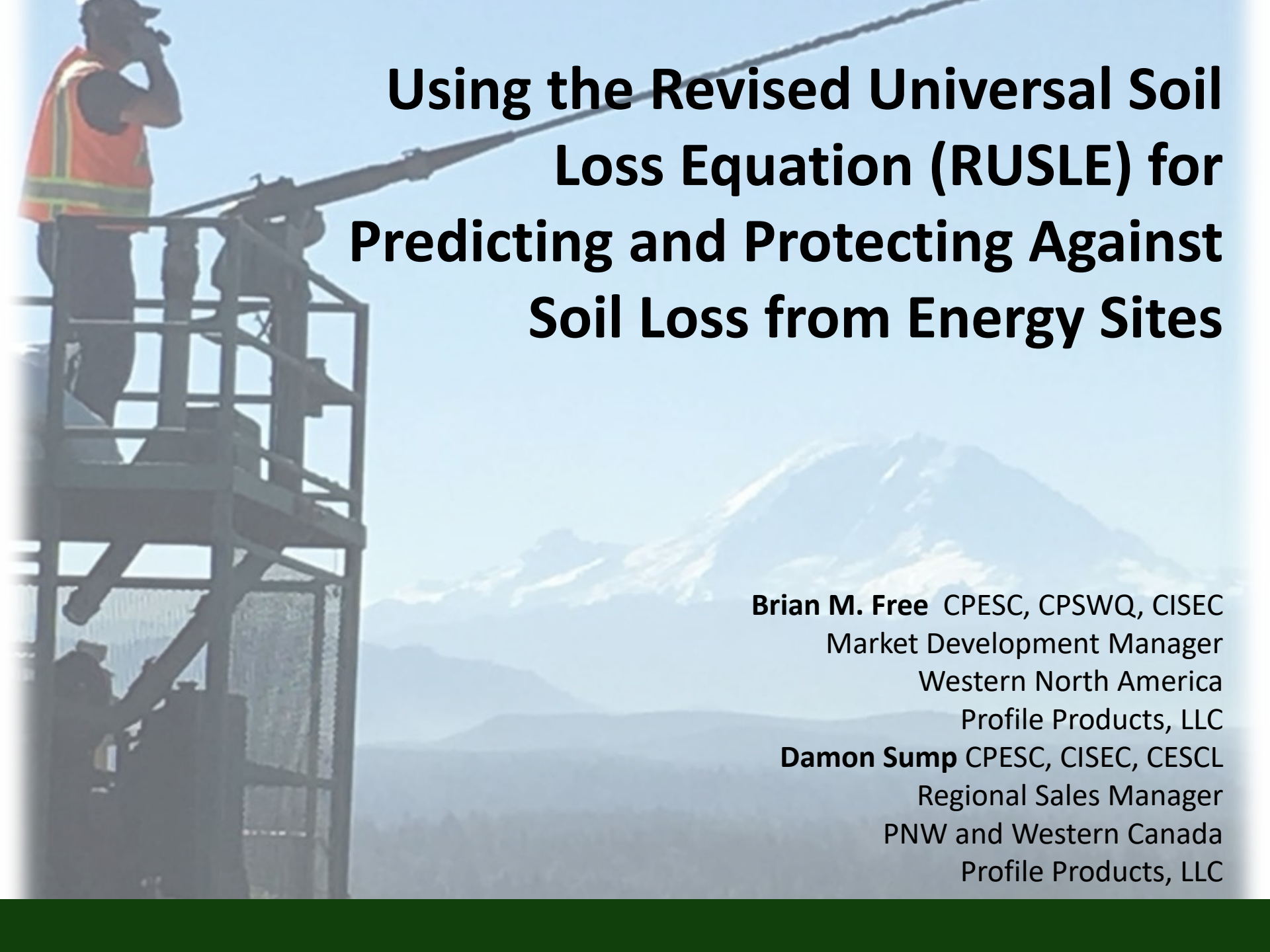

Using the Revised Universal Soil Loss Equation (RUSLE) for Predicting and Protecting Against Soil Loss from Energy Sites

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Controlling Soil Loss and Sedimentation is a Challenge on any Land Disturbing Activity

So Why Are We Here Today?


Sediment is the leading
pollutant in water


And we have laws to protect
water quality


How can we predict and protect against sediment loss from our sites?
Water Quality Affects All of Us!

