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RUSLEFAC

Revised Universal Soil Loss Equation for Application in Canada

A Handbook for Estimating Soil Loss from Water Erosion in Canada

Canada

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A Handbook for Estimating Soil Loss from Water Erosion in Canada

(Final version; based on 1997 draft)

Prepared by:
G.J. Wall, D.R. Coote, E.A. Pringle and I.J. Shelton (editors)
Research Branch
Agriculture and Agri-Food Canada
Ottawa, Ontario

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Copies of this report are available from:

Dr. E. C. Huffman
Eastern Cereal and Oilseed Research Centre
Research Branch, Agriculture and Agri-food Canada
Ottawa, ON K1A 0C6

huffmant@em.agr.ca

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EXECUTIVE SUMMARY

Soil erosion remains a sizable problem for Canadian agriculture, in terms of both cost and degradation of the natural productive capability of the soil. There exists a need for improved predictive models to estimate the nature and extent of the problem — at the local, regional and national levels.

The Agricultural Institute of Canada's (AIC) Soil Conservation Committee (1979) estimated that the average annual replacement cost of nutrients lost through erosion in Canada was \$15 - \$30/hectare (\$6 - \$12 per acre). The impact of erosion on a given soil type (and hence the tolerance level) varies, depending on the type and depth of soil. **The suggested tolerance level for most Canadian soils is 6 tonnes/hectare/year (3 tons per acre per year) or less.** Some soils may be able to tolerate higher losses (up to 11 tonnes/hectare/year or 5 tons/acre/year) and still maintain long-term productivity, but in general only the deepest and most fertile soils would be able to withstand such losses.

The purpose of this handbook is:
- to provide a reference document which describes methods for estimating soil loss from water erosion for use in conservation planning; and
- to provide a compilation of material required to predict soil erosion rates in Canada.

The methods used in this handbook are:
- the Universal Soil Loss Equation (USLE);
- the Revised USLE (RUSLE); and
- adaptations of these models for Application in Canada (RUSLEFAC).

Application of the earlier models has been limited, partly because of a lack of pertinent information, and partly because they were developed elsewhere and do not reflect Canadian conditions or scale of application. The development of RUSLEFAC provides researchers with the methods and means of determining soil erosion values for the different conditions encountered in the various agricultural regions of Canada.

Part 1: provides background information on soil erosion prediction in Canada and an explanation of the Universal Soil Loss Equation (USLE) and its revised version, RUSLE.

There are several general conditions, unique to any site, which effect erosion by water, and which are factors in the USLE or RUSLE equation.

The Rainfall and Runoff Factor (R)

- is a measure of the total annual erosive rainfall for a specific location, as well as the distribution of erosive rainfall throughout the year;
- is affected by storm energy and intensity, the amount of rainfall, snowfall and runoff that occurs during different seasons of the year, and snowmelt on top of frozen or partially frozen soil.

The Soil Erodibility Factor (K)

- is a quantitative measure of a soil's inherent susceptibility/resistance to erosion and the soil's influence on runoff amount and rate;
- is affected by soil texture and structure, organic matter content, permeability, and season of the year;
- soils tend to be most susceptible in spring, especially during thaw conditions and least erodible in fall when the soil is dry and consolidated after the growing season.

The Slope Factor (LS)

- is a measure of the effects of slope angle, length and complexity on erosion.

The Crop/Vegetation and Management Factor (C)

- is a measure of the relative effectiveness of soil and crop management systems in preventing or reducing soil loss;
- is affected by:
    - crop canopy (leaves and branches of the crop, which intercept the raindrops and dissipate some of their erosive force),
    - surface cover (crop residues and live vegetation on the soil surface),
    - soil biomass (all vegetative matter within the soil; residue helps to improve the flow of water into the soil and the soil water-holding capacity),
    - tillage (type, timing and frequency of tillage operations; has an effect on soil porosity, surface roughness and compaction),
    - previous year's crop,
    - distribution of erosive rainfall over the growing season.

The Support Practice Factor (P)

- is a measure of the effects of practices designed to modify the flow pattern, grade, or direction of surface runoff and thus reduce the amount of erosion.
- common support practices are: cross slope cultivation, contour farming, stripcropping, terracing, and grassed waterways.

Part 2: provides an extensive compilation of RUSLEFAC and USLE factors for Canadian conditions.

Part 3: provides case studies and step-by-step instructions for calculating soil loss using real data from various regions of Canada.

RÉSUMÉ

L'érosion du sol demeure un problème de taille pour l'agriculture canadienne, car elle entraîne des coûts et dégrade la productivité naturelle du sol. Il est donc nécessaire d'améliorer les modèles de prévision pour évaluer la nature et l'étendue de ce problème à l'échelle locale, régionale et nationale.

Selon les estimations du Comité de la conservation des sols de l'Institut agricole du Canada (IAC), le coût annuel moyen de remplacement des nutriments perdus à cause de l'érosion se situait entre 15 et 30 $ l'hectare (6 et 12 $ l'acre) au Canada en 1979. L'incidence de l'érosion sur un sol quelconque (et, partant, le niveau de tolérance) varie en fonction du type et de la profondeur du sol. **La perte tolérable recommandée pour la plupart des sols canadiens est de 6 tonnes l'hectare par année (3 tonnes l'acre par année) ou moins**. Certains sols peuvent peut-être tolérer des pertes plus élevées (jusqu'à 11 tonnes l'hectare ou 5 tonnes l'acre par année) et maintenir leur productivité à long terme; en règle générale, toutefois, seuls les sols les plus profonds et les plus fertiles pourraient tolérer de telles pertes.

Le présent document de référence vise à :

- décrire les méthodes d'estimation de la perte de sol causée par l'érosion hydrique, en vue de leur utilisation dans la planification des mesures de conservation;
- compiler les données nécessaires pour prévoir les taux d'érosion du sol au Canada.

Les méthodes utilisées dans le présent document sont :

- l'équation universelle des pertes en terre (EUPT);
- la version révisée de l'EUPT (REUPT);
- les adaptations de ces modèles pour fin d'application au Canada (REUPTAC).

L'application des modèles antérieurs a été limitée parce qu'on manquait de données pertinentes et aussi parce que ces modèles ont été conçus ailleurs et qu'ils ne reflètent pas les conditions ni l'échelle d'application du Canada. Avec la mise au point des REUPTAC, les chercheurs disposent des méthodes et des moyens nécessaires pour déterminer les valeurs de l'érosion du sol pour différentes conditions observées dans les régions agricoles du Canada.

Partie 1 : fournit des données de base pour la prévision de l'érosion du sol, ainsi qu'une explication de l'équation universelle des pertes en terre (EUPT) et de sa version révisée, la REUPT.

Il y a plusieurs conditions générales, uniques à chaque site, qui influent sur l'érosion hydrique et qui font partie des facteurs de l'EUPT ou de la REUPT.

Facteur de pluviosité et de ruissellement (R)

- Le facteur R est une mesure de la quantité annuelle totale de pluie érosive à un endroit donné, et de la répartition de cette pluie sur l'année.
- Le facteur R varie selon l'énergie et l'intensité des averses, la quantité de pluie, de neige et d'eau de ruissellement pendant les diverses saisons de l'année et la quantité de neige fondue sur le sol gelé ou partiellement gelé.

Facteur d'érosivité du sol (K)

- Le facteur K est une mesure quantitative de la sensibilité ou de la résistance inhérente d'un sol à l'érosion et de l'incidence du sol sur le volume et le débit de ruissellement.
- Le facteur K varie selon la texture et la structure du sol, la teneur en matières organiques et la saison.
- Les sols ont tendance à être plus sensibles au printemps, surtout pendant le dégel, et moins érodables l'automne, après la saison de croissance, lorsqu'ils sont secs et compacts.

Facteur de déclivité (LS)

- Le facteur LS est une mesure des effets de l'angle, de la longueur et de la complexité de la pente sur l'érosion.

Facteur de culture/végétation et de gestion (C)

- Le facteur C est une mesure de l'efficacité relative des systèmes de gestion des sols et des cultures dans la prévention ou la réduction de la perte de sol.
- Le facteur C varie selon :
  - la voûte de verdure (feuilles et branches qui interceptent les gouttes de pluie et dissipent une partie de leur force érosive);
  - la couverture végétale (résidus de culture et végétation vivante sur la surface du sol);
  - la biomasse du sol (toute la matière végétale dans le sol; les résidus aident à améliorer l'écoulement de l'eau dans le sol et la capacité de rétention du sol);
  - le travail du sol (type, période et fréquence de travail du sol; influe sur la porosité, la rugosité de surface et la compaction du sol);
  - la culture de l'année précédente;
  - la répartition de la pluie érosive sur la saison de croissance.

Facteur des pratiques de soutien (P)

- Le facteur P est une mesure des effets des pratiques visant à modifier le profil, la pente ou la direction de l'écoulement du ruissellement en surface et à réduire ainsi l'érosion.
- Les pratiques de soutien courantes sont : la culture en pente transversale, la culture en courbes de niveau, la culture en bande alternante, l'aménagement de terrasses et l'aménagement de voies d'eau gazonnées.

Partie 2 : fournit une vaste compilation de facteurs obtenus selon les méthodes REUPTAC et EUPT pour les conditions canadiennes.

Partie 3 : fournit des études de cas et des instructions détaillées pour le calcul de la perte de sol à l'aide de données réelles provenant des diverses régions du Canada.

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LIST OF AUTHORS

Introduction	I.J. Shelton and G.J. Wall
The Rainfall Factor	D.R. Coote and H.N. Hayhoe
The Soil Erodibility Factor	G.J. Wall
The Slope Factor	D.R. Coote
The Crop/Vegetation and Management Factor	I.J. Shelton
The Support Practice Factor	L.J.P. van Vliet

LIST OF CONTRIBUTORS

D. Bates	British Columbia Ministry of Agriculture
J. Dobb	British Columbia Ministry of Agriculture
G. Johnstone	British Columbia Ministry of Agriculture
M. Malmberg	British Columbia Ministry of Agriculture
K. McAra	British Columbia Ministry of Agriculture
T. Moore	British Columbia Ministry of Agriculture
K. Nickel	British Columbia Ministry of Agriculture
W. Odermatt	British Columbia Ministry of Agriculture
B. Peters	British Columbia Ministry of Agriculture
M. Sanders	British Columbia Ministry of Agriculture
M. Sweeney	British Columbia Ministry of Agriculture
J. Vielvoye	British Columbia Ministry of Agriculture
B. Weismiller	British Columbia Ministry of Agriculture
D. Holmstrom	Agriculture & Agri-Food Canada
E. Woodrow	Agriculture & Agri-Food Canada
C. Hookey	Newfoundland Department of Forestry & Agriculture
J-L. Daigle	New Brunswick Department of Agriculture
M. Stapleton	Newfoundland Department of Forestry & Agriculture
P. Johnson	Ontario Ministry of Agriculture, Food & Rural Affairs
H. Martin	Ontario Ministry of Agriculture, Food & Rural Affairs
J. McKinley	Ontario Ministry of Agriculture, Food & Rural Affairs
J. Schleihauf	Ontario Ministry of Agriculture, Food & Rural Affairs

The Staff of Alberta Agriculture, Food and Rural Development
The Staff of Manitoba Agriculture
The Staff of Saskatchewan Agriculture & Food
The Staff of Nova Scotia Department of Agriculture & Marketing, Plant Industry Branch

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PART 1 — PREDICTING SOIL EROSION IN CANADA

1.0 INTRODUCTION

> ***"Erosion of soil by water is the most widespread type of soil degradation and occurs in all provinces to some extent."***
>
> from: "Soil at risk - Canada's eroding future, 1984"
> Standing Senate Committee on Agriculture, Fisheries and Forestry

1.1 Purpose of the handbook

This handbook:

1. describes methods for estimating soil loss from water erosion in conservation farm planning
2. provides a compilation of material required to predict soil erosion rates in Canada

1.2 Organization of the handbook

Part 1 presents background information on erosion prediction in Canada and explains the Universal Soil Loss Equation (USLE) and its revised edition (RUSLE).

Part 2 is a compilation of RUSLEFAC (RUSLE For Application in Canada) and USLE factors for Canadian conditions

Part 3 contains case studies used to indicate how USLE/RUSLE can be used with actual data to produce soil loss estimates for a range of conditions in various regions of Canada.

1.3 Background — Erosion in Canada

Soil erosion is a widespread environmental challenge facing Canadians today. Erosion is defined as the movement of soil by water and wind, and it occurs in all regions of Canada under a wide range of land uses. In agricultural land it can also be caused by tillage translocation. Erosion by water can be dramatic during storm events, resulting in wash-outs and gullies. It can also be insidious, occurring as sheet and rill erosion during heavy rains and snowmelt. Most of the soil lost by water erosion is by the processes of sheet and rill erosion.

Erosion causes both on-farm and off-farm problems for Canadian agriculture. The off-farm impacts of sediment, bacteria from organic matter, nutrients and pesticides on the environmental quality and economic capability of surface water ecosystems are substantial and well-documented.

On-farm impacts of erosion concern not only the immediate loss of topsoil (plus surface applied crop inputs) from Canadian cropland, but also a long-term loss of productivity. The Agricultural Institute of Canada's (AIC) Soil Conservation Committee (1979) estimated that the average annual replacement cost of nutrients lost through erosion in Canada was \$15 - \$30/hectare (\$6 - \$12 per acre). In Ontario the value of the total loss of nutrients, pesticides and yield was estimated to be as high as \$15/hectare. These costs do not reflect the downgrading of important Class 1 and 2 agricultural lands to lower capability classes. It was regarding the loss of productivity that the Standing Committee on Agriculture, Fisheries and Forestry (1984; also known as the Sparrow Commission) concluded:

> *"Canada risks permanently losing a large portion of its agricultural capability if a major commitment to conserving the soil is not made immediately by all levels of government and by all Canadians"*

The National Soil Conservation Program (NSCP) followed the Sparrow Commission's recommendations. The program was targeted to regional problems but facilitated research, monitoring, technology transfer, awareness and financial assistance to producers for controlling soil degradation in all areas. The program accomplished much. At the farm level conservation tillage was adopted and fragile lands were retired. At the national level methods for predicting agricultural erosion received widespread use and data bases were enhanced to include all Canadian agricultural and agri-forestry conditions. Further, resource information such as the Water Erosion Risk maps (1:1,000,000) were generated to facilitate decisions regarding agricultural and environmental policy in Canada.

