RUSLE2 Learning Module

Alan Keninger

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Acknowledgements

- Allan Ciha
- Jesse Drew
- Tom Schultz
- Kenneth Moore
- Tom Lonachyn
- Shari, Alyssa, and Dustin

My Roots

- Family farm in North Central Iowa
- Six brothers and sisters
- Raised 500 head of feeder cattle.
- 500 head of laying hens.
- 1000 head farrow to finish swine.
- 300 acres of cropland
- Corn/Soybean rotation, with 15 acre permanent hay and 15 acres of oats.
- Tillage was conventional, plowed everything in the fall, disk, field cultivate in the spring before planting.
- Every acre of row crop was cultivated at least once.
- Manure was applied to oats and corn fields.
- Two brothers farm the family farm

Family

- Married for 24 years to my wife Shari
  - World Class Artistic Roller Skater
  - CPA
- Two children
  - Alyssa - senior at Simpson
    - Planning on attending Law School
    - On the Simpson Dance Team
  - Dustin - senior at Newton High School
    - Competitive Trap and Skeet Shooter
    - Plans on attending Ellsworth Community College in Building Trades

Hobbies

- Gardening
- Salsa
- Jalapeño Jelly
- Camping
- Hunting
- Canoeing (Boundary Waters)
- Working at Bass Pro Shop

Activities

- Jasper County Pheasant Forever Board
- Member of Isaac Walton League
- Coach Newton High School Trap Team
- State 4-H Safety and Education in Shooting Sports advisory committee
- Scholastic Clay Trap Program Board of Director

Education

- AAS Agriculture Business Ellsworth Community College 1982
- BS Agriculture Education from Iowa State University 1985
- MS Agriculture Education from Iowa State University 1990

Work Experience

- 1979-1981 Custom Applicator Regional Cooperative
- 1985-1990 High School Ag Science Teacher
- 1990-1994 Agronomy Sales Regional Cooperative
- 1994-1999 Agronomy Department Sales Management Regional Cooperative
- 2000-2001 Value-Added Specialist Regional Cooperative
- 2001-2009 County Extension Education Director Iowa State University
- 2009-Agronomy and Horticulture Program Specialist Iowa State University

Why Master of Science Agronomy Distance Education Program?

- As a kid I was loved playing in the dirt and helping my dad farm.
- Agronomy is the basis for all production agriculture, which is at the heart of Iowa's economy.
- Without the Distance Education Program I would not been able to complete my Masters of Science Degree.
- Job opportunities increase with a Masters of Science Degree in Agronomy.

Why RUSLE2 Learning Module?

- Love of farming and production agriculture
- CCA Credit
- RUSLE2 and Phosphorous Index Workshop April,2009
- THAT SMELL

RUSLE2 – Soil Loss Equation

Alan Keninger

Allan J. Ciha

Photos courtesy of NRCS

RUSLE2 – Soil Loss Equation

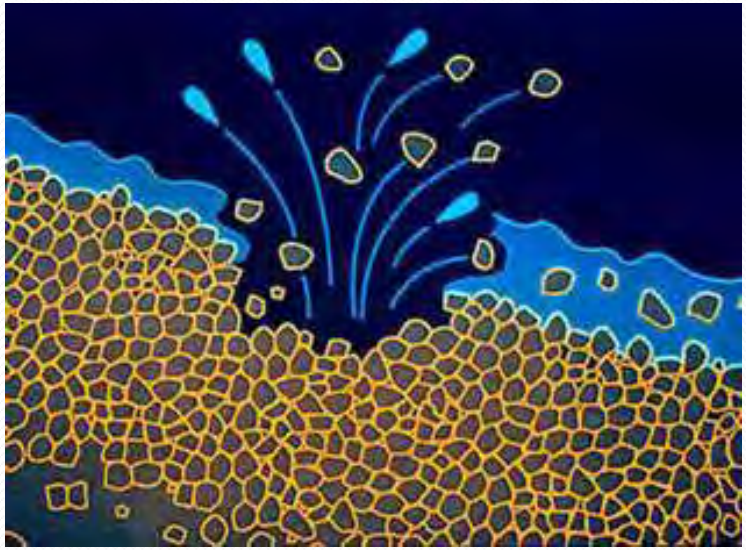
Course Index

Ephemeral gully. Courtesy of Lynn Betts, NRCS

Introduction

Soil erosion is defined as detachment of and movement of soil or rock by water, ice, or gravity (Brady and Weil, 2002**)**. During soil erosion there are three steps that are involved:

- Detachment of soil particles from the soil mass.
- Transportation of the detached particles downhill by floating, rolling, dragging, and splashing.
- Deposition of the transported particles at some place in lower elevation.



Rain-splash erosion. Courtesy of vbco.org.

Introduction

Many times in agriculture we look at tolerable soil loss. What is a tolerable soil loss?

Smith (1941) quantified this concept by introducing 'tolerable soil loss factor' which, if not exceeded, will not cause loss of productivity. He defined 'tolerable soil loss factor' as not exceeding 4 tons of soil per acre per year. In 1956, a tolerable soil loss or T-value of 5 tons per acre was proposed by the USDA. This acceptable soil loss was based on $2 per ton of N and P and a loss of more than $10 were considered to be unacceptable.

Alexander (1988) suggested that soil formation can occur at 0.24 tons per acre per year. With this being the case soil replacement is 10 to 100 times slower than our typical tolerable soil loss. Other soil scientists have suggested that an acceptable soil loss be equal to the amount of soil formation.

Whatever method is used to determine what an acceptable tolerable soil loss is, a way is needed to predict what the soil loss will be for each of our fields. This is where the Revised Universal Soil Loss Equation (RUSLE2) becomes important. The universal soil loss equation has six main components:

rainfall erosivity	soil erodibility	slope length
slope gradient	cover management	erosion control practices

Introduction

In this module we will consider the different types of erosion and look at the Revised Universal Soil Loss Equation (RUSLE2) and the factors that RUSLE 2 uses to calculate soil loss.

Objectives

- ✓ Identify and describe the six components of the RUSLE 2 soil loss equation.
- ✓ Discuss management changes that can take place to reduce soil loss.
- ✓ Examine a case study where the RUSLE 2 soil loss equation is used to determine soil loss.

Rill erosion. Courtesy of Lynn Betts.

Types of Soil Erosion

There are four main types of soil erosion. Each type of soil erosion plays a role in the overall soil loss equation. Sheet and rill erosion are the two erosion types that move the largest quantity of soil each year. The four main types of soil erosion caused by water are:

- Rain splash erosion
- Sheet erosion
- Rill erosion
- Gully erosion

Photos Courtesy of NRCS.

Types of Soil Erosion

Rill Erosion

As sheet erosion flow is concentrated into tiny channels (rills), rill erosion becomes dominant. Rills are common on fallow and freshly tilled soils with little or no vegetation.

Rills can be smoothed out by tillage. Even through rills can be removed, damage has been done to the soil. Soil has been dislodged and transported to another location.

Rill erosion is common in the Palouse region of Washington state where soil is frozen only an inch or so deep in the winter. Winter rainfall accumulates as it flows down hill and breaks through the frozen soil layer to the unfrozen soil. This becomes the rill channel for water flow down hill.

Example of rill erosion in NW Iowa. Courtesy of Lynn Betts, NRCS.

History of Soil Loss Equations

The Universal Soil Loss Equation (USLE) was developed and released in the early 1960s as a tool to aid conservationists in making farm plans. The USLE was used to provide an estimated soil loss per field and per farm. This allowed conservationists to make farm plans tailored to each producer's unique set of needs to aid in reducing soil erosion.

The USLE was widely used in the 1970s by conservationists. Since, its release in the early 1960s the USLE has gone through changes to make it a better modeling program. In 2003, the Revised Universal Soil Loss Equation 2 (RUSLE2) was developed jointly by the USDA-Agriculture Research Service (ARS), Natural Resources and Conservation Service (NRCS), and the University of Tennessee.