Erosion and Sediment Control is all about Risk Management

Majority of **Sediment Production RISK** is in **EXPOSED SOIL.**

Erosion Control is less expensive than **Sediment Control**

Raindrop Erosion

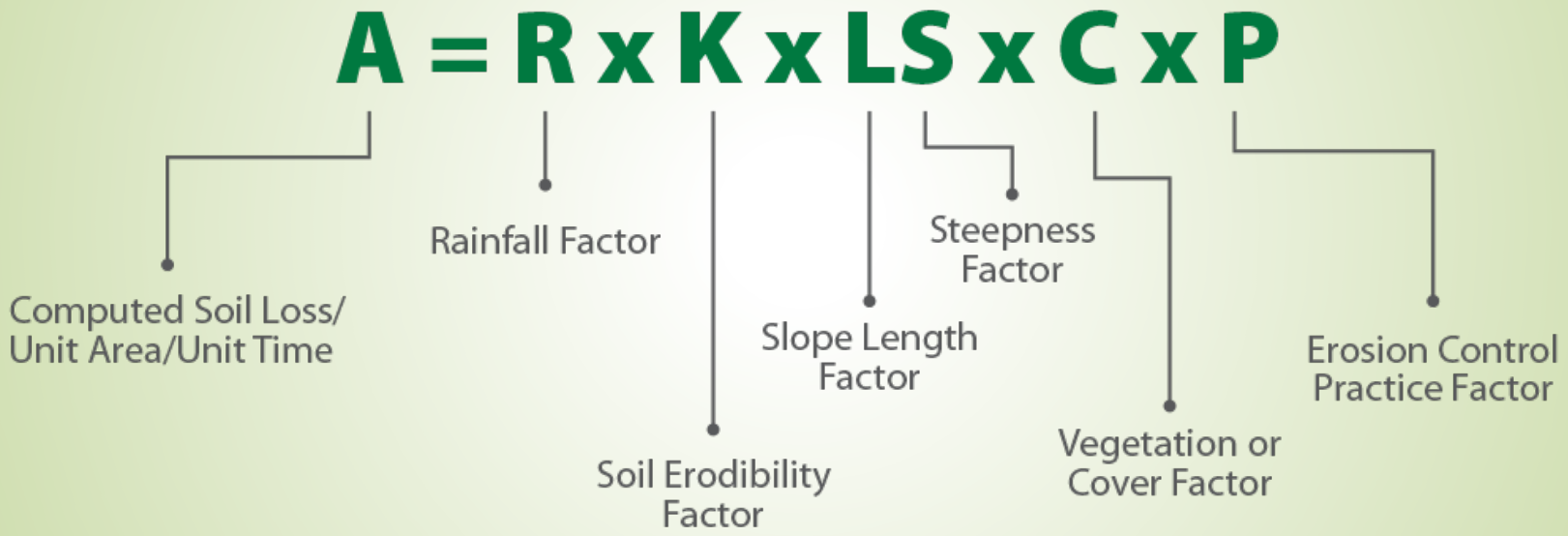
(a)

(b)

(c)

Predicting Soil Loss on Slopes

- Universal Soil Loss Equation (RUSLE)



Soil Loss Computations

Revised Universal Soil Loss Equation (RUSLE)

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

Where:

A = computed soil loss per unit area per unit time for a given storm period and intensity