Soil conservation is of concern to the Federal-Provincial committee on environmental sustainability. Its report "Growing Together" (1990) recommended the need for research on agricultural soil resources regarding the "development of indicators of degradation/conservation that can be used in monitoring the resource base". This work will have several applications: at the farm level — to predict the need for erosion control measures (using the Universal Soil Loss Equation or other models) as part of farm planning for environmental sustainability; at the regional level (i.e. watershed) to determine the nature and extent of on-farm and off-farm impacts or degradation/conservation; and at the national level — to predict the rate of degradation of soil and water resources using predictive models and geographical information systems (GIS) for the purposes of "state of the resources" reporting.

Soil erosion remains a sizable problem for Canadian agriculture. With this there exists a need for improved predictive models to estimate the nature and extent of the problem — at the local, regional or national levels.

1.4 Approaches to soil erosion prediction in Canada

Water erosion rates have been estimated in Canada, but no quantitative methods to predict erosion have been developed for Canadian conditions. Most predictive models have been developed elsewhere and fall into one of two categories based on scale; namely, that of a field or landscape profile (i.e. an erosion rate is predicted for each slope) or a watershed.

The Universal Soil Loss Equation (USLE) is a field scale model first developed in 1960 and updated in 1978 by Wischmeier and Smith of the United States Department of Agriculture. The USLE predicts the longterm average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, crop system and management practices. Soil conservationists can compare soil loss from a particular field with a specific crop and management system to "tolerable" soil loss rates (i.e. the maximum rate that could occur indefinitely without adversely affecting soil productivity) and to evaluate alternative management and crop systems on this basis.

Although the USLE has received widespread use in the U.S., its use in Canada has been limited since much of the information required to determine soil erosion rates has not been available. The USLE was first applied in Canada from 1970 to 1974 on erosion plots in Prince Edward Island (Steward and Himelman 1975). It was also used in southern Ontario in the International Joint Commission sponsored studies of pollution from land use activities (the PLUARG studies) in the Great Lakes Basin between 1973 and 1978 (van Vliet et al., 1978). The first Canadian refereed scientific publication using the USLE was that of van Vliet et al. in 1976 which dealt with the effects of land use on potential sheet erosion losses in southern Ontario.

1.4.1 Probable future developments in soil erosion prediction

A new generation of soil erosion models are being produced in the U.S.. The USDA Water Erosion Prediction Project (WEPP) is a “process” model that attempts to predict when and where soil loss and deposition will occur on a hillslope (HILLSLOPE version), in a small watershed (WATERSHED version) or in a large drainage basin (GRID version) through simulation of physical processes during erosion events (Lane and Nearing, 1989). The hillslope version of the model is now being validated across the U.S. and in Canada. Availability of the WEPP model for routine use outside of the research community is several years away after further testing, adjustment and modification for Canadian conditions. None of the new generation of soil erosion models are ready for widespread application.

1.4.2 The Revised USLE For Application in Canada (RUSLEFAC)

The Revised Universal Soil Loss Equation (RUSLE), developed as an interim improvement on the USLE, is intended to bridge the gap between what is now outdated technology (i.e. the USLE) and the new generation of process-based models (like WEPP) which are still in the developmental stage.

The RUSLE utilizes the same empirical equation used in the USLE. However, new methods have been introduced for the estimation of the values of the various factors of the USLE. These new methods allow for inclusion of quantitative information regarding seasonal variation of soil erodibility factor (K), irregular slopes (LS) and crop and management relationships (C) and the effect on erosion. Unlike the USLE, RUSLE's calculations are computerized as are the databases, which include information on soil erodibility (K) and climate (R) data for all major soils and cities across the United States but for no Canadian locations. Until now, the RUSLE soil loss equation has not been tested or modified for use in Canada.

The information presented in this report has been prepared to provide Canadian users with the data they need to use the RUSLE in Canada and does not require the use of a computer. This RUSLEFAC report contains information pertinent to Canadian conditions not found in the RUSLE documentation (e.g. probabilities of rainfall on thawed soil containing frozen layers, Figure R-4, Part 2). RUSLEFAC is the culmination of efforts by scientists in Agriculture Canada's Research Branch, soil conservationists of the Prairie Farm Rehabilitation Administration (PFRA), provincial agriculture departments and many universities across Canada.

RUSLEFAC is not yet available in the form of a computerized software and data package. However, if the demand is great enough this type of product might eventually be prepared. Until then, it is hoped that the information contained in this report will enable conservation planners to prepare accurate and consistent estimates of water erosion throughout Canada.

1.4.3 Rationale for using the USLE and RUSLE methods

The methods described in this handbook are essentially those published by Wischmeier and Smith (1965, 1978) for use in the United States east of the Rocky Mountains (USLE), revised version of these methods (McCool et al., 1991), and Canadian adaptations of these models (Cook, 1985; Hayhoe et al., 1992b, 1993).

Methods that provide greater accuracy than the USLE and RUSLE will be needed to bring the prediction of soil loss up to the needs of the 21st century. New methods are being developed in both the United States and in Canada. **However, the USLE and its revised version provide simple and reasonably accurate methods for which there is no better alternative available at the present time.**

1.5 An orientation to USLE / RUSLE / RUSLEFAC

The purpose of the USLE is to predict the longterm average annual rate of soil erosion for various land management practices in association with an area's rainfall pattern, specified soil type and topography (Wischmeier and Smith, 1978).

> USLE/RUSLE only predicts the amount of soil loss that results from sheet or rill erosion on a single slope and does <u>not</u> account for additional soil losses that might occur from gully, wind or tillage erosion, nor does it calculate sediment yield.

1.5.1 Inputs — Factors of the USLE/RUSLEFAC

There are several general conditions, unique to any site, which effect erosion by water. These are:
- climate
- soil
- topography
- vegetation or crop
- land use practices

Each of the conditions is represented by a different factor in the USLE or RUSLE equation as follows:

$$A = R \times K \times L \times S \times C \times P$$ (*Wischmeier and Smith*, 1978)

in which:

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

R is the rainfall factor (MJ mm ha^{-1} h^{-1})

K is the soil erodibility factor (t h MJ^{-1} mm^{-1})

L and *S* are the slope length and steepness factors, respectively (dimensionless)

C is the cropping-management factor (dimensionless)

P is the support practice factor (dimensionless)

> Detailed explanation of the USLE factors and methods used to calculate them are included in Chapters 2 to 6. Previously calculated factor values for Canadian conditions are tabulated in Part 2 of this report, and case studies for regions across the country are located in Part 3.

1.5.2 Outputs — Soil erosion rates and potential erosion classes

The following qualitative ranking system was developed (Table 1.1), based on the soil loss tolerance rates included in Table 1.2. **This class system places greater emphasis on the relative implications of soil loss (e.g. severe vs. negligible impact)** and less on the actual calculated soil loss rate. Five erosion classes have been identified, and are defined in Table 1.1.

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).

1.5.3 Interpretation of the outputs — tolerable soil losses

A tolerable soil loss is the maximum annual amount of soil which can be removed before the longterm natural soil productivity of a hillslope 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, stonefree topsoil materials and/or that have not been previously eroded are assumed to have a higher tolerance limit than soils which are shallow or previously eroded. Fine to medium textured soils tend to be more tolerant than coarser-textured soils, although this may vary depending on the specific characteristics and management of each soil.

The suggested tolerance level for most Canadian soils is 6 tonnes/hectare/year (3 tons per acre per year) or less. Some soils may be able to tolerate higher losses (up to 11 tonnes/hectare/year or 5 tons/acre/year) and still maintain long-term productivity, but in general only the deepest and most fertile soils would be amongst these.

Soil tolerance levels for several soil types have been arbitrarily estimated and are listed in Table 1.2. These values provide only a relative indication of the impact that erosion has on different soil types and will vary depending on the site. The object of good soil management should be to keep soil erosion well below these “maximum” rates.

1.5.4 Problems encountered with the use of the USLE in Canada

Widespread use of the USLE in all regions of Canada is limited by problems with data requirements and with interpretations. For example:

The R factor

Few determinations of this factor have been made using the procedure originally described by Wischmeier and Smith (1965), although the USLE is driven by the rainfall factor. Because of the time and data required to make the needed computations, Canadians have preferred to rely on simpler estimates such as that of Ateshian (1974). **Ateshian's R method has been shown to provide reasonable estimates of Wischmeier's “R” in the eastern United States, and in eastern Canada where U.S. “R” values were extrapolated across the border (Wall et al., 1983).** Unpublished data from the prairie region suggest that the Ateshian equation may seriously overestimate Wischmeier's “R”. Maule et al. (1993) report that sediment losses predicted with the Versatile Soil Moisture Budget model, which are in general agreement with measured sediment losses in the Prairies are at least an order of magnitude less than amounts predicted using Ateshian’s equation.

Severe erosion in the spring snow-melt period has been frequently noted in Canada, and occasionally measured (see, for example, Kirby and Mehuys, 1987). **Wischmeier and Smith's (1978) handbook for application of the USLE in the U.S. takes almost no account of the spring snow-melt period.** Adjustments, when attempted, have generally involved adding winter precipitation to the “R” factor (McCool et al., 1982), or adding an estimate of runoff from the melting of the “snow-on-ground at spring thaw” (Tajek et al., 1985).

K factor

Seasonal variations in soil erodibility have been observed and documented in Canada. **Soil erodibility varies in a way that makes erosion more likely during the winter-spring thaw period (Coote et al., 1988), but no account is taken of this in the USLE handbook.** Wall et al. (1988) have suggested adjustments to soil erodibility indices to help improve erosion prediction during this period. They suggest that the soil erodibility factor should be corrected by a factor of 2, to account for the increase in erodibility due to thawing conditions.

Table 1.2 Soil loss tolerance levels

SOIL DESCRIPTION	SOIL LOSS TOLERANCE[1] (tonnes/hectare/year)	SOIL LOSS TOLERANCE[1] (tons/acre/year)
Deep (30cm) topsoil, high organic matter content, well-structured, permeable subsoil	11	5
Topsoil in good condition, high organic matter, well-structured. Subsoil permeability within 60cm of surface is limited	6	3
Topsoil and subsoil are mixed in the well-structured plough layer. Dark and light coloured soil with good structure but subsoil permeability is restricted within 30cm of surface	< 6	< 3
All soils contributing runoff and sediments to streams or surface water supplies; shallow soils (<10cm) over bedrock	2	< 1
(adapted from Shelton et al.,1985)		

C factor

Most users of the USLE have estimated C factors from tables published by Wischmeier and Smith (1978). However, **few of the rotations and soil management practices that are common in Canada are to be found in the USLE handbook. In addition, there have been few measurements of the effectiveness of different crops and tillage practices used in Canada in mitigating erosion.** Recent research in Canada has begun to provide data from which it is possible to develop improved estimates of the USLE C-factor. It is expected that these will eventually be replaced by more sophisticated models when these have been thoroughly tested under Canadian conditions.

[1] This table represents the soil loss tolerance for soils with less-than-average erosion. Tolerance levels may be lower for soil with severe soil erosion and strong evidence of subsoil mixing with the topsoil, and/or soils with less than 10 cm of topsoil.

2.0 THE RAINFALL AND RUNOFF FACTOR (R) — *D.R. Coote and H.N. Hayhoe*

2.1 Purpose

- R is the rainfall and runoff erosivity index required to predict erosion by water using the USLE. Rainfall information is used in two ways in the USLE, as:
  - a measure of the total annual erosive rainfall for a specific location
  - a distribution of erosive rainfall throughout the year, expressed as a proportion of the total R per unit time

- The rainfall erosivity index is an indicator of the two variables most critical to a storm's erosivity — the amount of rainfall and the peak intensity sustained over an extended period. R is the average annual sum of all erosive rainfall events (EIs).

- EI is the total kinetic energy of a storm multiplied by the maximum 30-minute intensity, where:
  - E = the volume of rainfall and runoff, and
  - I = the prolonged-peak rates of detachment and runoff (Wischmeier and Smith, 1978)

2.2 Variables affecting the R factor

Generally, storms which generate a high volume of rainfall and runoff over a prolonged period of time have the highest R values (i.e. greater erosivity). Rainfall events which contribute low amounts of precipitation in a short period of time have little effect on soil erosion (e.g. precipitation of less than 1 cm, durations of under 30 minutes). Variables which affect R are described in Table 2.1.

2.3 Canadian applications

Summer conditions

- The high energy thunderstorms of the summer months are generally regarded to be the most potentially erosive events in most areas of Canada.

- These tend to be localized events, and, although large amounts of soil can be eroded it, might not move far from its source.

- Erosion in the summer tends to be limited by the infiltration capacity of the soil for numerous reasons (e.g. dry soils, cracks present, etc.)

Spring conditions

- Often, the soil is very wet or saturated and/or a frost layer is present. These conditions do not allow much if any of the excess surface water to infiltrate into the ground, and this encourages runoff of even the smallest amount of water.

- The surface drainage systems that form in spring are very efficient and are capable of moving most of the eroded soil directly off of the site.

- Spring showers tend to be less intense therefore limiting the amount of soil detached from the surface.

Table 2.1. Variables affecting the R factor

Variable	Description and Function	Effect on erosion	Management Implications
Storm energy	- the volume of rainfall and runoff produced during a storm	- long slow rain or short intensity, high volume can have same impact - low volumes over short periods with large intervals between storms have little erosive potential - when combined with other factors (e.g. see K section-highly erodible spring soil conditions) even relatively low intensity storms can produce significant erosion	- management systems which provide adequate cover during critical periods can reduce soil losses e.g. during spring periods (saturated soils, little surface cover) and summer conditions (highly erosive rainfall events)
Storm intensity	- the amount of rainfall per unit time (e.g. cm/hour)	- the greater the intensity the greater the potential for sediment detachment and transport	
Annual distribution of erosive precipita-tion	- the amount of rainfall and runoff that occurs during different seasons/months throughout the year	- generally, the most erosive storms occur in summer in most parts of Canada (i.e. large proportion of annual EI values)	
Winter precipita-tion	- total precipitation, snowfall and rainfall	- the greater the precipitation the greater the potential for snowmelt and runoff (Figure R-4, Part 2) - late winter/early spring rains on semi-frozen soil = greater runoff	- soils left bare, smooth at risk, especially on steeper slopes
Snowmelt	- the snowmelt that occurs on top of frozen or partially frozen soils - on frozen soil - runoff is immediate, very temporary surface ponding, high potential for concentrated flows to develop - on partially frozen soil - surface becomes saturated, runoff in sheet or concentrated flows	- In some areas, more than 50% of erosion attributed to snowmelt in areas of high snowfall and low growing season rainfall (Prairies) - this effect compounded by the amount of rainfall on frozen soil	- manure applications on frozen or semi-frozen soils will increase melting and the risk of nutrients being removed from the surface in runoff - risk of off-site damage high (sediments, manure contamination of water channels)

2.4 Calculations for Canadian conditions

There are three primary methods[2] to determine R (average annual erosivity index):

1. Calculate using measured rainstorm EI values,
   - suitable if 22 or more years of rainfall intensity data is available (Wischmeier and Smith, 1978)
2. Use equations which rely on an empirical relationship between R and the one-in-two year, 6 hour storm, (Ateshian, 1974; Madramootoo, 1988, Wall et al., 1983)
3. Use hourly precipitation records, where available, to predict R (Wigham and Stolte, 1986).