The objectives of RUSLE2 were to guide conservation planning, inventory erosion rates, and estimate sediment delivery. The State of Iowa also uses RUSLE2 to determine Phosphorus Index for Manure Management Plans. RUSLE2 is a tool that is moving from the conservationist's toolbox to a more mainstream general application and acceptance.

For more information about the history of USLE refer to the following publication from the NRCS. RUSLE2

Components of RUSLE2

To determine the quantity of soil loss that can occur from a field, scientists developed the RUSLE2 (**R**evised **U**niversal **S**oil **L**oss **E**quation, Version **2**). With this equation soil scientists can predict the quantity of soil loss that can occur from a field. The RUSLE2 formula consists of several factors that help in determining the soil lost.

RUSLE2 Equation

A = RKSLCP

A = computed average annual soil loss in tons of soil per year

R = rainfall factor
K = soil erodibility factor
S = slope gradient factor
L = slope length factor
C = crop management factor
P = erosion control practice factor

Components of RUSLE2

Rainfall Factor

The rainfall factor (R) for the Universal Soil Loss Equation (USLE) was derived in 1959 by Wischmeier and Smith. Their research indicated that when factors other than rain are held constant, soil losses from cultivated fields could be predicted.

Rainfall intensity and amount are two factors that are used to calculate the R factor along with the seasonality of rain events. In RUSLE2 the mean peak ½ hour rainfall is used to determine the R value for each month of the year. Rainfall factor represents the driving force for sheet and rill erosion. When comparing rainfall events, the more intense (inches/hour) the rainfall is; the more severe the erosion. A gentle 2-inch rain will cause less damage than a downpour that drops 0.5-inch in 30 minutes.

To compare rainfall factor numbers with locations to other parts of the United States and the Midwest (courtesy of Renard et al., 1997) view the attached maps.

As we go through the next few slides of this module we will do an example calculation of RUSLE2 for Ames, Iowa where the rainfall factor (R) is 150.

Components of RUSLE2

Soil Erodibility Factor

Here is an example that can be used to get a K value, this was provided by R. Borges.

With appropriate data, enter scale at left and proceed to points representing the soil's percent sand (0.10 - 2.0 mm) - represented in red, percent organic matter - represented in green, structure - represented in blue, and permeability - represented in orange in that sequence. Interpolate between plotted curves. The purple dotted line illustrates procedure for a soil having silt + very fine sand 65%, sand 5%, organic matter 2.8%, structure 2, permeability 4. The value of K = 0.31. We will use this number in our calculations for Ames, Iowa.

What would the K value be using the following information:

Silt, fine sand, and sand	50%	50%	50%
Organic matter	3%	2%	3%
Structure	3	3	3
Permeability	5	5	1

The correct answer is?	0.30	0.38	0.29

Components of RUSLE2

Slope Gradient and Slope Length

These sub-tables are for low, moderate, and high ratios of rill to inter-rill and thawing soils. L and S can be evaluated separately, but are generally evaluated together.

The table prepared by R. Borges provides values for L and S. For our example for Ames, Iowa use 4% slope and 75 feet in length. This will give a LS value of 0.47 for moderate rill to inter-rill erosion.

What we have in our equation so far is rainfall (R = 150), soil erodibility (K = 0.31), and slope length and slope steepness (LS = 0.47).

A = 150 X 0.31 X 0.47 X C X P.