R = rainfall factor

K = soil erodibility factor

L = slope length factor

S = steepness factor

C = vegetation or cover factor

P = erosion control practice factor

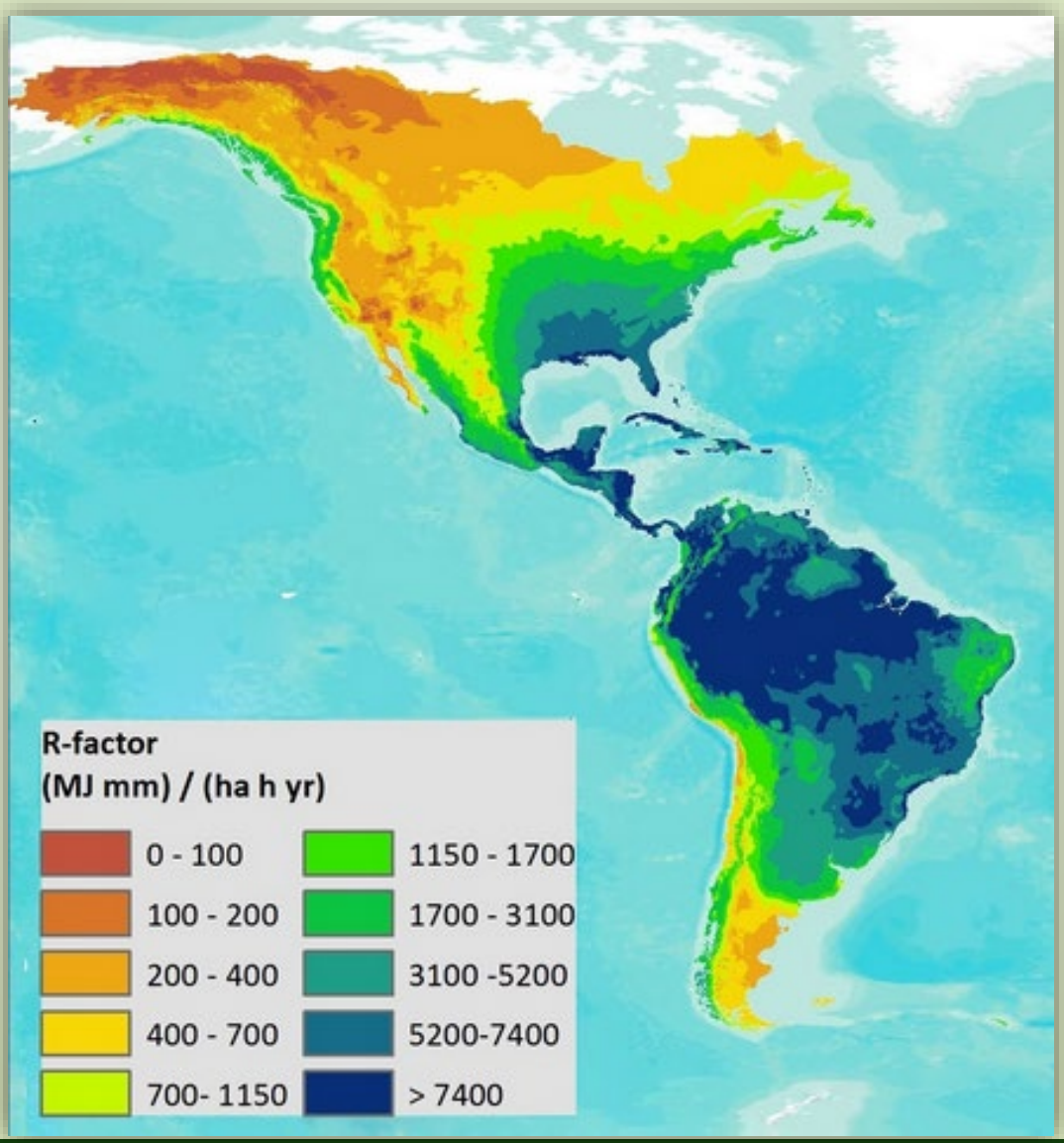
R (Rainfall and Runoff Erosivity Index)

- Erosion Index (EI) for a given storm:
  - Product of the kinetic energy of the falling raindrops and its maximum 30 minute intensity.
- R Factor = $\sum$ EI over a year / 100

$$R \text{ factor} = \frac{1}{n}\sum_{j=1}^{n}\left[\sum_{k=1}^{m}(E)(I_{30})_k\right]$$

$$EI = EI_{30} = \left(\sum_{k=1}^{m} e_r \Delta V_r\right) I_{30}$$

R (Rainfall and Runoff Erosivity Index)