The three R value methods have been used to produce the following reference materials for Canadian conditions:

[2] None of these methods account for the effect of winter conditions. Winter conditions vary regionally and can cause most of the annual erosion (Peace River and P.E.I.) to almost none (New Brunswick).

- isoerodent maps
  - indicate annual R values for an area
  - used to calculate average annual soil losses
- monthly distribution of R (EI values)
  - indicate the proportion of annual erosive rainfall that falls during each month
  - used to determine seasonal erodibility of rainfall (R), soils (K), crop and management systems (C)
- mean annual rainfall on frozen soil map
  - indicate areas where the amount of rain falling on frozen soil might pose an erosion risk

Isoerodent maps for R - eastern Canada
- see Part 2, R factor section (Figures R-1 & 2)

- for non-winter conditions

$$R = 0.417\, p^{2.17} \quad (\textit{Ateshian}, 1974)$$

where:
R = rainfall erosivity index (MJ mm ha $^{-1}$ h^{-1})
p = normal, once-in-two years, 6 hour storm (mm)

- for winter conditions

$$R_t = R(1 + (WP/100)) \quad (\textit{Madramootoo}, 1988)$$

where:
R_t = average annual erosivity index, adjusted for winter conditions
WP = the % of total annual precipitation occurring in winter (December - March)

Isoerodent maps for R - western Canada
- see Part 2, Figures R-3a,b,c and 4)

Prairie Region

- for **non-winter conditions**
  - maps were based on a map by Stolte and Wigham 1988 and was enhanced by 1990 data (Stolte and Owoputi, 1994)

- for **winter conditions**

$$R_s = m\, r_w\, k \quad (\textit{Hayhoe et al.}, 1992b \textit{ and } 1993)$$

where:
R_s = R for winter conditions
m = mean daily winter runoff rate (mm/day)
r_w = mean winter runoff (cm)

k = constant of 1, where R_s is in MJ mm $ha^{-1}h^{-1}$

British Columbia

! R values were calculated using the Ateshian formula

! winter conditions were based on R_s estimates based on the total snowfall for each month where š 10 cm of snow fell

! the exception was southwestern B.C. (annual snowfall ˜ 100 cm), where š 20 cm monthly snowfall was used as the threshold value.

Monthly distributions of R - see Part 2, Tables R-1 to R-4

Table R1 and R2 - Prairie Region and Eastern Canada

! **Eastern Canada**
- based on Wall et al. (1983),
- Madramootoo (1988) and Gordon and Madramootoo (1989)

! **Prairies**
- calculated by Stolte and Wigham (1988)
- winter conditions by Hayhoe et al. (1992a, 1992b, 1992b, 1993)

Table 3 - **British Columbia**

! expressed as % of annual precipitation derived from four major areas

Annual amount of rainfall on frozen soil - Figure R-5

! soil erosion risk is predicted for annual amount of rainfall on soils frozen to 5-20 cm depth.

! highest levels are in Eastern Canada - where there are intensive cropping practices and minimal winter cover. This is estimated to be an important risk/source of erosion.

2.5 How to determine the R factor

1. For general use with predictive models (USLE, RUSLE or GAMES (Cook et al., 1985)) R_t can be determined in the following manner

a) in Eastern Canada

! locate the area of interest in Figure R-1 and Figure R-2.

! extrapolate point or area relative to R factor contours

b) in Prairie provinces

! locate area of interest on Figures R-3a and R-3b

! add values to determine parameter R_t

c) in British Columbia
- ! locate area of interest on Figure R-4
- ! convert to SI metric units by multiplying by 17.02

2. For more detailed use obtain appropriate R_t from Table R-1

3. For calculation of seasonal R values
(as per use for estimating crop growth stage C factors with monthly EI values) use the following steps:

i) Select appropriate R value for area of interest from Table R-1
ii) Determine time of interest (e.g. cropstage, season, months, etc.)
iii) Select monthly distribution from climatic station closest to area of interest (Table R-1 or 2)[3]. Note monthly distributions are percentages of total annual R - the %s should add up to 100 for each station)
iv) Add the monthly[4] values of the annual R for the time of interest
v) Multiply the value by the total annual R value (R_t)

Source of R factors: Part 2; R factors
Pacific region - Table R-3; Figure R-4, Part 2
Prairie region - Table R-1; Figure 3 a & b
Eastern Canada - Tables R-1, R-2; Figure R-1 & 2

Examples

1. Annual R value - Montreal

- ! R = 920 (Table R-1)

To determine US customary units, divide by 17.02

- ! R = 54

2. Monthly EI values — proportion of annual R that occurs during June, July, August (Montreal - Table R-1)

- ! EI = 17 + 19 + 22
  = 58 % of total annual erosive rainfall (R)

[3] A similar approach can be used for B.C. using Table 3 and R_t values from Figure R-4.

[4] If erosion during winter months is of concern for seasonal EI calculations refer to Figure R-5. Particular attention should be paid to areas where annual rainfall exceeds 30 mm on bare, frozen soils — as severe conditions for erosion by water exists.

3.0 THE SOIL ERODIBILITY FACTOR (K) — *G.J. Wall*

3.1 Purpose

- ! The soil erodibility factor (K) represents the rate of soil loss per unit area as measured on a 3.7m x 22m (12' x 72') plot.

- ! 'K' is a quantitative measure of a soil's inherent susceptibility/resistance to erosion and the soil's influence on runoff amount and rate

3.2 Variables affecting the K factor

Some of the key factors which affect the response of a specific soil to the erosion process are described in Table 3.1.

> 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, *<u>on the basis of soil characteristics alone</u>*.

An indication of the general susceptibility of various soil textures to erosion is given in Table 3.2.

3.3 Canadian Applications

Freezing-thawing cycles affect erodibility — partially in soils with a low sand and high silt content.

- ! Under **winter conditions**, ice layers or ‘lenses’ develop at different depths in the soil, forcing the soil particles apart and decreasing the soil’s density.
  - The soil surface is relatively impermeable
  - Erosion risk is greater for wind than water

- ! Under **above-freezing (thaw) conditions** the soil surface thaws first, leaving the soil at greater depths frozen.
  - Water infiltrates into the upper thawed layer but further drainage is limited by the impermeable frozen sub-surface soil.
  - A low-density, saturated surface is created that is highly unstable in terms of its ability to resist water erosion.
  - Extensive transportation systems can develop which can efficiently transport eroded sediments to water channels even during relatively gentle rainfall events (Pall et al., 1982).

Table 3.1. Variables that affect the K factor

Variable	Description and Function	Effect on erosion	Management Implications
Soil texture	- size and distribution of the available soil particles - smaller particles, *once detached*, are easily transported - texture of a soil influences runoff amount and rate	- erodibility increases with silt plus very fine sand content (particles easily detached, readily form crusts which decrease infiltration, increase runoff (see Table 3.2)	- type of soil may limit: - agricultural uses - crops that can be grown - management systems
Organic matter content	- amount of humus present - organic material helps to bind the soil particles together - affects water-holding capacity of soil, influences infiltration/runoff amounts	- soils with high organic matter content more erosion resistant, hold more water - low organic matter = low erosion resistance	- maintenance of adequate organic matter levels (through residue and/or manure management) reduces erosion risk, increases fertility (which in turn can increase crop vigour/cover, increase soil protection...)
Structure	- the arrangement of soil particles and aggregates - gives an indication of how strongly the soil particles "bind" together to resist erosion	- soils which do not break down easily yet allow infiltration more erosion-resistant	
Permeability	- affects the amount of water that will infiltrate into the soil as opposed to flowing downslope or ponding on the surface	- better infiltration = less runoff, less erosion (e.g. medium and coarse sand)	- practices which lead to the development of consolidated, impermeable layers or ploughpans increase the risk of soil erosion
Seasonality	- soil characteristics that may vary on a seasonal basis and affect erodibility include water content, bulk density, structure, permeability, biological activity, and drainage	- soils tend to be most susceptible in spring (especially during thaw conditions - saturated, less dense soils over frozen soils with low permeability) - least erodible in fall (dry, consolidated after growing season)	- better cover (standing and/or residue), rougher surfaces in spring can help stabilize soil, reduce erosion

In the RUSLE several variables and relationships have been added to the K section of the USLE which are pertinent to Canadian conditions. These changes include:

! an expanded range of soil types for which K has been evaluated, namely: organic soils (peat), subsoils, low activity clays and soils high in mica content;

! the potential to adjust the K value to reflect the presence of rock fragments in the profile;

! the ability to compute K on a half-month basis. These half-monthly K values are weighted according to the annual R distributions to better reflect seasonal fluctuations in soil erodibility.

Table 3.2. Indication of the General Susceptibility of Soil Textures to Erosion

Surface Soil Texture	Relative Susceptibility to Water Erosion	K ranges[1]
Very fine sand	Very highly susceptible	>0.05
Loamy very fine sand Silt loam Very fine sandy loam Silty clay loam	Hiighly susceptible	0.04 - 0.05
Clay loam Loam Silty clay Clay Sandy clay loam	Moderately susceptible	0.03 - 0.04
Heavy clay Sandy loam Loamy fine sand Fine sand Coarse sandy loam	Slightly susceptible	0.007 - 0.03
Loamy sand Sand	Very slightly susceptible	<0.007
[1] K values may vary, depending on particle size distribution, organic matter, structure and permeability of individual soils		

Many of the RUSLE adjustments to K can only be derived from the RUSLE computer programs. Until these programs are verified for Canadian conditions and made readily available to a general audience, use the methods described in **Part 2 - K factors** to adjust K values.

3.4 Calculation of K values

The soil erodibility factor, K, represents the rate of soil loss per unit area as measured on a 3.7m x 22m plot. Information on the erodibility of various soils, based on over 10,000 plot years of data from the United States, was used to develop K factors (Wischmeier and Smith, 1978).

Calculation of a K value is based on five parameters, routinely characterized through standard soil profile descriptions and laboratory analyses. These five parameters are:

- percent silt plus very fine sand (0.05 to 0.10 mm),
- percent sand greater than 0.10 mm,
- organic matter content,
- structure, and
- permeability.

Source of K factor information:
Detailed descriptions of these five soil parameters and the methods for calculating them are included in the K factor section of Part 2.

A K value can be calculated for a specific soil, using the following equation (Wischmeier and Smith 1978):

$$100\,K = 2.1\,M^{1.14}(10^{-4})(12 - a) + 3.25(b - 2) + 2.5(c - 3)$$

where:

M = (percent silt + very fine sand) x (100 - percent clay)
a = percent organic matter
b = the soil structure code used in soil classification, and
c = the profile permeability class

The nomograph in Figure K-1 (Part 2, K factor section) provides a graphical solution for determining a soil's K value, and can be used if the percent sand and organic matter fractions in a particular soil are known.

> A separate K value should be determined for each soil series associated with the map unit, or for the 'predominant' soil series in the unit. Do not average the K values, as a combined value will not represent the inherent erodibility of any soil type and will produce misleading results.

3.5 How to determine K factors

There are two methods which can be used to determine a K factor. These are:

1. Use the Wischmeier and Smith (1978) equation, which is suitable if information is available for:
   - percent sand, very fine sand and clay
   - percent organic matter
   - structure of the soil
   - permeability

2. Use the nomograph (Figure K-1, Part 2)
   - to obtain a K factor based on all the parameters in method 1., or
   - to approximate a K factor, based on particle size percentages and organic matter.

Surface soil texture K factors (Table K-3, Part 2)

K factors have been estimated for a number of surface textures and for approximate organic matter content.

- **Major textural groups and their corresponding K values are listed in Table K-3**
  - This information can be used when specific soil information is not available.
  - K values have been approximated for soils with
    i) greater than 2% organic matter,
    ii) less than 2% organic matter, or
    iii) average (or unknown) percentages

Examples

1. The attributes of a particular loam are as follows:
   - 30% sand (25% very fine sand, 5% other sand diameters)
   - 40% silt
   - 30% clay
   - 2.8% organic matter
   - fine granular structure

- slow to moderate permeability

Using the soil erodibility nomograph (Figure K-1) the K value is estimated to be:

K = 0.040

2. If the soil structure and permeability were not known then the nomograph (Figure K-1) could be used with estimates of structure and permeability codes from Figure K-2 and Figure K-3, respectively. These estimates would yield a soil texture of Clay Loam with structural code 4 and permeability code 4. Using these codes in the nomograph (Figure K-1) leads to a value of K = 0.050.

3. If the particle size distribution of the same soil was unknown but the user was able to determine that:
   - the soil is a loam (through a hand-texture assessment), and
   - it probably contains more than 2% organic matter (because of its dark colour), then Table K-3 could be used to estimate K:

   K value for a loam = 0.038

Note the difference in K values determined in the previous examples. Using estimates of parameters in the nomograph (Figure K-1) and the more general means of estimating K (Table K-3) very general K values are produced that differ enough from the actual K value to produce very different soil loss estimates. Wherever possible, use detailed information, especially when estimating soil losses for specific sites.

4.0 THE SLOPE FACTOR (LS) — *D.R. Coote*

4.1 Purpose

- accounts for the effects of slope angle and length on erosion
- adjusts the erosion prediction for a given slope length and slope angle to account for differences from conditions present at standard erosion monitoring plots on which the USLE was based (72 ft or 22 m long, 9% slopes; Wischmeier and Smith, 1978)

4.2 Variables affecting the LS factor

The effects that the LS factor components have on soil erosion are summarized in Table 4.1.

