TECHNICAL NOTES

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The Soil Tillage Intensity Rating (STIR)

The Soil Disturbance Rating, used in the original version of the Soil Conditioning Index has been replaced with the Soil Tillage Intensity Rating (STIR). Doing this facilitates the incorporation of the Soil Conditioning Index into the Revised Universal Soil Loss Equation, Version 2 (RUSLE2), thus eliminating the need to repeat inputs for climate, soil, crop rotation, tillage, etc. when both soil erosion from water and the SCI index need to be determined. RUSLE2 fully incorporates both of these estimates while entering the required data only once. With the SCI in RUSLE2, the previously subjective Soil Disturbance Rating used in the SCI has been replaced with the Soil Tillage Intensity Rating, containing more scientifically based parameters.

The STIR rating in the Soil Conditioning Index can function as a stand-alone rating to evaluate tillage and/or planting systems on parameters other than the traditional ground cover and surface disturbance parameters. It replaces the subjective ratings contained in the Soil Disturbance Rating component of the SCI with more scientifically supported parameters. It utilizes the various operations database parameters in RUSLE2 to calculate a tillage intensity rating for the system used in growing a crop or a rotation. STIR ratings tend to show the differences between systems across the spectrum from true no-till all the way to conventional plow systems. It does this better than surface cover or surface disturbance criteria since the kind, severity and number of ground disturbing passes is evaluated rather than just the end result or a snapshot of conditions after planting.

The components of the STIR rating are the following parameters from the RUSLE2 operations database.

1. Recommended Operating Speed:
   This process represents the recommended speed for this operation. RUSLE2 can compute how speed of an implement affects residue burial. Speed between the range of a minimum and maximum can be entered in the management screen. The recommended speed that the manufacturer suggests for the implement is the default speed for this operation in RUSLE2, and indicates the assumed condition under which the flattening, burial and re-surfacing values are defined.

2. Tillage Type:
   Tillage type describes how the operation mixes the soil and associated residue. This variable refers to the type of mechanical disturbance on the soil, and how that affects the distribution of residue within the soil. The distribution of material, like plant residue, incorporated into the soil depends on the type of mechanical disturbance, referred to as

tillage type. Also, tillage type affects the distribution of material within the soil as subsequent mechanical disturbances, i.e., tillage operations, occur.

The following values are assigned to individual tillage types in the STIR rating:
1.0 – Inversion some mixing
0.8 – Mixing + some inversion
0.4 – Lifting and fracturing
0.7 – Mixing only
0.15 – Compression

a. **Inversion with some mixing** places most of the surface material in the lower half of the depth of soil disturbance (tillage depth). In effect, the soil in disturbance depth is "flipped over" with some mixing in the soil. A moldboard plow is an example of an implement that inverts the soil with some mixing.

b. **Mixing with some inversion** places most of the surface material in the upper half of the depth of soil disturbance (tillage depth). The next operation leaves a somewhat uniform distribution of the material in the soil. Tandem disk, chisel plows and field cultivators are examples of implements that are a tillage type of mixing with some inversion.

c. **Lifting and fracturing** places most of the surface material in the upper three-tenths of the depth of soil disturbance (tillage depth). The next operation or two leaves a somewhat uniform distribution of the material in the soil. Subsoilers, fertilizer and manure injectors and scarifiers are examples of implements of lifting and fracturing.

d. **Mixing only** places most of the surface material in the upper three-tenths of the depth of soil disturbance (tillage depth). The next operation or two leaves a somewhat uniform distribution of the material in the soil. The material becomes increasingly concentrated with subsequent operations and moves down in the soil in a "lump". Rotary tillers are examples of implements of mixing only.

e. **Compression** "pushes" surface material into the soil without the soil being disturbed. The initial distribution of material in the soil is the same as the mixing only tillage type. Examples of implements that are a compression type include sheep foot's rollers used on construction sites and cattle trampling.

3. Recommended Tillage Depth:

Many site operations disturb the soil, causing changes in soil properties and incorporation of surface residue. One of the key parameters is the depth to which the residue is incorporated. Note that this may or may not be the same as the actual depth of tillage. Typical implements work best at a particular tillage depth recommended by the manufacturer.