R Values for Prairie Region

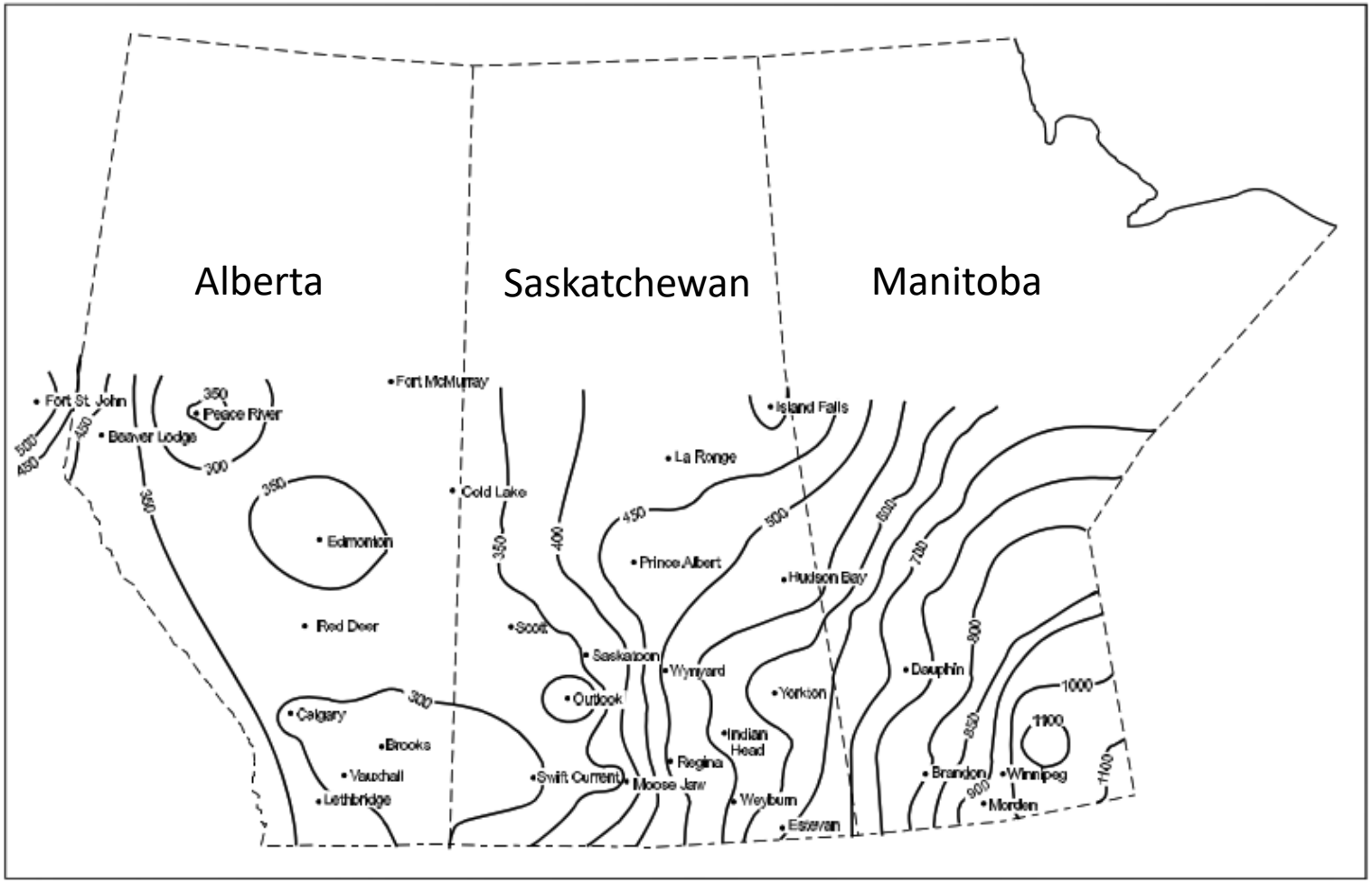


Figure R-3c. Isoerodent map showing R_1 values for the Prairie Region

RUSLE FAC

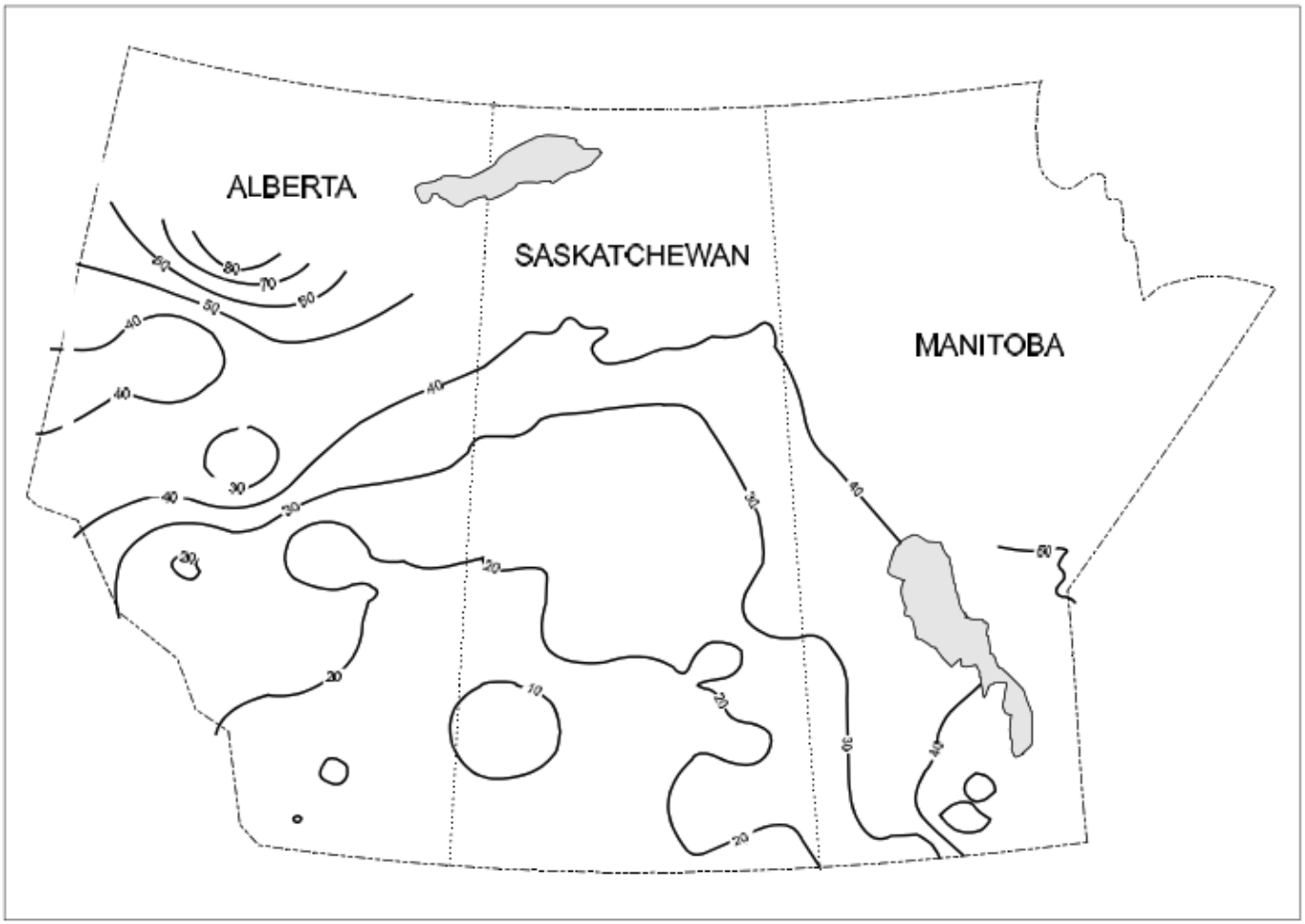


Figure R-3b. Adjustment for winter conditions. Rs for the Prairie Region

K (Soil Erodibility)

- Susceptibility of a soil to erosion by rainfall and runoff
- Dependent upon:
  - Texture, structure, organic matter content, and permeability

A = R x K x LS x C x P

Soil Type	% Sand	% Silt	% Clay	K Factor
Silt	5	80	15	0.55
Silt Loam	15	65	20	0.45
Silty Clay Loam	15	55	30	0.39
Silty Clay	10	48	42	0.33
Sandy Loam	65	20	15	0.26
Sand	85	15	0	0.2
Loamy Sand	70	10	20	0.18
Sandy Clay	60	10	30	0.15
Sandy Clay Loam	75	4	21	0.13
Clay Loam	25	5	70	0.08
Clay	0	15	85	0.05

Generally, soils with a high percent content of silt and very fine sand particles, a low organic matter content, poor structure and very low permeability will be most erodible, on the basis of soil characteristics alone.