4.3 Canadian application

Slope conditions in Canada vary little from those found in the U.S.A.. However, the condition that is commonly associated with severe water erosion in Canada is when rainfall occurs when there is a saturated, thawed soil layer at the surface and a frozen layer below (see Chapter 3.0). These conditions are often associated with **rill erosion**.

The LS component of the RUSLE equation can accomodate several conditions which relate to freeze-thaw variations, and the seasonal changes in the **rill:interrill ratio** which are caused by these variations (section 4.4).

4.4 Calculation of LS factors

The LS factor represents a ratio of soil loss under the given conditions to that at a site with the "standard" slope steepness of 9% and slope length of 22.13 m.

Uniform slopes

1. The original USLE - LS equation for a uniform slope is:

$$LS \text{ ' } (\text{ë}/22.13)^{m} (65.41 \sin^{2} \text{è} \,\%\, 4.56 \sin \text{è} \,\%\, 0.065) \qquad (4.1)$$

where:
ë is the slope length of the site (meters)
è is the angle of the slope (in degrees)
m is a coefficient related to the ratio of rill to inter-rill erosion, and is equal to:
0.5 for slopes of 5% or more,
0.4 for slopes of 3.5 to 4.5%,
0.3 for slopes of 1 to 3%, and
0.2 for slopes of less than 1% (all slopes being estimated to the nearest 0.5%)

Table 4.1. The effect of LS factor variables on erosion

Variable	Description	Effect on erosion	Management implications
Steepness	- slope is measured by **angle** and **percent**	- Runoff - velocity, quantity increases with increased slope gradient - Soil loss - increases more rapidly than runoff as slope steepens - Relationship between steepness and runoff, soil losses influenced by: type of crop, surface roughness, soil saturation (Note: these effects are not reflected in LS calculations)	Crops, practices which promote infiltration and decrease runoff (rough surfaces, good cover) can reduce the effect of steepness on erosion
Length	- measured from the point where surface flow begins to where: a) the runoff is concentrated into a channel, or b) the slope gradient decreases and deposition of eroded sediments occurs	- runoff, erosion increases with increasing slope length - greater accumulation of runoff on longer slopes increases detachment, transport potential - runoff usually concentrates in less than 120 m, and always concentrates in less than 300 m	- slopes where length has great impact on erosion generally have higher C values - slopes where length has little impact on potential erosion generally have more erosion-resistant cropping practices in use (C < 0.15)
Type	uniform, concave or convex slope	Concave slopes - will generally have a lower erosion rate (i.e. lower LS value) than a uniform slope of the same average gradient - gradient (and transport capability, erosion potential) decreases with distance from the top of the slope Convex slopes - will generally have a higher rate than uniform slope - gradient increases with distance from top of slope	

! The graphs in Figures LS-1 and LS-2 (Part 2) provide solutions to this equation in SI and US customary units.

! A chart was adapted from Wischmeier and Smith (1978) to provide a simple and rapid means of solving this equation for slopes from 0.2 to 20%, and slope lengths from 2 to 300 m (Table LS-7, Part 2).

2. The RUSLE - LS equation (1990)

The Revised USLE uses essentially the same relationship for estimating the slope length factor (i.e. $L=[la/22.13]^m$). However, surface conditions affecting the ratio of the rill to the inter-rill erosion process are now taken into account in the estimation of "m".

The slope factor "S" in RUSLE is now governed by several conditions (Foster et al., 1977; McCool et al., 1989):

$$S = 10.8 \sin\theta + 0.03 \qquad (4.2)$$

when slope is $< 9\%$, length ≥ 5m

$$S = 16.8 \sin\theta + 0.50 \qquad (4.3)$$

when slope is $\geq 9\%$, length ≥ 5m

$$S = 3.0 (\sin\theta)^{0.8} + 0.56 \qquad (4.4)$$

when length < 5m

For recently-tilled and thawing soils:

- Use eqn. 4.2 when slope is $< 9\%$, and

$$S = (\sin\theta/0.0896)^{0.6} \qquad (4.5)$$

when slope is $\geq 9\%$

LS conditions in RUSLE

L and S have been combined into a single LS factor. (Tables LS-1 to LS-4, Part 2). **To select the correct table to use, four conditions must be evaluated:**

i) for consolidated soil conditions, including rangeland where both rill and inter-rill processes are significant but inter-rill is dominant (applicable also to consolidated soils when thawing), use **Table LS-1**.

ii) for moderately consolidated soil conditions, including row-cropped agricultural land, with little to moderate cover, and where rill and inter-rill erosion process are of similar importance (not applicable to thawing soils), use **Table LS-2**.

iii) for highly disturbed soil conditions, including freshly prepared construction sites, with no to little cover, and where rill erosion is predominant (also not applicable to thawing soils), use **Table LS-3**.

iv) for thawing soils, where most of the erosion is caused by surface flow, and inter-rill erosion is predominant, use **Table LS-4**.

The Revised method for calculating LS should be used whenever possible. However, where no information is available concerning i) the nature of the erosion process (i.e. rill vs. interrill), ii) the soil condition (consolidated, unconsolidated) or the land use (agricultural, rangeland or construction site) the USLE - LS method can be used as a substitute.

About the RUSLE - LS tables

- Slope lengths vary from 1 to 300 m, and slopes range from 0.2 to 60%, encompassing the range of field conditions for which the RUSLE is likely to be used.

- The tables contain an anomaly in that for short slopes, less than 25 m, the LS is greater for the lower rill:inter-rill ratio situations (Tables LS-1 and LS-2) than for the high rill:inter-rill conditions (Table LS-3). (RUSLE developers believe that differences in K and C factors will account for these seeming anomalies.

- Conditions where soil loss varies little with slope length generally have relatively low C factor values, less than 0.15. Conditions where soil loss varies greatly with slope length typically have high C factor values (McCool et al., 1991).

Irregular slopes

The RUSLE provides a procedure for separating an irregular slope into segments. This procedure recognizes and adjusts for differences in the type of slope. For example:

- **a convex slope** will have a greater effective LS factor (i.e. a higher erosion estimate) than a uniform slope with the same average gradient. Conversely,

- **a concave slope** will generally have a lower effective erosion rate than a uniform slope of the same average gradient.

The irregular slope should be divided into a number of segments, preferably not exceeding five, that describe the slope and/or reflect major changes down the slope in soil type, cropping practices, etc.

The LS factor for a particular slope segment can be determined by multiplying the uniform slope LS factor for those conditions (Tables LS-1 to LS-4) by the appropriate soil loss factor (Table LS-6) using the correct m value (Table LS-5). The soil loss factors in Table LS-6 are obtained using the following equation:

$$Soil\ Loss\ Factor = No.\ of\ Segments \times \frac{(sequence\ no.)^{1+m} - (sequence\ no. - 1)^{1+m}}{(no.\ of\ segments)^{1+m}}$$

> LS calculations for irregular slopes are simplified if the segments chosen are of equal lengths. Although the equation can be applied to segments of unequal length, a computer is almost essential if computations are to be completed in a reasonable length of time.

4.5 How to determine LS factors

Information needed to calculate the LS factor includes:

- **Simple slope**
  - slope steepness - percent
    - slope degree

! **Irregular slopes**
- type of slope (concave or convex)
- number of segments that the slope can be divided into (preferably not exceeding five). These segments should reflect major changes down the slope in soil type, cropping practices, etc.
- slope steepness, length of each segment
- soil, cropping practice on each segment

! **All slopes**
- nature of erosion process (i.e. rill, interrill) which is dominant on the slope or within each irregular slope segment

Measurements

! **Slope angles**
- estimated in the field using a clinometer or a level
- can also be estimated from contour maps, as long as the interval is no more than 0.5 m.

! **Slope lengths** (see Figure 4.1)
- measured in horizontal distances[5]

Use of topographic maps is not recommended for estimating slope lengths, unless accompanied by low-level airphotos that show details of barriers to flow, shallow channels, and gullies.

Slope limits for slope lengths

! Upper end
- the top of the slope, or
- the divide down a ridge in the field.

! Lower end
- the lower end should be located by moving down the slope, perpendicular to the contours, until
  i) a broad area of deposition, or
  ii) a natural or constructed waterway is reached.

The point on the slope where runoff becomes confined in a distinct channel and is, by definition, the lower end of the slope length. The waterway or channel need not be eroded. However, it may be helpful to try to visualize where gullies might be expected to form in a field if a bare, unvegetated soil surface was maintained.

Note: Deposition is often observed where the slope angle becomes about 5% on steeper concave slopes (McCool et al., 1991). This can sometimes be used as an indication of the slope position to which slope length should be measured.

[5] In practice, the difference between length measured along slope and horizontal distance is so small that it can be ignored for fields that are normally cultivated. (e.g. On a slope of 14% - error is less than 1%; 20% slope - 2% error; 30% slope - 5% error.) Slope lengths should be converted to horizontal distances on slopes steeper than 15% if precision is important, and converted routinely on slopes greater than 30%).

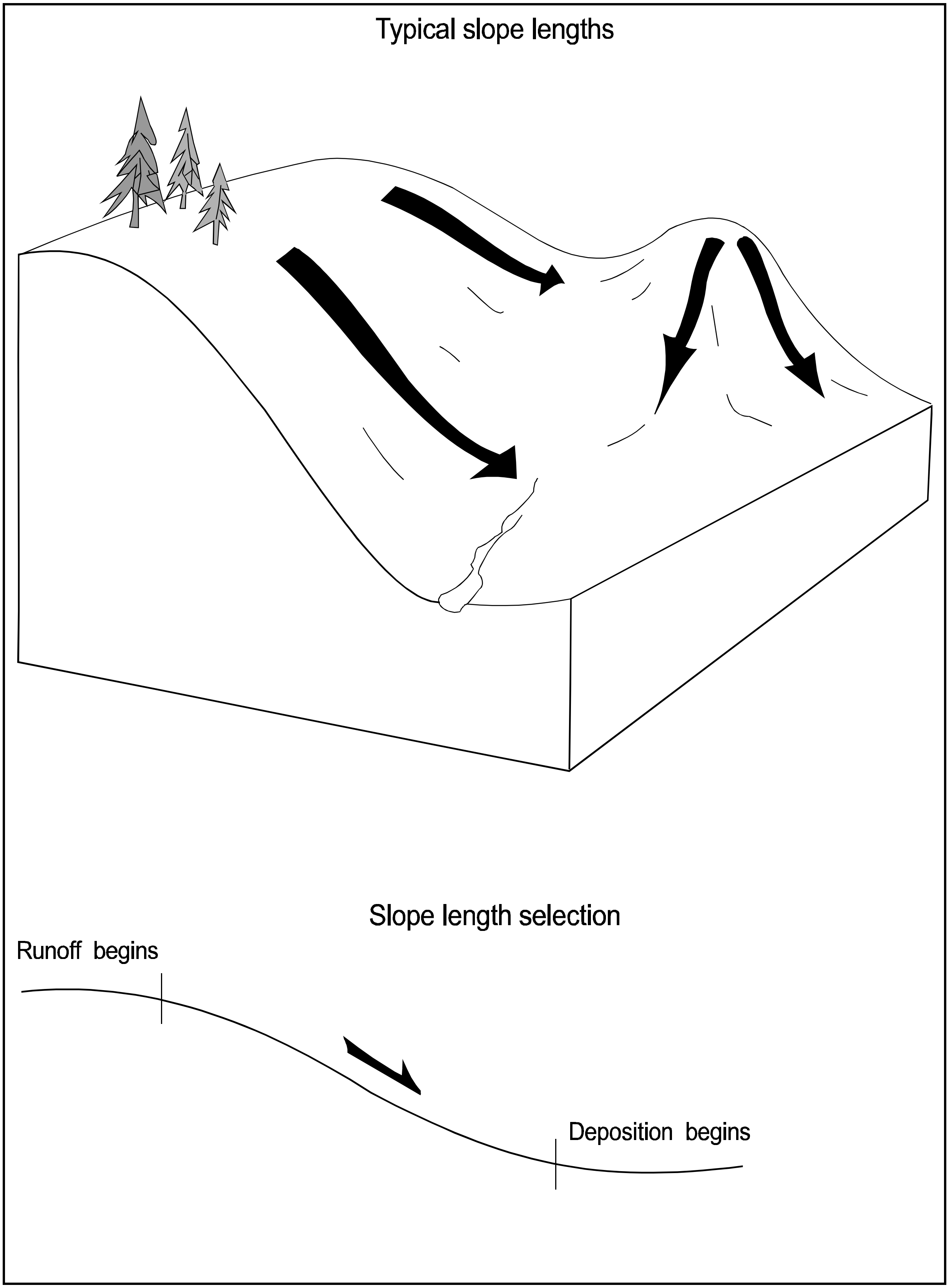

Figure 4.1. Typical slope lengths (Source: Soil and Water Conservation Society, 1993)

Source of LS factors:
RUSLE factors: Tables LS-1 to LS-6, Part 2, starting on page 62
USLE factors: Table LS-7, Figures LS-1 and LS-2

Examples

Case 1: **LS for uniform slope on agricultural land** (Table LS-2)

- Slope angle 5%
- Slope length 150 meters **LS = 1.23** (RUSLE)

- If no slope information other than steepness and length is available, then use Figure LS-1 (Table LS-7) **LS = 1.4**[6] (USLE)

Case 2: **LS calculation for irregular (convex and concave) slope (similar soils and cropping practices along slope)**

Table 4.2 shows the application of the slope segment approach to irregular slopes to a situation in which the soil types and the cropping practices are similar on each of the 3 segments. Table LS- (Part 2) can be used to estimate the soil loss factors for different segments according to the value of m for that segment.

Table 4.2: Calculation of LS for irregular slopes (convex and concave) of 300 m length with 3 equal segments, with similar soil conditions (i.e. equal rill:inter-rill ratios)

(1) Segment	(2) Slope (%)	(3) LS (Table LS-2)	(4) m (Table LS-5)	(5) Soil Loss Factor (Table LS-6)	(6) LS for *i*th Segment (Col.3xCol.5)
Convex:					
1	5	1.62	0.40	0.64	1.04
2	9	3.68	0.50	1.06	3.90
3	14	8.0	0.57	1.41	11.28
Mean for entire slope					5.41
Concave:					
1	14	8.0	0.57	0.54	4.32
2	9	3.68	0.50	1.06	3.90
3	5	1.62	0.40	1.30	2.11
Mean for entire slope					3.44

In this example (Table 4.2):

- the effective (mean) LS for:
  - the whole **convex** slope is **5.41**
  - the whole **concave** slope is **3.44**.

