



Revised Universal Soil Loss Equation

April 2003

Sustainable Agriculture Resource Section

In April 2002, the *Agricultural Crop Rotation Act* (ACRA) was adopted to protect water and soil quality on Prince Edward Island. The basic concepts of the Act are that regulated crops can not be grown in a field more frequently than once in three years or grown on land with a slope of 9 per cent or greater unless the crop is under a management plan approved by the Prince Edward Island Department of Agriculture and Forestry. Regulated crops may be grown on high sloped land (9% or greater) if soil erosion is limited to a recognized tolerance of 3 tons/acre/year.

The potential for erosion can be calculated using the Revised Universal Soil Loss Equation (RUSLE). The equation is written as $A = R \times K \times LS \times C \times P$ where:

A = predicted soil loss

R = rainfall and runoff

K = soil erodibility

LS = slope length and steepness

C = crop management

P = support practices (farming direction, strip cropping, etc.)

Soil erosion is considered by many to be a serious environmental problem in Prince Edward Island. It depletes soil quality, decreases productivity and can affect surface water quality. A tolerable soil loss is the maximum annual amount of soil which can be removed before the long term natural soil productivity is adversely affected. The recognized tolerance level for Prince Edward Island soils is 3 tons/acre/year or less. If RUSLE indicates potential soil loss greater than this level, a field must have alternate management practices applied to it to sustain long term productivity. One cubic yard of soil weighs approximately one ton.

The purpose of this document is to explain how to calculate soil loss using the RUSLE and to explain the factors that contribute to soil loss.

The RUSLE Factors

$$A = R \times K \times LS \times C \times P$$

A - the potential long term average annual soil loss in tons per acre per year. This is the amount, which is compared to the "tolerable soil loss" limits.

R- the rainfall and runoff factor. The greater the intensity and duration of the rain fall, the higher the erosion potential. The R factors for Prince Edward Island (Table 1) were calculated from the sum of the rainfall, the snow melt and the winter runoff.

K - the soil erodibility factor (Table 2). K is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting K, but structure, organic matter and permeability also contribute.

LS - the slope length and steepness factor. The LS factor represents a ratio of soil loss under given conditions. The steeper and longer the slope, the higher the risk for erosion. This is a very important factor in the overall erosion rate.

C - the crop management factor. It is used to determine the relative effectiveness of soil and crop management systems in terms of preventing soil loss. The C factor (Table 4) is a ratio comparing the soil loss from land under a specific crop and management system to the corresponding loss from continuously fallow and tilled land, which has a value of 1. The crop grown, type and timing of tillage, the use of winter cover and the application of solid manure will all impact on the C factor.

P - the support practices factor. The P factor (Table 5) compares the soil losses from up and down slope farming to losses that result from practices such as cross slope cultivation, contour farming and stripcropping.

Steps to Calculate the RUSLE:

1. Select the field on which the RUSLE is to be calculated.
2. Obtain a map showing field slopes and contours from the district agricultural office.
3. Select the R factor from Table 1 by choosing the location closest to the field.

Table 1: Determining the Rainfall and Runoff Factor (R)

Location	R factor
Tignish	80
Summerside	84
Charlottetown	89
Montague	94
Souris	94

4. Based on soil type, determine the K value from Table 2. If there is more than one soil type in the field, choose the type that represents the majority of the field. If no soil test analysis is available, select either 2.5% or 3.0% organic matter.

Table 2: Determining the Soil Erodibility Factor (K)

Soil Classification	% Organic Matter				
	2.0	2.5	3.0	3.5	4.0
Charlottetown	0.34	0.32	0.30	0.27	0.25
Alberry	0.34	0.32	0.30	0.27	0.25
Culloden	0.33	0.32	0.31	0.28	0.26
Tignish	0.40	0.37	0.34	0.32	0.29
O'Leary	0.40	0.37	0.34	0.32	0.29

5. Determine the slope length and grade for the longest slope and the steepest slope on the property. Compute the LS factor using the formula below.