Length and Slope Steepness Factors

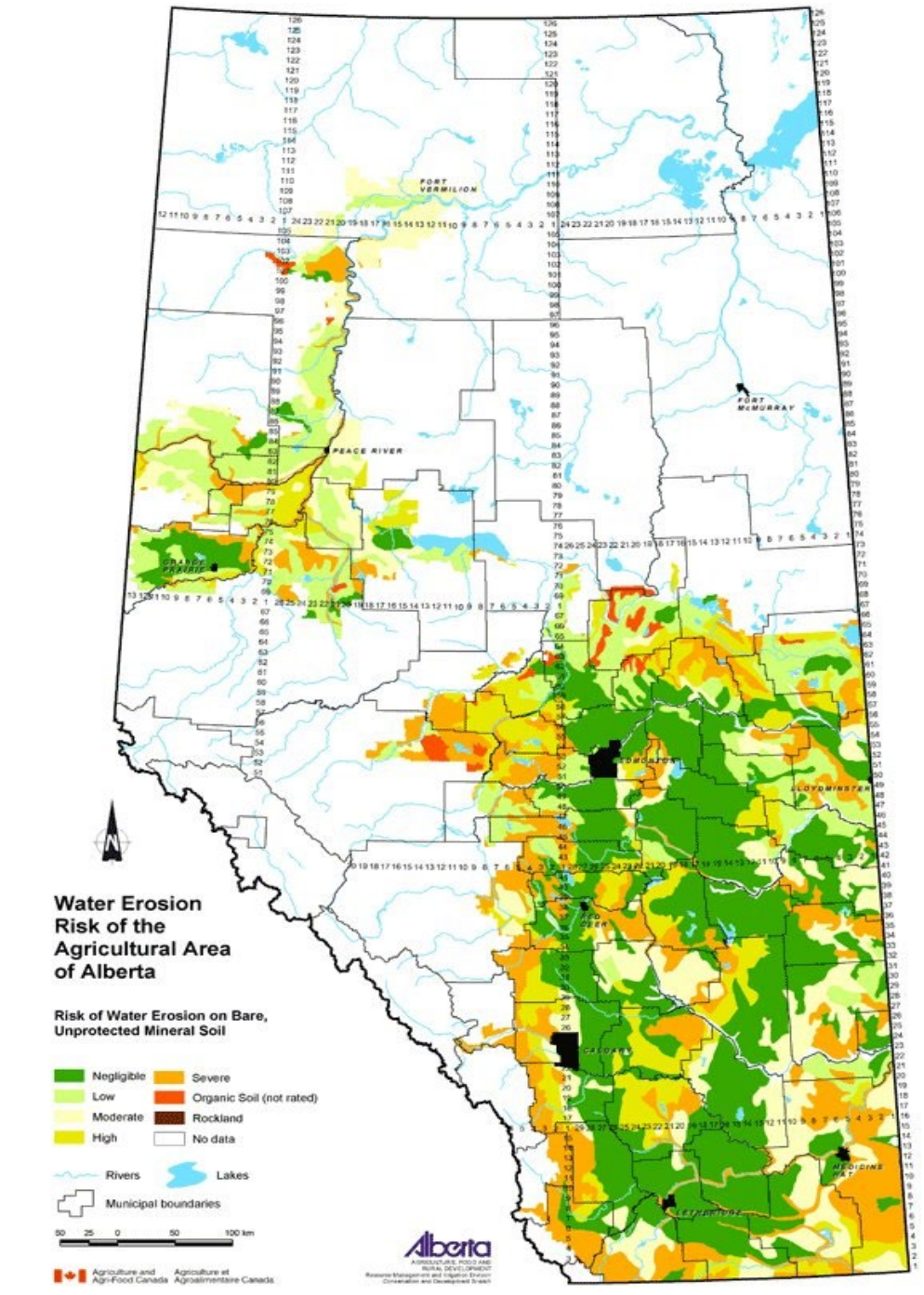
LS Values for High Ratio of Rill: Inter-Rill Erosion, such as highly disturbed soil conditions and freshly prepared Construction Sites, with little or no cover (not applicable to thawing soils)

	Slope Length in meters													
Slope %	1	2	4.57	5	10	15	25	50	75	100	150	200	250	300
0.20%	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
0.50%	0.07	0.07	0.07	0.07	0.07	0.08	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.13
1.00%	0.09	0.09	0.09	0.09	0.11	0.12	0.14	0.17	0.19	0.20	0.23	0.24	0.26	0.27
2.00%	0.13	0.13	0.13	0.14	0.18	0.21	0.26	0.34	0.40	0.44	0.52	0.58	0.64	0.68
3.00%	0.17	0.17	0.17	0.17	0.24	0.29	0.37	0.52	0.63	0.72	0.88	1.01	1.12	1.22
4.00%	0.20	0.20	0.20	0.21	0.30	0.38	0.49	0.71	0.88	1.03	1.28	1.49	1.67	1.84
5.00%	0.23	0.23	0.23	0.24	0.36	0.46	0.61	0.91	1.14	1.35	1.70	2.01	2.28	2.53
6.00%	0.26	0.26	0.26	0.28	0.42	0.54	0.73	1.11	1.42	1.68	2.15	2.56	2.93	3.27
7.00%	0.29	0.29	0.29	0.31	0.48	0.61	0.85	1.31	1.69	2.03	2.62	3.14	3.61	4.05
8.00%	0.32	0.32	0.32	0.34	0.53	0.69	0.96	1.51	1.97	2.38	3.09	3.73	4.31	4.86
9.00%	0.35	0.35	0.35	0.37	0.59	0.78	1.09	1.73	2.27	2.75	3.61	4.37	5.08	5.73
10.00%	0.35	0.36	0.40	0.42	0.68	0.90	1.27	2.04	2.69	3.28	4.32	5.26	6.13	6.94
12.00%	0.36	0.40	0.49	0.53	0.86	1.14	1.64	2.67	3.56	4.36	5.80	7.11	8.32	9.46
14.00%	0.38	0.44	0.58	0.62	1.03	1.38	2.00	3.30	4.43	5.45	7.32	9.01	10.59	12.09
16.00%	0.39	0.47	0.67	0.72	1.20	1.62	2.36	3.93	5.31	6.57	8.86	10.96	12.92	14.79
20.00%	0.41	0.53	0.84	0.90	1.53	2.08	3.07	5.20	7.07	8.81	11.99	14.92	17.69	20.32
22.00%	0.43	0.57	0.92	0.99	1.69	2.31	3.42	5.82	7.95	9.93	13.56	16.92	20.09	23.11
25.00%	0.45	0.62	1.04	1.12	1.92	2.64	3.93	6.75	9.26	11.59	15.91	19.91	23.70	27.32
30.00%	0.48	0.69	1.24	1.33	2.30	3.18	4.77	8.26	11.40	14.33	19.77	24.84	29.65	34.27
40.00%	0.53	0.83	1.59	1.71	3.01	4.19	6.34	11.13	15.46	19.53	27.15	34.30	41.11	47.67
50.00%	0.58	0.95	1.91	2.06	3.65	5.09	7.75	13.72	19.17	24.29	33.93	43.00	51.68	60.05
60.00%	0.63	1.07	2.19	2.36	4.21	5.89	9.01	16.04	22.48	28.55	40.00	50.82	61.18	71.20