[6] Note that the differences in the LS values calculated with the use of the USLE and Revised USLE reflect the advances in slope-erosion relationships presented by the RUSLE.

Note: If the slope had been uniform, with an average slope of 9.33%, the LS would be **3.87** (interpolated from Table LS-2 in Part 2)

Case 3: **LS calculation for irregular (convex and concave) slopes (different soils and cropping practices along slope)**

Table 4.3 shows the application of the RUSLE slope segment approach to irregular slopes to a situation in which the soil types and the cropping practices are different on each of the 3 segments.

Table 4.3: Illustration of the computation of LS for an irregular slope (convex) of 300 m length with 3 equal segments and different soils and cropping in each segment

(1) Segment i	**(2) Slope (%)**	**(3) LS (Tbls LS-1, LS-2)**	**(4) m (Tbl LS-5)**	**(5) Soil loss factor (Tbl LS-6)**	**(6) LS for segment (Col.3 x Col.5)**	**(7) $Rk_iC_iP_i$ (see note)**	**(8) Erosion rate for (t/ha/yr)**
1	5	1.62	0.40	0.64	1.04	35.0	36.4
2	9	3.68	0.50	1.06	3.90	32.5	126.8
3	14	5.12	0.40	1.30	6.66	1.5	10.0
For entire slope					3.87		57.7

Note: Assuming cultivated crops on segments 1 and 2, with slightly less erodible soil in segment 2, and pasture on segment 3; P was assumed to be 1.0; R would be the same for all segments

In this example (Table 4.3):

! the first two segments were in cultivated crops
- Table LS-2 was used to estimate the segment LS
- the middle column of Table LS-5 was used to estimate “m”

! the third segment was assumed to be in pasture, so
- LS was obtained from Table LS-1, and
- “m” from the first column of Table LS-5.

! the **slope LS is the mean of the three segment LS values**, i.e. 3.87 (compared with 5.51 when the rill:inter-rill ratios were assumed to be similar).

Assuming R, K, C and P values that give the products shown in column (7) above:

! **the slope erosion estimate is 57.7 t/ha/y** (RUSLE)

If a uniform slope LS is estimated using the **USLE** approach, and a mean RKCP (23.0) is used, then the erosion rate estimate would be [3.90 (from Eqn. 4.1) x 23.0] = 89.7, which is **56% higher than the estimate using the RUSLE**.

5.0 THE CROP/VEGETATION AND MANAGEMENT FACTOR (C) — *I.J. Shelton*

5.1 Purpose

- ! The C factor is used to determine the relative effectiveness of soil and crop management systems in terms of preventing or reducing soil loss.

- ! A C value is a ratio comparing the soil eroded under a specifc crop and management system to continuous fallow conditions.

5.2 Variables affecting the C factor

The variables affecting the factor are described in Table 5.1.

5.3 Canadian applications

C factors for the cropping, tillage and soil management systems of Canadian crops have been developed for major agricultural regions of the country. The regions (as shown in the map in Figure C-1) have been defined on the basis of:

- ! climate and annual rainfall distribution,
- ! similarity of cropping, tillage and soil management systems, management practices[7]
- ! crop types, development and maturation,
- ! growing season length and timing of operations, general types and quality of practices regarding tillage, planting and harvesting

These regions are used as a framework to develop C factors for single crops and crop rotations.

5.4 Calculation of C factors

The calculation of a C factor takes into account:

- ! the variables affecting it (e.g. crop type, residues - surface and buried, tillage, residual effects of prior land use/crops, and the distribution of rainfall over time)
- ! how the relative impact of each variable changes over the season; and
- ! how these variables interrelate over the entire year.

The annual C factor is the integration and summation of the above variables, and their relative and compounded influences over time.

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[7] Where detailed information was unavailable, C values were estimated or extrapolated (e.g. specialty crops or in some high residue systems)

Table 5.1. Variables that affect the C factor.

Variable	Description and function	Effect on erosion	Management implications
crop canopy	- leaves and branches of the crop above the surface (i.e. not touching) intercept the raindrops before reaching soil - some of raindrops' erosive force is dissipated - infiltration facilitated	- raindrops that fall from canopy do not have the same erosive force as raindrops not intercepted - the greater the extent of the crop (areal cover) the better the erosion protection - effectiveness will change over the growing season (i.e. better protection with greater canopy coverage; decreased with crop removal) - loss of canopy will have impact on other variables (e.g. defoliage will increase surface residue cover)	- erosive force of rain is reduced with crops that have higher surface area coverage, especially during peak erosive rainfall periods (e.g. spring/early summer conditions)
surface cover	- includes: residues from previous and present crop, live vegetation touching surface, rock fragments, cryptograms (i.e. moss, lichens, etc.) on soil surface - intercept the drops at the ground level - reduces much of rainfall's impact - encourages ponding	- the higher the proportion of surface area covered by residues the greater the erosion control effect - reduces detachment, runoff and transport capacity - effectiveness decreases as residues decompose (as a function of rainfall, air temperature) - residues incorporated by tillage break down more quickly than those on surface	- certain tillage systems (e.g. reduced, mulch, ridge, zone) will leave crop residues on the soil surface to help control erosion - tillage impact a function of implement used, speed, soil moisture conditions during operation etc.)
soil biomass	- includes all vegetative matter within the soil (e.g. living and dead roots, buried crop residues) - water flows more readily into soil, following the channels, macropores created by roots, residues, stalks, etc. - porosity, infiltration rate at the soil surface is enhanced - residue helps to improve both surface and sub-surface water-holding capacity	- greater biomass generally indicates better resistance to erosion - runoff, transport capability decreased - infiltration facilitated	- tillage redistributes biomass through plough layer, kills living roots - tillage practices that are too deep, aggressive and frequent will bury residues sufficiently to negate erosion control benefits
tillage	- the type, timing and frequency of primary and secondary tillage operations affects soil physical properties such as: soil porosity (nature, extent of pore space in the soil as affected by tillage), roughness (cloddiness), structure (aggregate size, shape, strength) compaction, microtopography and soil macro- and microfauna	- soil physical properties affect: infiltration, surface water storage, runoff velocity and particle detachability - rougher surfaces promote infiltration - good soil structure (i.e. medium to fine, strong, granular to subangular blocky aggregates) facilitates infiltration and are more water stable - organic matter binds soil particles to form aggregates (increased number of tillage passes reduce sizes of aggregates, increase surface areas of aggregates (i.e. greater loss of organic material takes place through increased mineralization) - excessive tillage, especially in wet conditions, can compact soil and decrease porosity, infiltration	- well-timed practices which maintain good soil structure, minimize compaction and surface crusting, retain residues and organic matter are conducive to crop germination and emergence (which in turn provides better erosion protection) - residue levels decrease with more aggressive tillage systems, greater number of passes

Table 5.1. (cont'd) surface rough-ness[1]	- microtopography of the surface - water ponds in the depressions, giving surface water time to infiltrate - runoff is trapped or slowed, reducing its potential erosivity - indirect indicator of cloddiness, potential for the surface to seal	- erosivity of raindrops, runoff is reduced - rougher surfaces (i.e. deeper depressions) trap more water - roughness (and hence effectivess) is reduced over time as soil surface subsides after tillage operations, depressions gradually fill with sediments) - rate of roughness decline - function of amount of annual rainfall after tillage operations	- tillage produces greater roughness in fine soils, less rough surface produced in coarse textured soils - oughness increases with increases in biomass
prior land use	- the residual effects of prior land use systems include: amount of soil consolidation, biomass, biological activity, soil quality	- the beneficial residual effects of management systems where the soil remains unworked for at least a year (e.g. forages, rangeland, forests) are edident for years, even after a land use change - in contrast , residual effects from some row crops may be barely perceptible even immediately after harvest - “recovery” of the soil from any disturbance is estimated to take 7 years - after this, erosion rate = 40% of rate of continuous cropland	- soils with high organic matter additions, minimal disturbance will have soil physical proerties that facilitate infiltration, surface storage and minimize runoff
Distribu-tion of erosive rainfall over the growing season	- the potenial for soil erosion varies geographically, depending on the distribution of erosive rainfall that falls throughout the growing season and the remainder of the year. - better erosion protection (i.e. crop cover) at key times of the year when the proportion of annual erosive rainfall is highest can reduce soil erosion significantly	- generally, more potentially erosive rainfall (higher energy and/or intensity) falls during the summer months in most parts of Canada. unoff may be greatest under spring conditions. Good surface cover at these times will reduce erosion. Conversely, if canopy cover, residue management are minimal at times of intense, long seasonal rains - C factor would be higher and erosion rates would follow	- management systems which recognize and address peak erosion periods will facilitate erosion reduction

[1] Surface roughness applies only to random roughness associated with the crop operations. Oriented roughness, such as that produced by contoured tillage operations, is described in the P factor section.

Crop information from each of the Pacific, Prairie, Great Lakes/St. Lawrence and Atlantic regions described in section 5.3 was used to calculate cropstage soil loss ratios (SLR) and erosion indices (EI) and produce C factors[8] for single, commonly grown crops.

The C values for all crops/management systems in the Canadian regions (Part 2) were all calculated using the USLE methods described by Wischmeier and Smith (1978).
The information needed to calculate C values using both the USLE and RUSLE procedures is indicated in the latter section of Part 2 (C factor section).

[8] More than one C value was calculated if special conditions existed e.g. wet and dry years in Prairie provinces

The USLE formula for the C factor is:

$$C = (SLR \times EI)$$

where:

C = crop and management factor,

SLR = soil loss ratio (ratio of soil loss under specific practice during crop stage to soil loss on a similar field of bare soil)

EI = erosivity index

The SLR factor -

- takes into account the relative and compounded impact of crop canopy cover, crop residues, tillage practices and residual soil quality for a particular crop.
- SLRs will vary throughout the year and for different cropstages
- SLR factors have been developed for most crops and are integrated into the C factors for the regions of Canada

The EI factor -

- is the proportion of annual erosive rainfall occurring during each cropstage
- generally, the greatest proportion of erosive rains fall during the middle of the growing season (this varies regionally - see Chapter 2.

Note: The RUSLE calculations for C are also based on the relationship between crop and rainfall. RUSLE was not used for these calculations because of the lack of detailed information on Canadian conditions and because not enough research has been done to determine if the United States RUSLE crop/variable relationship data can be applied to Canadian conditions.

How the C factor works for a cultivated cereal crop (see Figure 5.1)

At planting time

- the EI factor is MODERATE to LOW, and
- the SLR factor is HIGH (low residue, fine seedbed, no crop canopy)

The C factor for this crop stage (EI x SLR) is moderately high due to the nearly bare soil conditions.

At crop maturity

- the EI factor is HIGH, but
- the SLR factor is VERY LOW (due to fully developed crop canopy)

The crop stage C factor is relatively low due to the protection of the soil from the mature crop canopy — irrespective of the intensity of rainfall at this time of the year.

The total C factor for a particular crop is calculated by adding up the cropstage C values (SLR x EI) for the entire year. Notice how the C factor for the crop, cereal, can vary across crop stages and how this is evidenced by the differences in total C for that crop.

- C is the ratio of soil loss in a cropped condition to that of a bare soil condition (the greater the protection, the lower the C value)
- The potential soil loss for a field or site under clean-tilled, continuous fallow is represented by the product of RKLS in the U.S.L.E. This represents a "worst-case" soil loss under bare soil conditions where C = 1.0 (i.e. bare soil). This can be determined by multiplying R x K x LS

A Comparison of C factor calculations in the USLE and RUSLE

C value relationships were reevaluated and revised in RUSLE to reflect additional information on the effects of cover and management on erosion. Table 5.2 lists some of the additional information which is included in the RUSLE methods.

The relationships between variables have been re-evaluated and quantified; however, the outcome of these calculations remains the same — a soil loss ratio (SLR). The RUSLE SLR, which remains a ratio comparing soil losses under specific practices to bare soil conditions, is still determined for a specific period during the year. In the USLE calculations, this period corresponded to variable-length cropstage periods, reflecting a crop's development (e.g. planting stage, canopy development, crop maturation, etc.). The RUSLE formula divides the year into 15 day periods.

The key variables, under which C factor considerations are grouped, are:

- **Prior land use**
- **Canopy cover**
- **Surface cover**
- **Surface roughness**
- **Soil moisture**

These subfactors encompass a range of variables, such as: prior cropping practices and crops, tillage, soil consolidation, biological activity and the effects of meadows over time, tillage (expanded information on existing and new types), crop height, the effectiveness of residue and other mulch types (e.g. stones), the erosion process(es) in effect (rill, interrill or both) and the impact of low rainfall and antecedent moisture on soil protection by crops (Foster et al., 1977).

Many of the RUSLE C factor relationships have not been verified for Canada (i.e. residue weights, surface roughness (associated with tillage practices), crop heights, percent cover by other mulches, adjustments for soil moisture depletion and the type of water erosion process(es) in effect). As additional information on crop and management practices becomes available the list of C values for regions of Canada (Part 2) can be expanded and updated.

How the C factor is used in the U.S.L.E.

The effect of the C factor is to lower the soil loss relative to the bare soil condition. This can be shown with the following example:

$$A = RKLSCP$$

- If $RKLS$ = 22.4 tonnes/hectare/year (10 tons/acre/year)

- and C = 0.40 (conventionally tilled corn)
- and P = 1,
- then $A = 10 \times 0.40 = 9$ *tonnes/hectare/year (4 tons/acre/year)*

In the example above, a C value of 0.4 indicates that, under a particular management system, soil losses would only be 40% of that lost from the same field if it were under under continuous fallow conditions. C values range from >1.0 to nearly 0 for complete vegetation cover (grassland, continuous forest cover). Some situations, such as potatoes grown on ridges oriented up and down the slope, may have C values greater than 1.0.

Table 5.2 A comparison of variables used to calculate C values for the Universal Soil Loss Equation (USLE) and the revised equation (RUSLE)

Variable	Calculation components	
	USLE	**RUSLE**
crop, canopy cover	- crop type - yield - quality of growth - crop development (10, 50, 75+ % canopy cover) - timing of crop stage development (start, duration of each stage) - % cover at maturation	same as USLE, + - crop/ vegetation height - cropstage periods are replaced by 15 day intervals - additional crop types included
surface residue	- % cover after planting - % cover after harvest	same as USLE, + - residue weight after planting, harvest - residue effectiveness - other mulch types - type of erosion process (rill, interrill or a combination)
incorp-orated residues	- type of tillage - residue management (left on or incorporated into surface, removed from field)	same as USLE
tillage	- type(s) - number of passes - timing	same as USLE, + - surface roughness - additional types
land use residuals	- use of forages - effects of forage crop for up to two years after crop change accounted for	same as USLE, + - more detailed information on prior land use (including crops, tillage, soil consolidation, biological activity, forage crop effects over time)
crop rotations	- number of crops - sequence of crops	- same as USLE - additional information on prior land uses incorporated (see above)
addi-tional variables		- antecedent soil moisture taken into consideration for low rainfall areas - adjustment for soil moisture depletion possible

See Figure 5.1 for how the C-factor works for a cereal crop.