Length (L-ft) and Slope (S-%)	Low rill to inter-rill erosion [a]	Moderate rill to inter-rill erosion [b]	High rill to inter-rill erosion [c]	Thawing soils
L=75				
S=1.0	0.14	0.14	0.14	0.14
S=4.0	0.46	0.47	0.47	0.47
S=8.0	0.90	0.91	0.91	0.91
L=200				
S=1.0	0.15	0.16	0.18	0.23
S=4.0	0.43	0.67	0.79	0.77
S=8.0	1.23	1.45	1.72	1.48

a= rangeland and coils with cover crop
b=generally row-cropped agricultural land
c= freshly prepared soil or highly disturbed soil
Adopted from R. Borges Chapter 4 Agronomy 532

Components of RUSLE2

Crop Management

Tillage was previously looked at as a way of reducing soil loss, however another way to reduce soil loss is to change crop rotation. By reducing the amount of time a soil is exposed to rainfall will reduce soil loss. This can be accomplished by adding a solid seeded crop to a typical corn-soybean rotation. By adding oats to a corn-soybean rotation, the soil loss factor for crop management is reduced by approximately one-third.

When crop management factors are considered, three goals are trying to be achieved:

- Minimize raindrop impact on the soil
- Reduce runoff
- Reduce runoff velocities

If we can accomplish these goals, the amount of soil loss that occurs will be lowered. To complete our equation we will use 40% residue in a corn-soybean rotation with all tillage in the spring, then C = 0.17.

	Primary Tillage				No-Till	
	Fall		Spring			
	20%	40%	20%	40%	50%	70%
CS	0.26	0.19	0.24	0.17	0.13	0.06
CSO_x	0.22	0.15	0.18	0.13	0.09	0.06
CSOM	0.1	0.08	0.09	0.07	0.06	0.04

X oats with green manure
Adopted from R. Borges, Agronomy 532 Chapter 4

Our RUSLE2 equation should look like:

A = 150 x 0.31 x 0.47 x 0.17 x P

Components of RUSLE2

Erosion Control Practice Factor

Grass waterways are a strip of grass strategically placed where water flow occurs during rain events.

A grass waterway is intent to intercept the water and slow the velocity of the water. When this happens sediment is dropped and deposited at the head of the waterway or further downstream of the waterway.

Because of soil deposition maintenance is required to keep the grass waterway as efficient as possible. If a grass waterway is not maintained, water will begin to flow along the edge of the grass waterway and grass waterway's effectiveness is reduced.

Waterways are areas where water is intercepted from nearby fields. Courtesy of Tim McCabe, NRCS.

Calculating RUSLE2

Simple Hand Calculations

	Conservation Practice				
Slope %	Contour	Strip-Cropping	Terrace interval (ft)	Closed outlets	Open Outlets
1-2%	0.6	0.3	100	0.5	0.7
3-8%	0.5	0.25	145	0.6	0.8
9-12%	0.6	0.3	178	0.7	0.8

Adopted from Wischmeier and Smith (1978).

Length (L-ft) and Slope (S-%)	Low rill to inter-rill erosion [a]	Moderate rill to inter-rill erosion [b]	High rill to inter-rill erosion [c]	Thawing soils
L=75				
S=1.0	0.14	0.14	0.14	0.14
S=4.0	0.46	0.47	0.47	0.47
S=8.0	0.90	0.91	0.91	0.91
L=200				
S=1.0	0.15	0.16	0.18	0.23
S=4.0	0.43	0.67	0.79	0.77
S=8.0	1.23	1.45	1.72	1.48

a= rangeland and soils with cover crop
b=generally row-cropped agricultural land
c= freshly prepared soil or highly disturbed soil

Table provided by R. Borges

Calculate the annual soil loss of a field that has a slope length of 200 feet and a 4% slope, corn-soybean rotation, contours, strip tills, and no-tills with 70% residue cover. We will use 150 for rainfall and 0.31 for soil erodibility.

	Primary Tillage				No-Till	
	Fall		Spring			
	20%	40%	20%	40%	50%	70%
CS	0.26	0.19	0.24	0.17	0.13	0.06
CSO_x	0.22	0.15	0.18	0.13	0.09	0.06
CSOM	0.10	0.08	0.09	0.07	0.06	0.04

Adopted from R. Borges, Agronomy 532 Chapter 4.

What is your answer?

Correct answer is?