Table 3-2: Values for topographic factor (LS) for a high ratio of rill:inter-rill erosion

Source: RUSLE-FAC Handbook, Agriculture Canada (modified by: Joe Buchner, CPESC)

- Water Erosion Risk Map for Alberta
- **Sediment Risk** (KLS) (Soil Erosivity * Length * Steepness)
- Shows Regional Water Board Boundaries



Crop/Vegetation and Management Cover or "C" Factor

- Calculated as soil loss ratio of treated surface versus an untreated control surface … 5 lb/100 lb = 0.05
- Several variables may be evaluated such as:
  - Slope Gradient (2H:1V, 3H:1V)
  - Length (m)
  - Soil Type (sand, clay, loam)
  - Design or Rainfall Event (mm/hr)
  - Duration of Event (1/2 hr - 1 hr)
  - Application Rate (kg/ha) or Method of Installation
  - Time After Installation

Lower C-Factor means More Effective

How to Derive Percent Effectiveness (PE) from C Factor

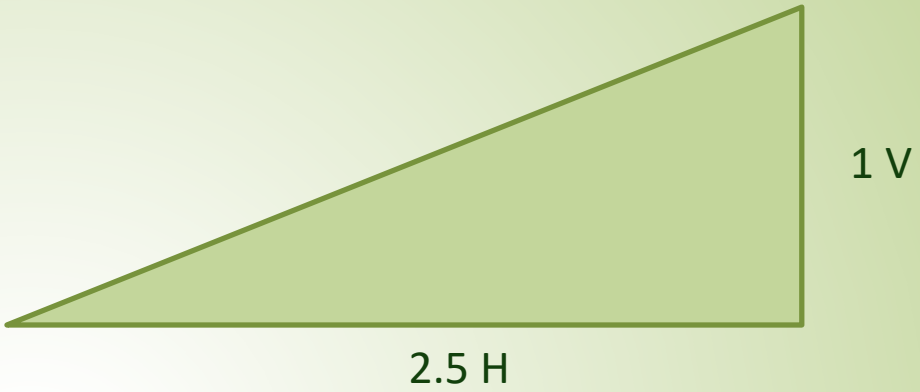
- PE = One minus C-Factor x 100%
- For example:
  - C-Factor = 0.05
  - % Effectiveness = 1.00 - 0.05 = 0.95