Month	J	F	M	A	M	J	J	A	S	O	N	D
EI values (proportion of annual R value) (Winnipeg, Table R-1)	0	0	1	3	12	18	21	32	12	2	0	0
- for RUSLE 15 day periods	.00 .00	.00 .00	.05 .05	.02 .02	.06 .06	.09 .09	.11 .11	.16 .16	.06 .06	.01 .01	.00 .00	.00 .00
-for USLE cropstage periods			.03		.13	.28	.10	.32	.14			
SLR for cropstage (USLE)			.35		.6	.5	.3	.15	.3			
Calculations for cropstage C values (Cropstage SLR x cropstage EI)			.01		.08	.14	.03	.05	.04			.35 Crop C Value
						Canopy Cover						
			Fallow (Ploughed)		Seed-bed prep., plant	10%	50%	75%	Harvest	Fall Ploughed		
Comparison to wheat crop grown in southwestern Ontario (Table R-2)	4	4	4	9	7	13	17	14	11	7	5	5
Cropstage EI			.34		.08	.10	.15	.23	.11			
SLR values			.35		.6	.5	.3	.15	.3			
Cropstage C value Total C value			.12		.05	.05	.05	.03	.03			.33 Crop C Value

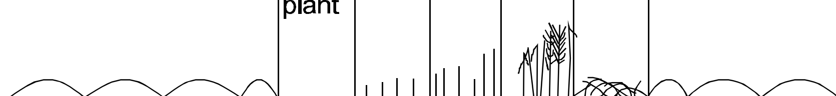

Figure 5.1 How the C factor works for a cereal crop

5.5 How to determine C factors

To obtain the appropriate C value for a specific crop from the tables in Part 2, the following information is required:

C values for a single crop

- ! location (see Part 2, Figures C-1 & C-3)
- ! crop or vegetation type
- ! previous crop
- ! tillage (primary and secondary)

C value for a rotation

- ! crops in rotation (type, number, sequence) plus information for each single crop in rotation

Source of C values
The calculated C values for single crops and crop rotations are presented by province and regions in Part 2, Tables C-1 to C-4

Examples

Case 1: **Single crops**

- ! Spring wheat crop, fall primary (chisel plough) and spring secondary tillage
- ! London, Ontario area (Part 2, Table C-3)

C = 0.29

Case 2: **Crop rotations**

Regardless of region, crop rotations are an integral part of most farm enterprises in Canada. With careful selection of crops and their sequence in rotation benefits can be accrued through a production increase, increased returns, disease and pest control, improved residual soil quality and environmental protection.

C factors have been developed for the most common[9] crop rotations of each region and province as follows:
1. Sequence and frequency of crops in rotation was determined.
2. C values from single crop tables for appropriate province/region are listed and added together.
3. The sum of these C values is divided by the number of years in the rotation.

See Table 5.3 for the calculation of crop rotation C values in Saskatchewan.

[9] C values have been developed for the most common crop rotations. Use the single-crop values and method above to calculate C values for crop rotations not listed in Tables C-1 to C-4.

Table 5.3. Comparison of various crop rotations in Saskatchewan (Melfort area)

Crop rotation	C values for crops	No. of years in rotation	Average annual C value for rotation
Barley - summer fallow	.44 .5	2	.47
Barley - summer fallow - canola	.35 .5 .5	3	.45
Barley - winter wheat - summer fallow	.44 .33 .5	3	.42
Wheat-wheat-barley-forage- forage-forage	.16, .23 .35, .04 .006, .006	6	.13

Case 3: **Generalized C-factor Values**

Often, when determining C-factor values for a crop, the details of tillage practices and previous crops are not known. Generalized C-factor values for each province are provided in Part 2.

Evaluating the Effectiveness of Alternative Practices Using the U.S.L.E.

The tolerable rate of erosion varies across Canada, depending on the type, depth and condition of soil and past erosion.

! To determine the crop and management practices that could be used to help keep annual erosion to this recommended tolerance level (T), substitute 'T' for 'A' and rearrange the equation to read:

$$C = \frac{T}{RKLSP}$$

By using this equation, producers or planners can determine:

! the maximum C value allowable to maintain potential erosion at a tolerable level or lower.

By referring to the appropriate C value table for a particular region, a range of cropping and management C values below the C value limit can be chosen to reduce soil erosion to a tolerable limit.

6.0 THE SUPPORT PRACTICE FACTOR (P) — *L.J.P. van Vliet*

6.1 Purpose

- The P factor accounts for the erosion control effectiveness of support practices
- 'P' supports the cover and management factor

The P factor reflects the effects of practices that will reduce the amount and rate of the runoff water by modifying the flow pattern, grade, or direction of surface runoff and thus reduce the amount of erosion.

> Generally, a support practice is most effective when it causes eroded sediments to be deposited far upslope, very close to their source. Deposition close to the end of the slope is of less benefit from a conservation planning perspective.

The most commonly used supporting cropland practice are:

- Cross slope cultivation
- Contour farming
- Stripcropping
- Terracing

6.2 Variables affecting the P factor

Comparisons between various support practices, their function and relative effectiveness in erosion reduction are shown in Table 6.1.

6.3 Canadian applications

Some Canadian data from erosion plot studies are available, and is presented in the "P Factor" section (Part 2).

- There is not sufficient Canadian data available to develop P-values for the range in climate, soil, crop management and topographic conditions encountered in Canada.
- The modest amount of data for certain practices, such as terracing, reflects the limited use of these practices except under very specific conditions (i.e. growing high-valued crops on very undulating topography).

6.4 Calculation of P factors

Additional information has been incorporated into the P factor calculations through the Revised USLE. The RUSLE method:

- computes a P factor for conservation planning that is between 1.0 (no consideration for deposition) and the sediment delivery factor (full consideration for deposition; RUSLE, 1993);

Table 6.1. Variables that affect the P factor

Variable (practice)	Description and function	Effect on erosion	Management implications
Cross slope farming (P range 0.75-1.0)	Description - cultivation, planting done across slope Function - tillage, crop rows create ridges which act as small dams across slope - ridges redirect runoff, modify downslope flow pattern, reduce erosive capacity of runoff	Erosion reduction up to 25% - almost complete protection from storms of low to moderate intensity - little or no protection against severe storms (extensive runoff breakovers of ridges, rows) - effectiveness influenced by slope length, soil properties, crop management, tillage type, rainfall, snowmelt - stabilized (grass) waterways required to carry accumulated excess runoff from depressional areas downslope without causing rill or gully erosion - grass strips do not reduce upslope erosion but are effective in reducing or even preventing sediments from entering a drainage system - compatible with almost any type of cropping system - waterways diffuse or spread flow of water, which reduces runoff velocity, decreases erosive capability of runoff and allows sediment deposition within strip	- up and down slope tillage, planting promotes runoff, rill and gully development, erosion - cross slope tillage provides runoff barriers, increases infiltration, decreases runoff and erosion - rougher soil surfaces (e.g. ridged) provide better protection than smooth surfaces (soil loss decreases as ridge height increases) - closely grown stems of stiff vegetation (e.g.forages, grain) act like ridges Examples of ridge heights: HIGH - left by twisted shoven chisel plough, ridge tillage LOW - left after small grain drilling
Contour farming (P range 0.50-0.90)	Description - cultivation, planting is done following topographic contours of slope Function - ridges created along contour have a zero gradient - water flows uniformly over ridges along entire length	Erosion reduction 10 to 50 % - almost complete protection from storms of low to moderate intensity, more effective than cross slope farming - little or no protection against severe storms (extensive runoff breakovers of ridges, rows) - most effective on slopes 3 to 8% - most effective on ridges >15 cm - if ridges are not level water will flow along ridge to lowest point, and can create rills or gullies at this point - requires stablized waterways (e.g. per-manent grass) on slopes greater than 8 % - combination of P practices required, or change in C practices`	
Strip cropping (P range 0.25 - 0.90)	Description - crops grown in systematic arrangement of strips or bands (across slope or on contour) - alternating strips of close growing vegetation (grass or forage) with row crops either across slope or along contour - crops rotated between strips in systematic order, grass or legume covers a portion of slope year round Function - runoff diffused and reduced, infiltration increased at grass strip - soil eroded from annually cultivated crop strip filtered out within first several metres of adjacent downslope grass strip	Erosion reduction - 10 to 75 % - reduces erosion in the grass, legume strips - deposition occurs at upper edge of grass strips (infiltration increases, transport capacity decreases) - more effective than contouring alone - strip cropping factor accounts for soil movement leaving the field, but not for all movement and redistribution within	- strips of economically higher-return row or cereal crops in combination with erosion-resistant grasses, legumes can limit soil movement - strip width depends on: slope steepness and length, infiltration capacity and other properties of soil, crop management, precipitation characteristics - longer, steeper slopes should incorporate wider forage bands, narrower row crop bands
Terracing (P range 0.10-0.90)	Description - large soil ridges constructed across slope at regular intervals Function - divides slope into shorter lengths - runoff intercepted, collected, conveyed off field at nonerosive velocities - sediment trapped, deposited within field or in sediment traps	Erosion reduction - 10 to 90 % - reduces sheet, rill erosion on the terrace interval - causes deposition on the terrace channel if gradiant is less than 1 % - soil losses from uniform grade vary exponentially with grade (soil loss increases as grade increases) - P factor considers both the benefit of localized deposition (i.e. close to source) and amount of soil deposited	- relatively expensive, permanent changes made to microtopography of slope

! provides the potential to estimate sediment yield, in the form of a ratio of the amount of sediment leaving the end of the slope length to the amount of sediment produced on the slope length. Models such as the USLE-based GAMES have been used in Canada to estimate sediment movement off of a field and onto adjacent fields or into streams. The sediment yield P factor can be used in future modelling efforts such as GAMES.

- incorporates Runoff Index Values RIV into the calculation (which reflect the effects of tillage roughness, reduced infiltration due to frost);

- can be used with the RIV to compute the effect of rough surface conditions on runoff and erosion; and

- quantifies the benefits of additional practices e.g. subsurface drainage

Subsurface drainage and permanent grass bufferstrips at the bottom of a cropped slope are also effective in controlling soil erosion under certain conditions, but P-values are either very general or not available for these practices. Subsurface drainage can reduce erosion up to 40 % where the area is uniform, the tile system covers most of the area and tile drainage significantly reduces runoff (RUSLE). This practice is effective on slopes up to 6%.

How the P factor works in the RUSLE equation

Factor P is, by definition, the ratio of soil loss with a specific support practice to the corresponding loss with up and down slope cultivation and planting (Wischmeier and Smith, 1978).

In the absence of any support practice, P assumes unity and equals 1 in the USLE.

Table 6.2 contains generalized P value information on basic support practices. **The lower the P value, the more effectively the practice helps to cause deposition to occur close to the source.** For example, cross slope farming can limit soil loss to 75% of soil loss without the practice. Conversely, strip cropping on the coutour reduces erosion by 75% (P = .25).

Table 6.2 General P values

Support practice	P-value
No support practice	1.00
Cross slope farming	0.75
Contour farming (3-8% slopes)	0.50
Strip cropping, cross slope (3-8% slopes)[1]	0.38
Strip cropping, on contour (3-8% slopes)	0.25

[1] derived by interpolation

6.5 How to determine P factors

Information needed to calculate the factor includes:

- **General**
  - type of support practice(s) used

- ! **Strip cropping**
  - type(s) of crops planted
  - width of strips
  - slope gradient (percent)
- ! **Terraces**
  - slope gradient
  - slope length of terrace
  - contoured or strip cropped?
  - type of outlet — sod channel or underground?

Source of P factors
Part 2, P factor section 1
Generalized support practice data: Tables P-1 to P-4
Canadian support practice data: Table P-5

Examples

Case 1: **Field with one support practice in place**
(Contour farming)

- ! Conditions - crop planted on contour, 7% slope
  P = 0.5 (Table P-1)

Case 2: **Field with two support practices**
(contouring, terracing)

- ! Conditions
  - 50 m terrace, closed outlet (P = 0.70, Table P-3)
  - contouring - 4 % slope (P = 0.50, Table P-1)

To compute soil loss with the USLE, values for the terrace P factor in Table P-3 are multiplied by other factor values for contouring and strip cropping in the interterrace areas.

$$\mathbf{P = 0.50 \times 0.70 = 0.35}$$

"P" may well be the least accurate and most subject to error of the USLE factors, because of a deficient data base compared to that for other factors in the USLE.