Equation for Calculating Slope Length-Gradient Factor (LS)

A calculator with an exponent feature is required to complete the calculation.

$$LS = \left[0.065 + 0.0456 (\text{slope}) + 0.006541 (\text{slope})^2 \right] \left[\frac{\text{slope length}}{72.5} \right]^{NN}$$

Where: slope = slope steepness (%)
 slope length = length of slope (ft.)
 NN = see Table 3

Table 3: Determining the NN value for (LS)

Slope steepness	less than 1%	equal to or greater than 1% but less than 3%	equal to or greater than 3% but less than 5%	5% or greater
NN	.2	.3	.4	.5

6. Using Table 4, determine the C factor by adding together the C factors for each year of the rotation and then dividing the total by the number of years in the rotation.

Table 4: Determining the Crop Management Factor (C)

POTATOES	C Factor
Potatoes following small grains with spring plowing	0.31
Potatoes following small grains with fall plowing	0.35
Potatoes following small grains with 10% residue on surface after planting	0.28
Potatoes following small grains with 30% residue on surface after planting	0.20
Potatoes with a winter cover following small grains with spring plowing	0.29
Potatoes with a winter cover following small grains with fall plowing	0.30
Potatoes with a winter cover following small grains with 30% residue on surface after	0.16
Potatoes following row crops with spring plowing	0.41
Potatoes following row crops with fall plowing	0.48
Potatoes following row crops with 10% residue on surface after planting	0.36
Potatoes following row crops with 30% residue on surface after planting	0.30
Potatoes with a winter cover following row crops with spring plowing	0.39
Potatoes following hay with spring plowing or conservation tillage with 30% residue on	0.16
Potatoes following hay with fall plowing	0.26
Potatoes with a winter cover following hay with spring plowing or or conservation tillage	0.13
Potatoes with a winter cover following hay with fall plowing	0.20
Potatoes following ryegrass with spring plowing and winter cover	0.16
Potatoes following ryegrass with spring plowing	0.19
Potatoes following ryegrass with fall plowing and no winter cover	0.26
Potatoes with spring plowing and a winter cover following grain underseeded with	0.16
SMALL GRAIN (cereals & soybeans)	
Small grain following a high residue crop (grain corn, cereal crop) with the straw removed	0.13
Small grain following a high residue crop (grain corn, cereal crop)	0.09
Small grain under seeded following a high residue crop (grain corn, cereal crop)	0.04
Small grain following a low residue crop (corn silage, potatoes) with the straw removed	0.18
Small grain following a low residue crop (corn silage, potatoes)	0.15
Small grain under seeded following a low residue crop (corn silage, potatoes)	0.10

SILAGE CORN	
Silage corn following small grains with spring plowing	0.30
Silage corn following small grains with fall plowing	0.33
Silage corn following small grains with 10% residue on surface after planting	0.23
Silage corn following small grains with 30% residue on surface after planting	0.12
Silage corn following row crops with spring plowing	0.30
Silage corn following row crops with fall plowing	0.34
Silage corn following row crops with 10% residue on surface after planting	0.21
Silage corn following row crops with 30% residue on surface after planting	0.17
Silage corn following row crops with manure* applied	0.24
Silage corn following hay with spring plowing	0.18
Silage corn following hay with fall plowing	0.20
Silage corn with winter cover following small grains and spring plowing	0.26
Silage corn with winter cover following row crops with spring plowing	0.24
Silage corn with winter cover following row crops with 10% residue on surface after	0.17
Silage corn with winter cover following row crops with manure* applied	0.16
Silage corn with winter cover following hay and spring plowed	0.14
Silage corn intercropped with ryegrass following corn silage or potatoes	0.19
Silage corn intercropped with ryegrass following corn silage intercropped with ryegrass	0.12
Silage corn intercropped with ryegrass following small grain	0.17
Silage corn intercropped with ryegrass following silage corn intercropped with ryegrass	0.09
Silage corn no-till planted into winter cover	0.11
Silage corn no-till planted into a well established sod	0.05
Silage corn no-till planted second year after sod	0.15
Silage corn no-till planted third year or more after sod	0.18
GRAIN CORN	
Grain corn following small grains with spring plowing	0.21
Grain corn following small grains with fall plowing	0.28
Grain corn following small grains with 10% residue on surface after planting	0.15

