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Background

The Universal Soil Loss Equation (USLE) predicts the long-term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, crop system and management practices. USLE only predicts the amount of soil loss that results from sheet or rill erosion on a single slope and does not account for additional soil losses that might occur from gully, wind or tillage erosion. This erosion model was created for use in selected cropping and management systems, but is also applicable to non-agricultural conditions such as construction sites. The USLE can be used to compare soil losses from a particular field with a specific crop and management system to "tolerable soil loss" rates. Alternative management and crop systems may also be evaluated to determine the adequacy of conservation measures in farm planning.

Five major factors are used to calculate the soil loss for a given site. Each factor is the numerical estimate of a specific condition that affects the severity of soil erosion at a particular location. The erosion values reflected by these factors can vary considerably due to varying weather conditions. Therefore, the values obtained from the USLE more accurately represent long-term averages.

A calculation of soil losses using the USLE may also be done in OMAFRA's NMAN Nutrient Management Software, SOF001. The soil loss value generated from the USLE equation is used to determine the "soil erosion rating value" in the calculation of the Phosphorus Index. See the OMAFRA Factsheet **Determining the Phosphorus Index for a Field**, Order No. 05-067.

Universal Soil Loss Equation (USLE)

A = R x K x LS x C x P

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

R is the rainfall and runoff factor by geographic location as given in **Table 1**. The greater the intensity and duration of the rain storm, the higher the erosion potential. Select the R factor from **Table 1** based on the upper tier municipality designation and corresponding weather station where the calculation is to be made.
K is the soil erodibility factor (**Table 2**). It is the average soil loss in tonnes/hectare (tons/acre) for a particular soil in cultivated, continuous fallow with an arbitrarily selected slope length of 22.13 m (72.6 ft) and slope steepness of 9%. 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 is the slope length-gradient factor. The LS factor represents a ratio of soil loss under given conditions to that at a site with the "standard" slope steepness of 9% and slope length of 22.13 m (72.6 ft). The steeper and longer the slope, the higher the risk for erosion. Use either **Table 3A** or the "Equation for Calculating LS" included in this Factsheet to obtain LS.
C is the crop/vegetation and 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 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. The C Factor can be determined by selecting the crop type and tillage method (**Table 4A** and **Table 4B**, respectively) that corresponds to the field and then multiplying these factors together.

The C factor resulting from this calculation is a generalized C factor value for a specific crop that does not account for crop rotations or climate and annual rainfall distribution for the different agricultural regions of the country. This generalized C factor, however, provides relative numbers for the different cropping and tillage systems, thereby helping you weigh the merits of each system.

P is the support practice factor. It reflects the effects of practices that will reduce the amount and rate of the water runoff and thus reduce the amount of erosion. The P factor represents the ratio of soil loss by a support practice to that of straight-row farming up and down the slope. The most commonly used supporting cropland practices are cross-slope cultivation, contour farming and strip cropping (**Table 5**).

Procedure for Using the USLE

1. Determine the R Factor (**Table 1**).
2. Based on the soil texture, determine the K value (**Table 2**). If there is more than one soil type in a field and the soil textures are not very different, use the soil type that represents the majority of the field. Repeat for other soil types as necessary.
3. Divide the field into sections of uniform slope gradient and length. Assign an LS value to each section (**Table 3A**).
4. Choose the crop type factor and tillage method factor for the crop to be grown. Multiply these two factors together to obtain the C factor.
5. Select the P factor based on the support practice used (**Table 5**).
6. Multiply the 5 factors together to obtain the soil loss per hectare (acre).

Table 1. R Factor Data

Weather Station	Upper Tier Municipality Designation	R Factor
Brantford	County of Brant	90
Delhi		100
Essex	County of Essex	110
Fergus	Counties of Dufferin and Wellington	120
Glen Allen		130
Guelph		100
Hamilton	City of Hamilton; Regional Municipality of Halton	100
Kingston	City of Prince Edward County; Counties of Frontenac and Lennox & Addington	90
Kitchener	Regional Municipality of Waterloo	110
London	Counties of Lambton, Middlesex, and Oxford	100
Mount Forest	Counties of Bruce, Grey, Haliburton, and Simcoe; District of Muskoka	90
Niagara	Regional Municipality of Niagara	90
Northern Ontario	Districts of Algoma, Cochrane, Kenora, Manitoulin Island, Parry Sound, Rainy River, Sudbury, Thunder Bay, and Timiskaming	90
Ottawa	City of Ottawa; Counties of Lanark and Renfrew; United Counties of Leeds and Grenville, Prescott and Russell, and Stormont, Dundas and Glengarry; District of Nipissing	90
Prospect Hill	Counties of Huron and Perth	120
Ridgetown	Municipality of Chatham-Kent	110
Simcoe	Counties of Haldimand and Norfolk	120
St. Catherines		100
St. Thomas	County of Elgin	90
Toronto	City of Toronto, Regional Municipalities of Peel and York	90
Tweed	City of Kawartha Lakes; Counties of Hastings, Northumberland, and Peterborough; Regional Municipality of Durham	90
Windsor		110