7.0 REFERENCES AND SOURCES

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Information Sources:

Agriculture and Agri-Food Canada
Research Branch
Land Resource Units

Alberta (Edmonton)
Alberta Land Resource Unit
Terrace Plaza Tower, 6th floor,
4445 Calgary Trail South T6H 5R7
(403) 495-4243
Fax (403) 495-5344

British Columbia (Vancouver)
Pacific Agri-Food Research Centre
Summerland,
British Columbia
(250) 494-6355
Fax (250) 494-0755

Manitoba (Winnipeg)
Manitoba Land Resource Unit
Room 362, Ellis Building,
University of Manitoba, R3T 2N2
(204) 474-6118
Fax (204) 275-5817

New Brunswick (Fredericton)
New Brunswick Land Resource Unit
Research Station, Room 366
850 Lincoln Road,
P.O. Box 20280, E3B 4Z7
(506) 452-3260
Fax (506) 452-3316

Newfoundland (St. John's)
Newfoundland Land Resource Unit
Research Branch, Research Station
P.O. Box 7098, A1E 3Y3
(709) 772-5964
Fax (709) 772-6810

Nova Scotia (Truro)
Nova Scotia Land Resource Unit
Research branch, N.S. Agricultural College
P.O. Box 550, B2N 5E3
(902) 893-6600
Fax (902) 893-0244

Ontario (Guelph)
Ontario Land Resource Unit
Land Resource Division
70 Fountain St. N1H 3N6
(519) 826-2086
Fax (519) 826-2090

Prince Edward Island (Charlottetown)
Prince Edward Island Land Resource Unit
P.O. Box 1210,
University Avenue, C1A 7M8
(902) 566-6860
Fax (902) 566-6821

Quebec (Ste-Foy)
Quebec Land Resource Unit
Equipe Pedologique Federale
350, Rue Franquet Entree 20 G1P 4P3
(418) 648-7749
Fax (418) 648-5489

Saskatchewan (Saskatoon)
Saskatchewan Land Resource Unit
c/o the Soil Science department,
University of Saskatchewan campus
Agriculture Canada, Land Resource Unit
Room 5C26 Agriculture Building S7N 0W0
(306) 975-4060
Fax (306) 966-4226

Yukon (Whitehorse)
Yukon Land Resource Unit
c/o Department of Renewable Resources
P.O. Box 2703 Y1A 1C3
(403) 667-5272
Fax (403) 668-3955

8.0 CONVERSION OF RUSLEFAC FACTOR VALUES TO U.S. CUSTOMARY UNITS

To convert from:	SI Units	Multiply by	To obtain U.S. customary units
Annual Erosivity (R)	$\frac{\text{Megajoule•millimeter}}{\text{hectare•hour•year}}$	0.059	$\frac{\text{hundreds of foot-tonf•inch}}{\text{acre•hour•year}}$
Soil Erodibility (K)	$\frac{\text{tonne•hectare•hour}}{\text{hectare•megajoule•millimeter}}$	7.59	$\frac{\text{ton•acre•hour}}{\text{hundreds of acre•foot-tonf•inch}}$
Soil Loss (A)	$\frac{\text{tonne}}{\text{hectare•year}}$	0.446	$\frac{\text{ton}}{\text{acre•year}}$

PART 2 — FACTOR VALUES

R VALUES

Table R-1. Erosivity index and monthly distribution (%) for sites in the Prairie Region and eastern Canada

Site	R_t	Monthly percentage of erosivity index (R)											
		J	F	M	A	M	J	J	A	S	O	N	D
Beaverlodge, B.C.	378	0	0	4	9	3	20	23	34	7	0	0	0
Lethbridge, Alta.	346	0	0	1	4	11	22	37	16	10	0	0	0
Peace River, Alta.	226	0	0	4	10	5	17	41	17	7	1	0	0
Vauxhall, Alta.	270	0	0	2	13	9	24	24	16	11	0	0	0
Broadview, Sask.	342	0	0	2	7	8	12	24	31	15	2	0	0
Estevan, Sask.	680	0	0	1	2	8	22	41	18	9	1	0	0
Outlook, Sask.	261	0	0	1	4	8	39	32	12	5	0	0	0
Saskatoon, Sask.	348	0	0	2	6	13	38	33	5	3	0	0	0
Swift Current, Sask.	268	0	0	1	3	7	43	25	16	5	0	0	0
Wynyard, Sask.	572	0	0	1	2	13	18	39	22	4	1	0	0
Yorkton, Sask.	663	0	0	1	2	7	23	26	28	10	2	0	0
Hudson Bay	510	0	0	2	5	5	22	37	18	10	1	0	0
Glenlea	1029	0	0	2	5	11	23	31	20	6	3	0	0
Gimli, Man.	848	0	0	1	4	6	25	24	27	11	3	0	0
Winnipeg, Man.	1093	0	0	1	3	12	18	21	32	12	2	0	0
White River, Ont.	1075	0	0	0	2	8	16	17	26	23	5	3	0
Windsor, Ont.	1615	2	3	5	9	6	15	20	18	9	5	4	4
London, Ont.	1330	3	3	3	9	7	14	18	15	11	7	6	4
Montreal, Que.	920	0	0	0	6	5	17	19	22	15	9	7	0
Moncton, N.B.	1225	3	4	4	4	8	10	14	15	10	12	11	5
Halifax, N.S.	1790	*	*	*	2	11	16	19	24	19	8	1	0
Kentville, N.S.	1975	4	6	7	6	3	12	12	15	10	10	7	8
Nappan, N.S.	1900	3	3	3	9	7	14	18	15	11	7	6	4
Truro, N.S.	2000	4	8	5	5	5	7	6	13	11	11	15	10
Charlottetown, P.E.I.	1520	4	4	4	9	7	13	17	14	11	7	5	5
St. John's, Nfld.	1700	4	8	5	5	5	7	6	13	11	11	17	8

* Data not available
Units for R = MJ mm ha^{-1} h^{-1}

Table R-2. Monthly distribution of rainfall and runoff erosivity index (%) for selected areas in Ontario and Quebec

Region	Monthly percentage of annual precipitation											
	J	F	M	A	M	J	J	A	S	O	N	D
Southwestern Ontario	4	4	4	9	7	13	17	14	11	7	5	5
Eastern Ontario-Western Quebec	0	0	5	10	8	15	19	16	13	8	4	2
Southern Quebec	0	0	5	10	9	14	16	12	10	6	5	4
Eastern Quebec	0	0	8	11	10	14	18	16	9	8	6	0

Table R-3. Monthly distribution of precipitation normals expressed as the percentage of annual precipitation in British Columbia

Region	Monthly percentage of annual precipitation											
	J	F	M	A	M	J	J	A	S	O	N	D
Vancouver Region	15	10	9	6	4	4	3	4	6	10	14	15
Summerland Region	12	7	6	6	8	10	7	9	7	7	9	12
Prince George Region	10	6	6	4	7	10	9	10	10	10	9	10
Dawson Creek Region	7	6	6	4	9	14	15	12	8	6	7	7