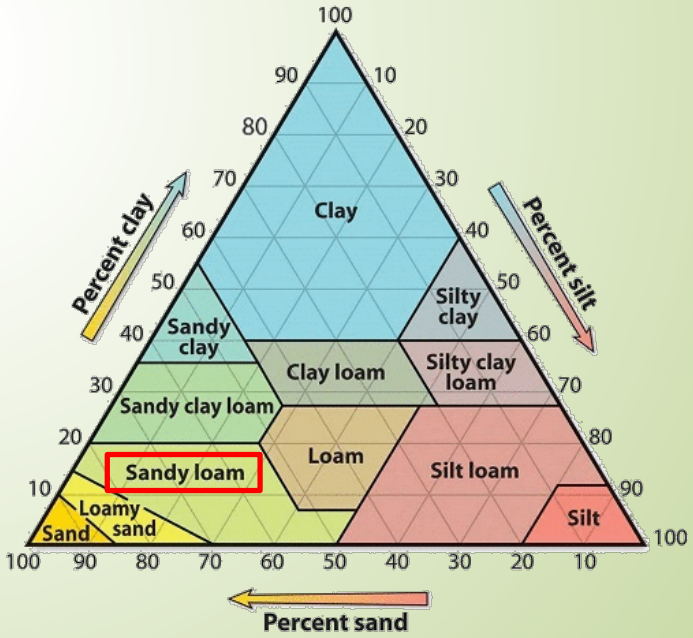
    0.95 x 100% = 95%

Obtaining a C-Factor: Large Scale Lab Testing

Utah Water Research Lab Protocol

- Slope gradient:
  - 2.5H : 1 V
- Soil Type:
  - Sandy Loam
- Rainfall Intensity:
  - 5 inches/hour (127 mm/hr)
- Duration:
  - 60 minutes





Testing Can and Should Be Very Destructive!

Texas Transportation Institute (TTI)
Note effects from rainfall impact

Need sufficient gradient, length, intensity and kinetic energy

C – Factor Soil Loss

C-Factor	% Effectiveness	Potential Soil Loss (kilograms/hectare/year)	Ranking
0.01	99	3,750	Best
0.02	98	7,487	Best
0.05	95	18,700	Better
0.1	90	37,480	Good
0.2	80	78,816	Marginal
0.3	70	112,225	Poor
0.5	50	187,040	Poor
0.75	25	280,212	Poor
1	0	374,364	Untreated

Based upon standardized testing at the Utah Water Research Laboratory

P – Factor Examination

P-Factor Practice	P-Factor Value	Potential Soil Loss Relative to P-Factor = 1.0 (lb/acre)
Compact and Smooth Surface	1.2	120,000
Loose – Disked Plow Layer	1.0	100,000
Rough Surface with Tracks in all Directions	0.9	90,000
Tracked Up and Down Slope	0.7	70,000

Based upon standardized testing at the Utah Water Research Laboratory

71% increase in potential soil loss on smooth versus rough graded slopes

Cat Tracking on Sudbury, Ontario Nickel Mine

Alberta Oil and Gas Project with High Potential for Erosion

Alberta Oil and Gas Project

Alberta Oil and Gas project

C Factor = 0.01

P Factor = 0.70

Alberta Oil and Gas Project
Grow In at 10 months after installation

Assigning Risk

Table 1.1. Guidelines for Assessing Potential Soil Erosion Classes

Soil Erosion Class	Potential Soil Loss	
	tonnes/hectare/year	tons/acre/year
1 Very low (i.e. tolerable)	< 6	< 3
2 Low	6-11	3-5
3 Moderate	11-22	5-10
4 High	22-33	10-15
5 Severe	> 33	> 15

Class 1 (Very Low)

- Soils in this class have very slight to no erosion potential. Minimal erosion problems should occur if good soil conservation management methods are used. Long-term sustainable productivity should be maintainable under average management practices. Potential soil erosion loss for this class is less than 6 tonnes/hectare/year (<3 tons/acre/year); however; the tolerable soil loss limit may be exceeded for soils that are shallow, low in organic matter, of poor structure or previously eroded.

Class 2 (Low)

- Low to moderate soil losses will occur without the use of crop rotations and cross slope farming. Potential soil erosion losses range from 6 to 11 tonnes/hectare/year (3 - 5 tonnes/acre/year).

Class 3 (Moderate)

- Moderate to high soil losses will occur unless conservation measures such as conservation tillage, contour cropping and grass waterways are used. Potential soil erosion losses range from 11 to 22 tonnes/hectare/year (5 - 10 tons/acre/year).

Class 4 (High)

- High soil losses will occur unless measures such as zero tillage, sod-based rotations, terraces, cross-slope or contour strip cropping are employed. Potential soil erosion losses range from 22 to 33 tonnes/hectare/year (10 - 15 tons/acre/year).

Class 5 (Severe)

- Severe soil losses will occur unless a soil cover of permanent vegetation is maintained. Potential soil erosion losses are greater than 33 tonnes/hectare/year (>15 tons/acre/year).

Strategies to Combat Soil Loss

- Use RUSLE FAC to predict Water Erosion Risks
- Reduce Slope Steepness and Length when possible
- Select Erosion Control Treatments with low C Factors
- Use Practice Factors that reduce erosion potential and increase vegetation establishment

Thank you!

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