Table 2. K Factor Data

Textural Class	K Factor tonnes/hectare (tons/acre)		
	Average OMC*	Less than 2% OMC	More than 2% OMC
Clay	0.49 (0.22)	0.54 (0.24)	0.47 (0.21)
Clay loam	0.67 (0.30)	0.74 (0.33)	0.63 (0.28)
Coarse sandy loam	0.16 (0.07)	–	0.16 (0.07)
Fine sand	0.18 (0.08)	0.20 (0.09)	0.13 (0.06)
Fine sandy loam	0.40 (0.18)	0.49 (0.22)	0.38 (0.17)
Heavy clay	0.38 (0.17)	0.43 (0.19)	0.34 (0.15)
Loam	0.67 (0.30)	0.76 (0.34)	0.58 (0.26)
Loamy fine sand	0.25 (0.11)	0.34 (0.15)	0.20 (0.09)
Loamy sand	0.09 (0.04)	0.11 (0.05)	0.09 (0.04)
Loamy very fine sand	0.87 (0.39)	0.99 (0.44)	0.56 (0.25)
Sand	0.04 (0.02)	0.07 (0.03)	0.02 (0.01)
Sandy clay loam	0.45 (0.20)	–	0.45 (0.20)
Sandy loam	0.29 (0.13)	0.31 (0.14)	0.27 (0.12)
Silt loam	0.85 (0.38)	0.92 (0.41)	0.83 (0.37)
Silty clay	0.58 (0.26)	0.61 (0.27)	0.58 (0.26)
Silty clay loam	0.72 (0.32)	0.79 (0.35)	0.67 (0.30)
Very fine sand	0.96 (0.43)	1.03 (0.46)	0.83 (0.37)
Very fine sandy loam	0.79 (0.35)	0.92 (0.41)	0.74 (0.33)

* Organic matter content

Soil Loss Tolerance Rates

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 impact of erosion on a given soil type, and hence the tolerance level, varies, depending on the type and depth of soil. Generally, soils with deep, uniform, stone-free topsoil materials and/or not previously eroded have been assumed to have a higher tolerance limit than soils that are shallow or previously eroded.

Soil loss tolerance rates are included in **Table 6**.

The suggested tolerance level for most soils in Ontario is 6.7 tonnes/hectare/year (3 tons/acre/year) or less.

Management Strategies to Reduce Soil Losses

Having obtained an estimate of the potential annual soil loss for a field, you may want to consider ways to reduce this loss to a tolerable level. **Table 7** outlines management strategies to help you reduce soil erosion.

Table 3A. LS Factor Calculation

Slope Length: m (ft)	Slope (%)	LS Factor
30.5 (100)	10	1.38
	8	1.00
	6	0.67
	5	0.54
	4	0.40
	3	0.30
	2	0.20
	1	0.13
	0	0.07
61 (200)	10	1.95
	8	1.41
	6	0.95
	5	0.76
	4	0.53
	3	0.39
	2	0.25
	1	0.16
	0	0.08
122 (400)	10	2.76
	8	1.99
	6	1.35
	5	1.07
	4	0.70
	3	0.52
	2	0.30
	1	0.20
	0	0.09

244 (800)	10	3.90
	8	2.82
	6	1.91
	5	1.52
	4	0.92
	3	0.68
	2	0.37
	1	0.24
	0	0.11
488 (1,600)	10	5.52
	8	3.99
	6	2.70
	5	2.15
	4	1.21
	3	0.90
	2	0.46
	1	0.30
	0	0.12
975 (3,200)	10	7.81
	8	5.64
	6	3.81
	5	3.03
	4	1.60
	3	1.19
	2	0.57
	1	0.36
	0	0.14

Equation for Calculation of LS (if Not Using Table 3A)

$LS = [0.065 + 0.0456\ (\text{slope}) + 0.006541\ (\text{slope})^2](\text{slope length} \div \text{constant})^{NN}$

