs are presented in more detail below and are used in an example that shows how conservation practices can affect these values in a Piedmont farming operation.

What is the SCI (Soil Conditioning Index)?

In farming operations, soil organic matter is the foundation of a good, productive soil. Organic matter is the building block for improving soil bio-diversity and health, increasing infiltration and reducing runoff and erosion. The SCI is a tool that predicts the effects of different farming operations on the amount of organic matter in the soil profile. The SCI of a particular soil is calculated based on the following equation:

$$SCI = OM + FO + ER$$

where the different factors are defined as:

Organic Matter	(OM)	Amount of organic matter returned to the soil
Field Operations	(FO)	Effect of field operations that stimulate organic matter decomposition
Erosion	(ER)	Removal of soil material as a result of erosion

In the above equation, the organic matter (OM) and field operation (FO) factors account for 80% (40% each) of the SCI value. The remaining 20% is accounted for by the erosion (ER) fraction of the equation.

The SCI value can be negative or positive. A negative value suggests that these farming operations are causing a decline in soil organic matter, whereas a positive value predicts an increase in soil organic matter. A zero or near-zero value suggests that soil organic matter is not changing. One thing to note is that the SCI is a qualitative assessment of the potential for soil organic carbon gain or loss only and should not be taken as an absolute value for planning.

What is the STIR (Soil Tillage Intensity Rating) Factor?

Along with the SCI, the RUSLE2 program calculates and outputs STIR values both for the entire rotation and for each crop year interval. This value is an indication of the amount of soil disturbance occurring during farm operations. Soil disturbance tends to release carbon stored in the soil and reduce soil organic matter content. It is useful to use STIR to compare the relative amount and severity of soil disturbance of different tillage systems. Conventional tillage systems have high STIR values while reduced tillage systems have lower STIR values.

Example: The following site description and table are used as an example of the input data and simulation output from the RUSLE2 program to demonstrate how the SCI and STIR values change with crop rotation and tillage.

Site Description

Soil:	Cecil sandy loam, 2% to 6% slope, eroded
T value:	4.0 tons per acre per year
Slope Length:	100 feet
Average Slope:	5.0%
Location:	Clarke County, Georgia

For the above location and soil, the RUSLE2 model was run multiple times to simulate various tillage operations (conventional verses reduced tillage) and various rotations. The outputs for calculated Soil Loss, SCI and STIR are presented in Table 1.

Table 1. RUSLE2 output from various field operations simulated on a Cecil sandy loam in Clarke County, Georgia. The data shown represent a three-year reduced and conventional tillage rotation. The cover crops in the conservation tillage (No-Till) system were planted in November.
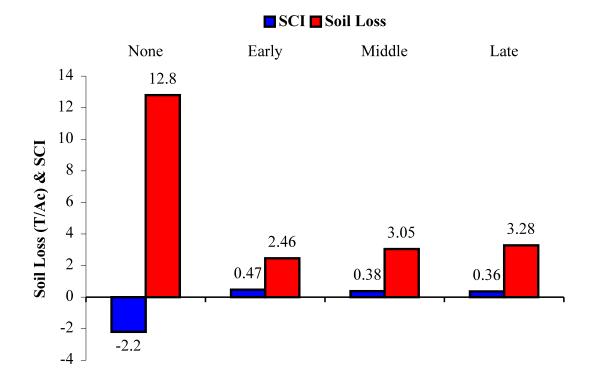
Tillage Type	Rotation*	Soil Loss Tons/Ac	SCI	STIR
Conventional	CO-CO-CO-NC	29.70	-2.20	63.0
Conventional	CR-CR-CO-NC	17.60	-1.30	94.9
Conventional	CR-CR-CR-NC	12.80	-0.95	111.0
No-Till	CO-CO-CO-CC	15.90	-0.96	10.6
No-Till	CR-CR-CO-CC	3.07	0.34	9.7
No-Till	CR-CR-CR-CC	3.05	0.38	11.1