Grain corn following small grains with 30% residue on surface after planting	0.08
Grain corn following row crops with spring plowing	0.18
Grain corn following row crops with fall plowing	0.24
Grain corn following row crops with 10% residue on surface after planting	0.10
Grain corn following row crops with 30% residue on surface after planting	0.07
Grain corn following row crops with manure* applied	0.13
Grain corn following hay with spring plowing	0.11
Grain corn following hay with spring plowing	0.18
VEGETABLES	
Mixed vegetables after mixed vegetables	0.50
Mixed vegetables with winter cover	0.42
Cole crop following a row crop	0.29
Cole crop with winter cover following a row crop	0.25
Cole crop with spring plowing or residue management after hay	0.16
Cole crop with spring plowing or residue management and winter crop after hay	0.13
Cole crop after hay with fall plowing	0.24
Cole crop with winter crop after hay with fall plowing	0.18
Rutabagas following potatoes	0.30
Rutabagas with winter cover following potatoes	0.26
Vine crop following hay with fall plowing	0.20
Vine crop with spring plowing or winter cover following hay	0.16
Vine crop following vine crop with winter cover	0.24
Vine crop with 10% residue following mulched vine crop	0.17
Sequential planting of lettuce with spring plowing following a ryegrass cover crop	0.16
Carrots after hay with fall plowing	0.30
Carrots with a winter cover following hay with fall plowing	0.24
Carrots following grain with fall plowing	0.50
Carrots, spring plowed following grain	0.46
Onions with spring plowing and winter cover, following under seeded grain	0.40
Onions with 30% residue and winter cover, following under seeded grain	0.26

HAY - ESTABLISHMENT YEAR	
Direct seeding in spring following high residue crop	0.14
Direct seeding in summer following high residue crop	0.14
Direct seeding in spring following low residue crop	0.15
Direct seeding in summer following low residue crop	0.15
Direct seeding ryegrass with fertility management	0.10
HAY - SEASON AFTER ESTABLISHMENT	
Legume hay (not plowed or killed)	0.01
Hay land killed with glyphosate no fall tillage	0.02
Fall plowed hay land	0.03
ESTABLISHED GRASSLAND	
Grass	0.005
Legume	0.005
Permanent Pasture	0.005
FALLOW LAND	1.00

**manure assumes 2-3 tons of dry matter/acre applied in spring*

7. Select the P factor from Table 5 based on the support practice used.

Table 5: Determining the Support Practice Factor (P)

Support Practice	P Factor
Up & Down Slope	1.00
Cross Slope	0.75
Strip cropping, 2 year rotation	0.50
Strip cropping, 3 year rotation	0.30

8. Multiply the five factors together to determine the soil loss.

Management Strategies That Can Be Used to Reduce Soil Loss:

It may be necessary to modify management practices in a field if the RUSLE indicates that the soil loss is greater than the tolerable level of 3 ton/acre/year. For example:

- Increasing the organic matter level will decrease the K factor.
- Constructing terraces or farmable berms to reduce slope length will decrease the LS factor.
- Selecting crop types, tillage practices, winter cover crops and the application of solid manure can decrease the C factor.
- Selecting a support practice with a lower P factor.

Determining Acceptable Erosion Rates

If regulated crops are grown on land with less than 9 per cent slope, but more frequently than once in three years, there are two options:

- to develop a rotation with a C factor of .13 or less
- to match the management to the topography to achieve an acceptable erosion rate of 3 tons/acre/year or less, using the factors in the RUSLE equation.

If regulated crops are to be grown on land with 9 per cent or greater slope, the RUSLE must be used to determine if the erosion rate is acceptable.

Calculating RUSLE Using a Farming Example:

A field in western PEI has traditionally been farmed with two regulated crops in a five year rotation — potatoes/grain/potatoes/grain/hay. No winter cover was established after the first crop of potatoes was harvested. Fall mold-board plowing occurred before the potato crops and grain crops. The grain crops were under-seeded. The field has a slope length of 1000 feet and a 3% grade. The field is cropped up and down the slope. The soil type is O'Leary and has 2.5 % organic matter.