Where:

slope = slope steepness in %

slope length = length of slope in m (ft)

constant = 22.1 metric (72.5 Imperial)

NN = see **Table 3B** below

Table 3B. NN Values

S	< 1	1 ≤ Slope < 3	3 ≤ Slope < 5	≥ 5
NN	0.2	0.3	0.4	0.5

Table 4A. Crop Type Factor

Crop Type	Factor
Grain corn	0.40
Silage corn, beans & canola	0.50
Cereals (spring & winter)	0.35
Seasonal horticultural crops	0.50
Fruit trees	0.10
Hay and pasture	0.02

Table 4B. Tillage Method Factor

Tillage Method	Factor
Fall plow	1.0
Spring plow	0.90
Mulch tillage	0.60
Ridge tillage	0.35
Zone tillage	0.25
No-till	0.25

Table 5. P Factor Data

Support Practice	P Factor
Up & down slope	1.0
Cross slope	0.75
Contour farming	0.50
Strip cropping, cross slope	0.37
Strip cropping, contour	0.25

Table 6. Soil Loss Tolerance Rates

Soil Erosion Class	Potential Soil Losstonnes/hectare/year (tons/acre/year)
Very low (tolerable)	<6.7 (3)
Low	6.7 (3)–11.2 (5)
Moderate	11.2 (5)–22.4 (10)
High	22.4 (10)–33.6 (15)
Severe	>33.6 (15)

Table 7. Management Strategies to Reduce Soil Losses

Factor	Management Strategies	Example
R	The R Factor for a field cannot be altered.	–
K	The K Factor for a field cannot be altered.	–
LS	Terraces may be constructed to reduce the slope length resulting in lower soil losses.	Terracing requires additional investment and will cause some inconvenience in farming. Investigate other soil conservation practices first.
C	The selection of crop types and tillage methods that result in the lowest possible C factor will result in less soil erosion.	Consider cropping systems that will provide maximum protection for the soil. Use minimum tillage systems where possible.
P	The selection of a support practice that has the lowest possible factor associated with it will result in lower soil losses.	Use support practices such as cross-slope farming that will cause deposition of sediment to occur close to the source.

Example: Calculation of Soil Erosion Using USLE

A = R x K x LS x C x P

Rainfall and Runoff Factor (R)

The sample field is in Middlesex County. Therefore the R Factor is obtained in **Table 1** from the London weather station.

R Factor = 100

Soil Erodibility Factor (K)

The sample field consists of fine sandy loam soil with an average organic matter content. The K Factor is obtained from **Table 2**.

K Factor = 0.40

Slope Length-Gradient Factor (LS)

The sample field is 244 m (800 ft) long with a 6% slope. The LS factor can be obtained directly from **Table 3A** or may be calculated using the equation on page 4. The NN value from **Table 3B** to be used in the equation is 0.5.

LS Factor = 1.91

Crop/Vegetation and Management Factor (C)

The sample field was plowed in the spring and grain corn was planted. The C Factor is obtained from the crop type factor (**Table 4A**) and the tillage method factor (**Table 4B**).

Crop Type Factor for grain corn = 0.4

Tillage Method Factor for spring plow = 0.9

C Factor = 0.4 x 0.9 = 0.36

Support Practice Factor (P)

Cross-slope farming is used on this sample field. The P Factor was obtained from **Table 5**.

P Factor = 0.75

Therefore,

A = R x K x LS x C x P

= 100 x 0.40 x 1.91 x 0.36 x 0.75

= 20.63 tonnes/hectare/year (9.28 tons/acre/year)

Referring to **Table 6** in this Factsheet, you will see that this soil loss rate of 20.63 tonnes/hectare/year (9.28 tons/acre/year) is in the moderate range and considerably higher than the "tolerable loss level" of 6.7 tonnes/hectare/year (3 tons/acre/year). To reduce the soil losses for this sample field below 6.7 tonnes/hectare/year (3 tons/acre/year) we will make the following changes to the above example.

Change tillage method from "spring plow (0.9)" to "no-till (0.25)"

Therefore, C Factor (revised) = 0.4 x .25 = 0.10

The adjusted annual soil loss value is

A = R x K x LS x C x P

= 100 x 0.40 x 1.91 x 0.10 x 0.75

= 5.73 tonnes/hectare/year (2.58 tons/acre/year)

Thus by changing the tillage practice, the average annual predicted soil loss for this field is below the "tolerable soil loss" of 6.7 tonnes/hectare/year (3 tons/acre/year).