* The crop rotation symbols are: Corn – CR, Cotton – CO, Cover Crop – CC, No Cover Crop – NC
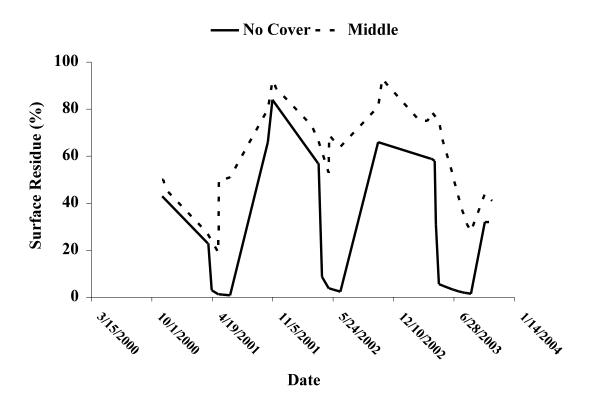
The values in Table 1 are the RUSLE2 output values for a three-year rotation with cover crops being planted in mid-November on the conservation tillage simulations. The data could be used by conservation planners to show that the implementation of conservation tillage with cover crops in a corn-corn-corn rotation reduces soil loss from 12.8 tons per acre to 3.05 tons per acre and changes the SCI value from negative to positive. The STIR value also drops. The positive SCI and lower STIR values can make the farming operation eligible for financial assistance under some NRCS programs. In some states, the lower the STIR value, the higher the conservation practice incentive payment is to the farmer. **Another finding from this example is that the only way to actually build soil carbon levels (positive SCI) in these conditions is with reduced tillage and a cover crop.**

RUSLE2 Outputs: The Impact of Cover Crop Management

Although crop rotation and cover crop management can impact SCI and soil loss, management of the winter cover crop is also important. The SCI and soil loss data for the corn-corn-corn rotation can be seen in Figure 1. Trends in the amount of surface residue predicted by RUSLE2 when the cover crop was planted November 15 (middle) are shown in Figure 2. In a conservation tillage system, the dotted lines show that soil surface is covered with residue all year, whereas, with no cover (solid line), the soil is exposed to the elements and total soil losses are likely to increase due to erosion.

Figure 1. The graph represents RUSLE2 output for SCI and soil loss based on simulations of a corn-corn-corn rotation with alternate cover crop planting dates, including Early (Oct.), Middle (Nov.) and Late (Dec.).

Figure 2. The graph shows that even with late-planted cover crop (November, in this example) in a continuous corn rotation, the soil surface is covered year-round compared to conventional tillage systems without a cover crop. This covered soil results in a lower STIR value and a higher SCI value.

Availability of the RUSLE2 Program

The RUSLE2 program can be downloaded from the Internet. The model can be used by farmers or anyone wanting to run different simulations to get an idea of how changing conservation practices, rotations and planting times can change the SCI and STIR numbers. However, the authors recommend that farmers provide the information to NRCS personnel and work directly with them to provide specific information that will define a particular farming operation. NRCS personnel can also use RUSLE2 output to better explain results of implementing conservation practices and to provide financial assistance options.

Conclusion

RUSLE2 is a simulation program that is used as a guide for NRCS personnel to establish on-farm conservation management systems. Outputs provided by RUSLE2 to develop or evaluate conservation plans include soil erosion, the SCI (Soil Conditioning Index) value and the STIR (Soil Tillage Intensity Rating) value. These two values, as well as soil loss estimates, are dependent on cover crop management, crop rotation and tillage operations used by the farmer. The RUSLE2 model can also be used to compare fuel costs for various operations. Currently, when farmers apply for federal financial assistance programs or technical assistance from the NRCS, the RUSLE2 program is used to indicate potential soil loss rates, SCI values and STIR values. Operations having a positive SCI and low STIR value indicate that the farming operation is potentially building soil organic matter and thereby increasing their eligibility for federal financial assistance programs.

For more information about RUSLE2, the SCI or STIR please contact your local NRCS office.