4. Surface area disturbed:

The value sought here is used to determine the impact of the operation on long-term soil consolidation. A plow assumed to completely invert the surface layer would receive a

value of 100%, while a no-till planter which cuts a 3-inch slot every 30 inches could be assumed to disturb 10% of the surface.

Disturbing the soil causes erosion to increase. Soil that has not been disturbed for an extended period (the time to soil consolidation—typically assumed to be seven years) is assumed in RUSLE2 to only be about 45% as erodible as soil that has been recently disturbed. Operations like planters and drills typically disturb the soil in strips. The fraction (percent) of the total soil surface that is disturbed is the value entered.

Selection of a value for the fraction of the surface disturbed sometimes requires special consideration. In general, the area actually disturbed plus the area receiving soil “thrown” (displaced) by the soil disturbance is used for the input. However, if the displaced soil is very thin, the area of disturbance may be limited to the fraction of the soil surface (source area) that produces (generates) the displaced soil. This consideration is especially important in certain no-till cropping systems where the displaced soil doesn’t interfere with the typical effects of no-till with a buildup of organic matter in an upper surface layer of soil of about 2 inches (50 mm).

Another special consideration is in the Northwest Wheat and Range Region (NWRR) where most of the erosion is by surface runoff. Erosion by surface runoff, which is rill erosion, is concentrated on much less than the total surface. In this situation, a value less than the surface actually disturbed and that actually receives displaced soil can be used so that the proper effects of no-till are represented by RUSLE2.

The parameters used in the STIR rating are derived from the RUSLE2 operations database. Those values are based on a set of Agricultural Research Service (ARS) core operations which the RUSLE2 model developers obtained from various research studies. The STIR rating for an individual operation is calculated by multiplying the individual parameter values and by applying "weighting" factors for each. They are speed x 0.5; tillage type x 3.25; average depth x 1; and surface soil disturbance x 1. This was done in order to calibrate the STIR component to the SCI so the resulting answer would be representative of the original SCI. All of the operations involved in tilling, fertilizing, planting, controlling pests, harvesting the crop and managing residues are evaluated in the STIR rating for a tillage system for a given crop. STIR ratings can be calculated for single crops or for crop rotations. Higher STIR ratings are shown for systems with greater disturbance and more frequent operations. Comparison of STIR ratings for different tillage and planting systems provides insight into the carbon loss, moisture depletion and fugitive dust issues related to tillage of the soil.

Example:

Operation Name	# of Trips	STIR
Year 1		
Grain Sorghum		
Shredder, flail or rotary	1	0.15
Manure spreader, solid and semi-solid	1	0.20
Disk, tandem secondary op.	1	32.50
Disk, tandem light finishing	1	19.50
Planter, runner opener	1	2.60
Cultivator, row 1 inch ridge	1	14.63
Cultivator, row, high residue	1	8.13
Harvest, killing crop 50pct standing stubble	1	0.15
Year 2		
Winter Wheat		
Shredder, flail or rotary	1	0.15
Sweep plow 20-40 inches wide	1	9.75
Disk, tandem secondary op.	1	32.50
Disk, tandem light finishing	1	19.50
Drill or air seeder, hoe/chisel openers 6-12 inch spacing	1	23.40
Harvest, killing crop 50pct standing stubble	1	0.15
Year 3		
Cotton		
Disk, tandem secondary op.	1	32.50
Disk, tandem secondary op.	1	32.50
Disk, tandem light finishing	1	19.50
Planter, runner opener	1	2.60
Cultivator, row 1 inch ridge	1	14.63
Cultivator, row 1 inch ridge	1	14.63
Cultivator, row 1 inch ridge	1	14.63
Cultivator, row, high residue	1	8.13
Harvest, cotton	1	0.15

Cumulative (Total) Soil Disturbance Rating (SDR) 302.55

Average Annual SDR = 302.55 / 3 = 100.85 for the rotation