150 x 0.31 x 0.67 x 0.5 x .25 x 0.06 = 0.23 tons per acre.

Calculating RUSLE2

Simple Hand Calculations

	Conservation Practice				
Slope %	Contour	Strip-Cropping	Terrace interval (ft)	Closed outlets	Open Outlets
1-2%	0.6	0.3	100	0.5	0.7
3-8%	0.5	0.25	145	0.6	0.8
9-12%	0.6	0.3	178	0.7	0.8

Adopted from Wischmeier and Smith (1978)

Calculate the annual soil loss of a field having a slope length of 200 feet and a 4% slope, corn-soybean rotation with 40% residue cover with fall tillage. We will use 150 for rainfall and 0.31 for soil erodibility.

What is your answer?

Correct answer is?

150 x 0.31 x 0.67 x 0.19 = 2.80 tons per year

Length (L-ft) and Slope (S-%)	Low rill to inter-rill erosion [a]	Moderate rill to inter-rill erosion [b]	High rill to inter-rill erosion [c]	Thawing soils
L=75				
S=1.0	0.14	0.14	0.14	0.14
S=4.0	0.46	0.47	0.47	0.47
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Adopted from R. Borges, Agronomy 532 Chapter 4.

Ways to Reduce Soil Loss Potential

Tillage Practices

When comparing different tillage methods it is important to recognize that it is the type of tillage equipment that determines soil loss by the quantity of residue left on the soil surface.

Timing of the tillage also impacts the amount of soil loss. If tillage is done after the rainy season, soil loss will be less than if the tillage is done before the rainy season.

Mold board plow. Courtesy of John Deere.

Chisel plow minimum tillage. Courtesy of John Deere.

Ridge till planting. Courtesy of Lynn Betts.

No-till planting. Courtesy of ipm.iastate.edu.

Case Study

Midwest Corn-Soybean Rotation

A producer has a field located in Jasper County Iowa. The field is 80 acres and is located in the NE1/4 of a section. The predominated soil are a silty clay loam soil. Slopes range from A to C2 slopes. Slope length will range from 30-200 feet. The current crop rotation is corn-soybeans. Corn stalks are chiseled plowed in the fall with straight shanks and field cultivated and planted with a double disk opener planter in the spring. Corn is no-tilled in to bean stubble. R factor for this farm is 150 and the K factor is 0.31. There currently are no C or P practices being done on the farm.

What are four options the producer can do to reduce soil loss on this farm?

Contour planting Strip till No-till
Terraces Ridge-till planting Grass waterways
Buffer strips Cover crops

Summary

The Revised Universal Soil Loss Equation (RUSLE2) is a tool used to help estimate soil loss from a particular field situation under given conditions. The information is based on climatic history, research, and soil functionality.

The forces of erosion and types of erosion are required to better understand how RUSLE2 calculates soil loss. Erosion is defined as the detachment of and movement of soil or rock by water, ice, or gravity. During the soil erosion there are three main steps - detachment, transportation, and deposition of soil. The four main types of erosion are rain splash, sheet, rill, and gully erosion. Sheet and rill erosion move the largest volume of soil.

The equation for RUSLE2 is A = RKSLCP

A = computed average annual soil loss in tons per acre

R = rainfall factor
K = soil erodibility factor
S = slope gradient factor
L = slope length factor
C = crop management factor

Summary

RUSLE2 is a tool that agronomist can use to predict soil loss. With this prediction changes to farming operation can be made to reduce soil loss. These changes will not only save valuable resources of the producers but will be protecting the investment of the producer.

Protection of the producers investment can be made by changing their management practices. Slowing or stopping water flow is a way soil loss can be reduced. This can be accomplished by leaving more crop residues on the surface and reducing slope length.

The reduction of soil loss is a concentrated management effort and it has to be a priority. Soil formation occurs at the rate of about 0.1 inch of soil per year. If the soil loss is greater than this, an eventual reduction in soil to an unproductive mass that is no longer capable of economically feasible crop production.

Thank You

Questions