Although the slope is less than 9%, a management plan will be required for this field since the rotation has regulated crops grown more frequently than once in three years. When developing a plan for the field there are two options:

1. Determine if the rotation has a C factor of .13 or less

Calculating the C Factor (Use Table 4)

C factor for 1 st potato crop	0.26
C factor for 1 st grain crop (under seeded)	0.10
C factor for 2 nd potato crop	0.35
C factor for 2 nd grain crop (under seeded)	0.10
C factor for hay	0.03
Total	0.84

C factor for this five year rotation is 0.168 (0.84/5). Since the C Factor is greater than .13 the rotation is not acceptable.

2. Using RUSLE

R - Rainfall and Runoff Factor

Using Table 1, select the location closest to the field. This field is closest to Tignish, therefore, the R factor is 80.

K - Soil Erodibility Factor

Using Table 2, select the soil type and organic matter level. The soil type is O'Leary and the organic matter level is 2.5%; therefore, the K factor is 0.37.

LS - Slope Length-Steepness Factor

This field is 1000 feet long. Table 3 indicates that a 3% slope has a NN value of 0.4. Solving the equation below results in a LS factor of .74.

$$LS = \left[0.065 + 0.0456 (3) + 0.006541 (3)^2 \right] \left[\frac{1000}{72.5} \right]^{.4}$$

C - Crop Management Factor (from Table 4)

C factor for 1 st potato crop	0.26
C factor for 1 st grain crop (under seeded)	0.10
C factor for 2 nd potato crop	0.35
C factor for 2 nd grain crop (under seeded)	0.10
C factor for hay	0.03
Total	0.84

The C factor is $(0.84/5) = .168$.

P - Support Practice Factor

The P factor in Table 5 for up and down slope is 1.0.

Use the numerical values for each of the factors to solve the RUSLE equation:

$$\begin{aligned} A &= R \times K \times LS \times C \times P \\ &= 80 \times .37 \times .74 \times .168 \times 1.0 \\ &= 3.68 \text{ tons/acre/year} \end{aligned}$$

The soil loss of 3.68 tons/acre/year exceeds the acceptable level of 3 tons/acre/year. This rotation is not acceptable. Management practices must be adjusted to meet the *Agricultural Crop Rotation Act* requirements.

Examples of Management Practices That Could Decrease Soil Loss:

- Constructing a farmable berm at mid-slope will change the slope length from 1000 to 500 feet and result in the LS factor being decreased to .56.

$$LS = \left[0.065 + 0.0456 (3) + 0.006541 (3)^2 \right] \left[\frac{500}{72.5} \right]^4$$

$$\begin{aligned} A &= R \times K \times LS \times C \times P \\ &= 80 \times .37 \times .56 \times .168 \times 1.0 \\ &= 2.78 \text{ tons/acre/year} \end{aligned}$$

As a result of this change the soil loss is decreased from 3.68 tons/acre/year to 2.78 tons/acre/year. This is within the acceptable limit of 3.0 tons.

- Another option is to reduce the C factor by changing agronomic practices; for example, using conservation tillage after the first grain crop and establishing winter cover after the second potato crop.

C factor for 1 st potato crop	0.26
C factor for 1 st grain crop (under seeded)	0.10
C factor for 2 nd potato crop with winter cover & 30% residue	0.16
C factor for 2 nd grain crop (under seeded)	0.10
C factor for hay	0.03
Total	0.65

The C factor is 0.13 (0.65/5) and meets the requirements of the *Agricultural Crop Rotation Act*.

Contact Information:

- Gwen Vessey
Sustainable Agriculture Resources Section
PEI Department of Agriculture and Forestry
- Tel #: (902) 368-5650
 - Fax #: (902) 368-5661
 - E-mail: gtvessey@gov.pe.ca
 - Mail: PO Box 1600, Charlottetown, PE Canada C1A 7N3