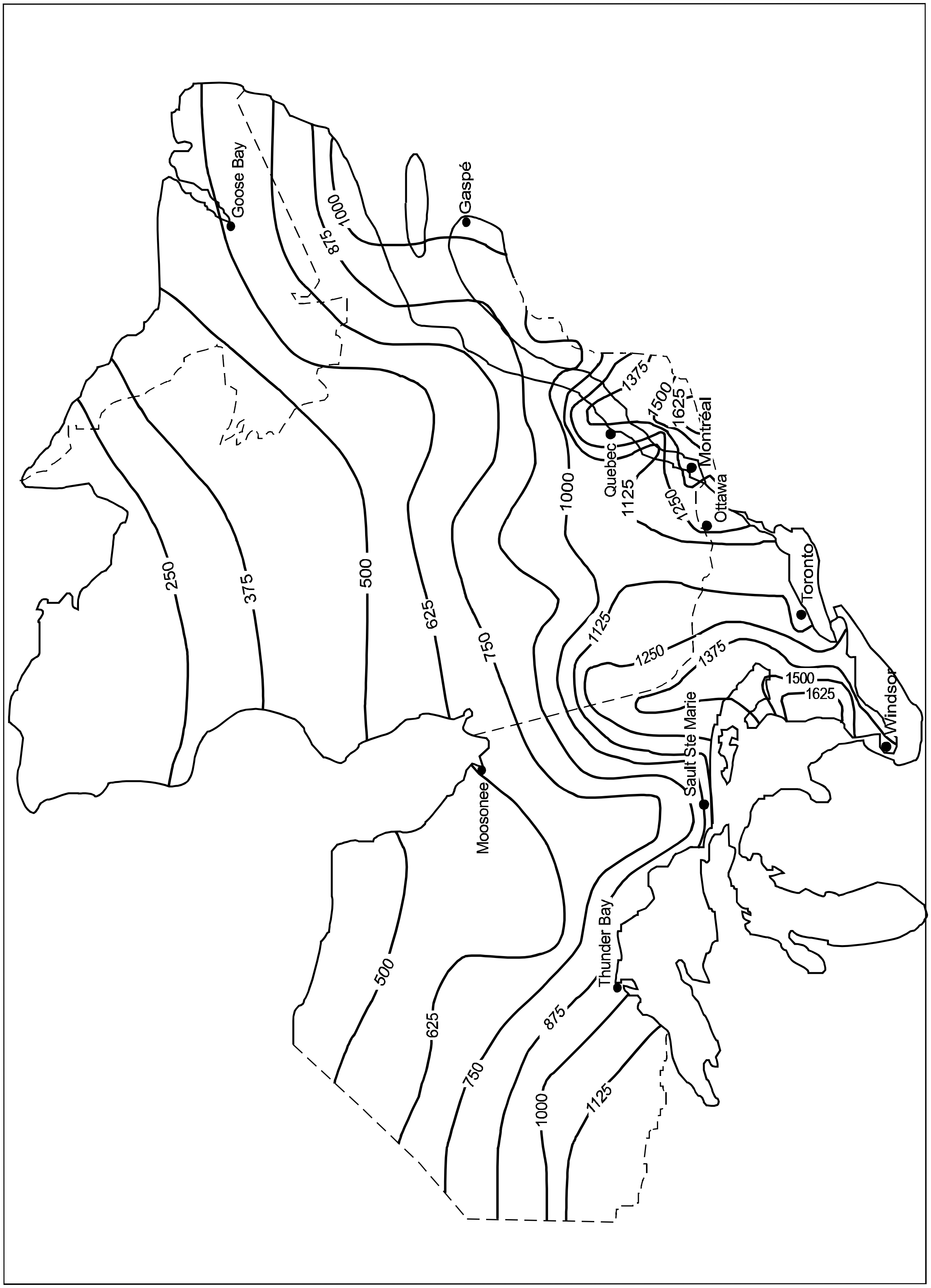

Figure R-1. Isoerodent map showing R_1 values for Ontario & Quebec

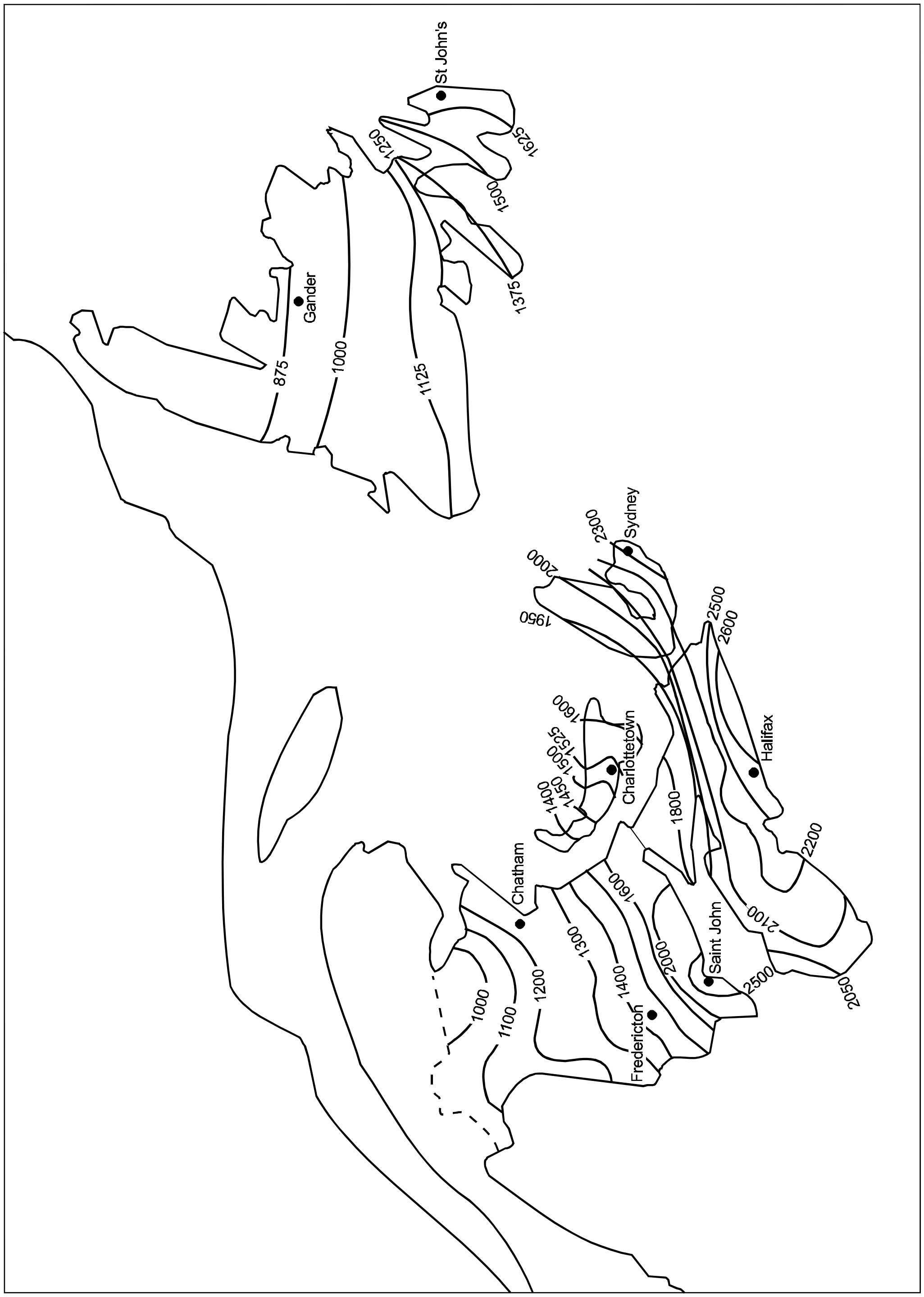

Figure R-2. Isoerodent map showing R_1 values for the Maritime Region

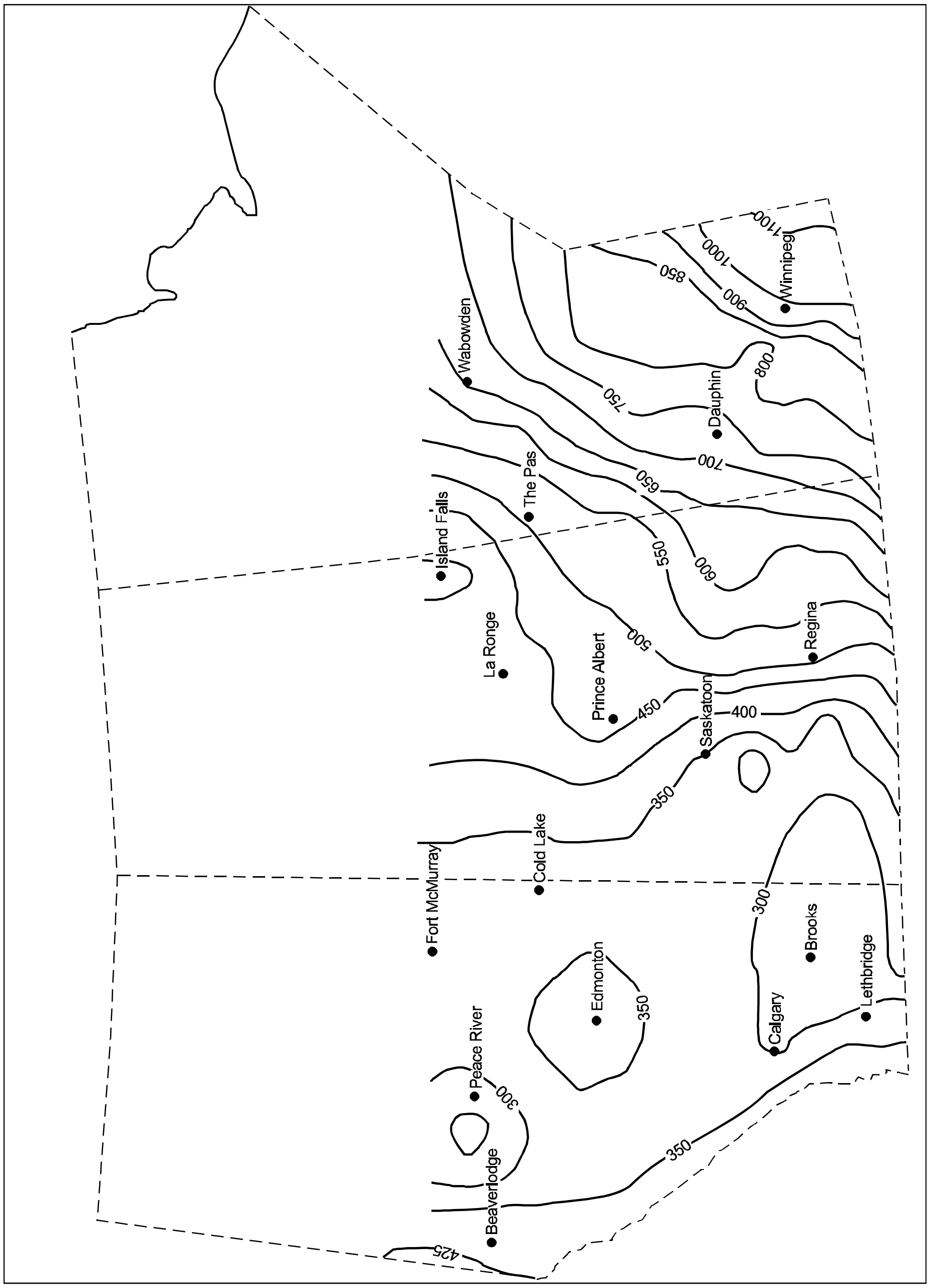

Figure R-3a. Isoerodent map showing R values for the Prairie Region

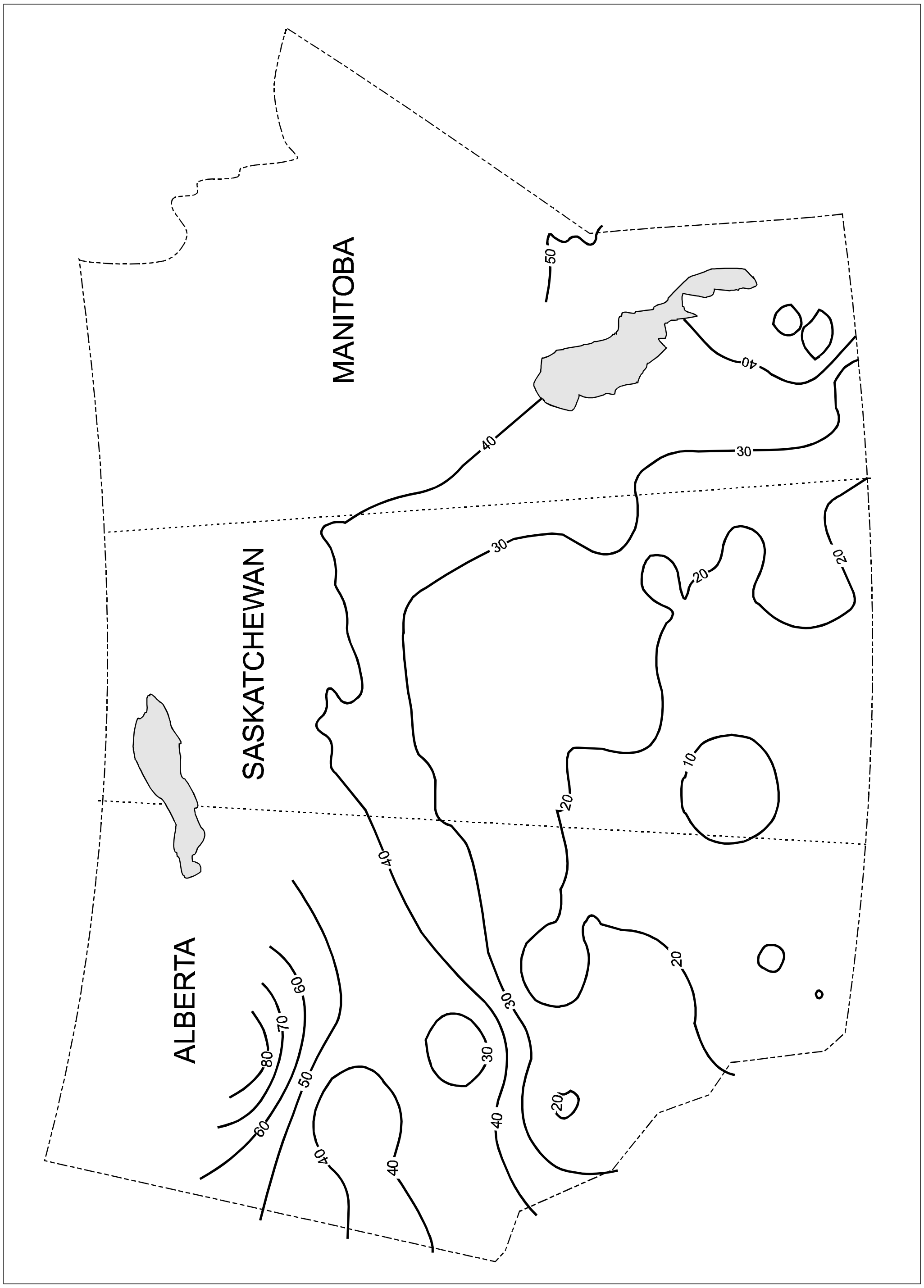

Figure R-3b. Adjustment for winter conditions. Rs for the Prairie Region

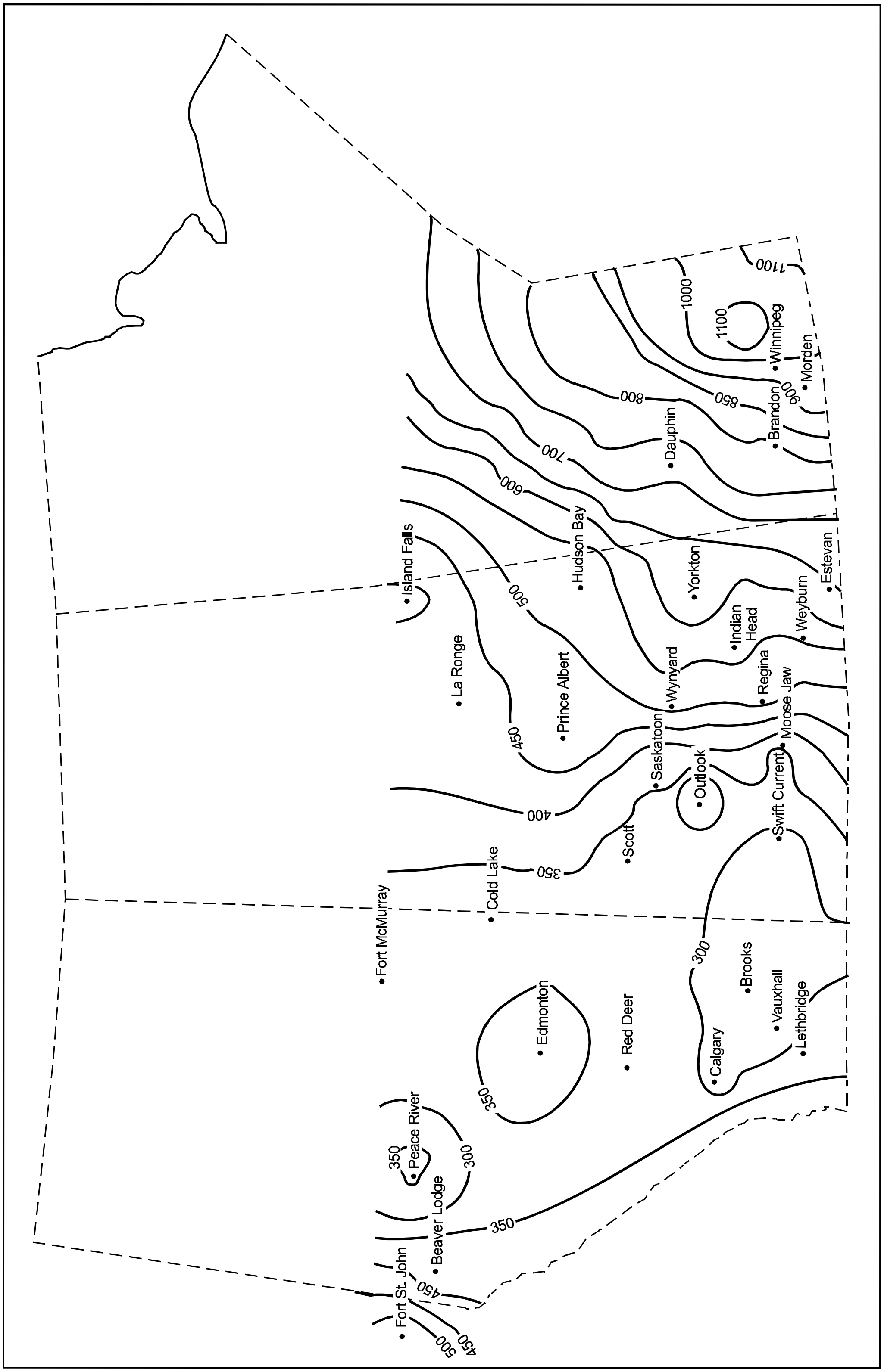

Figure R-3c. Isoerodent map showing R_1 values for the Prairie Region

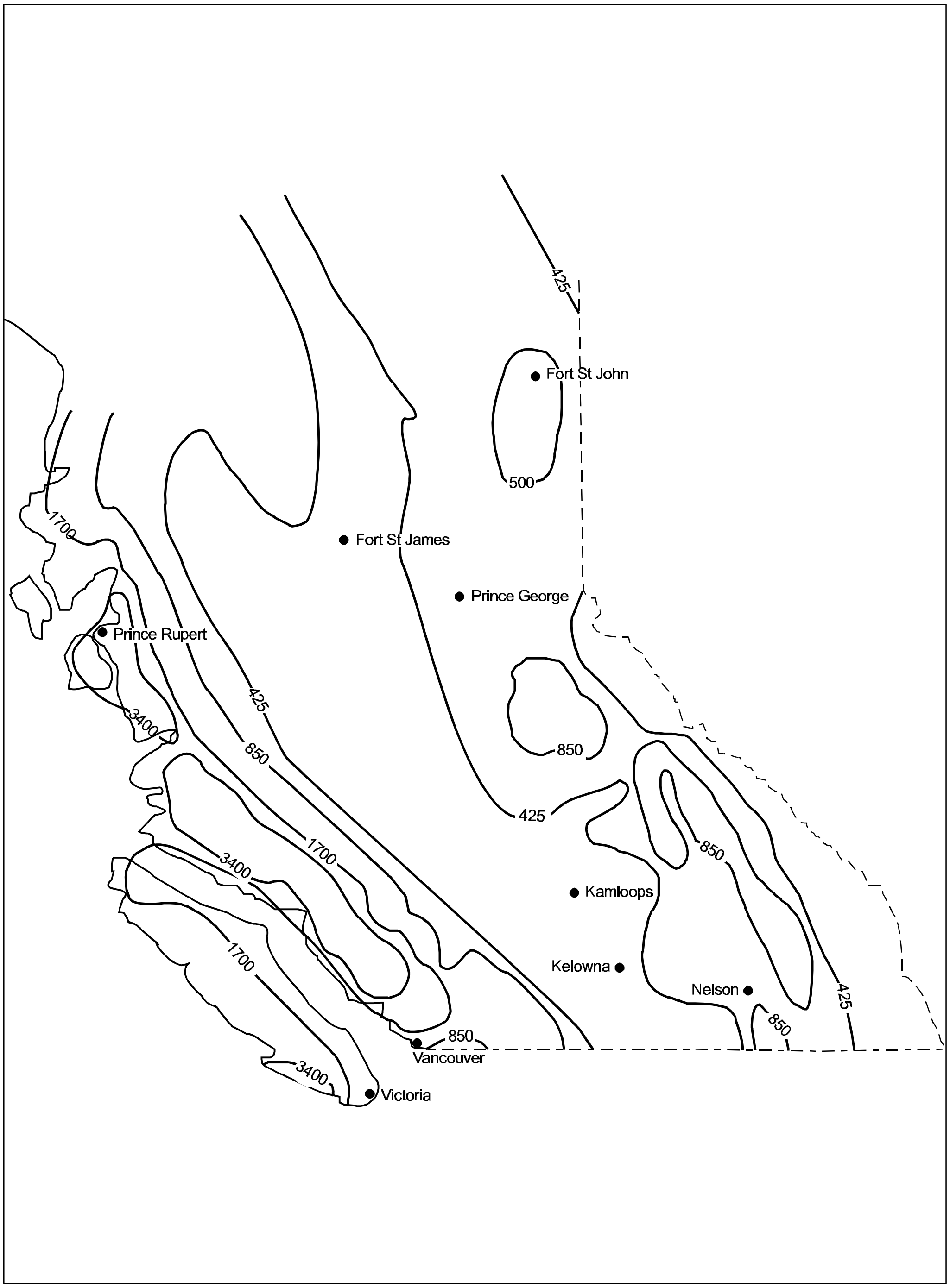

Figure R-4. Isoerodent map showing R_1 values for British Columbia

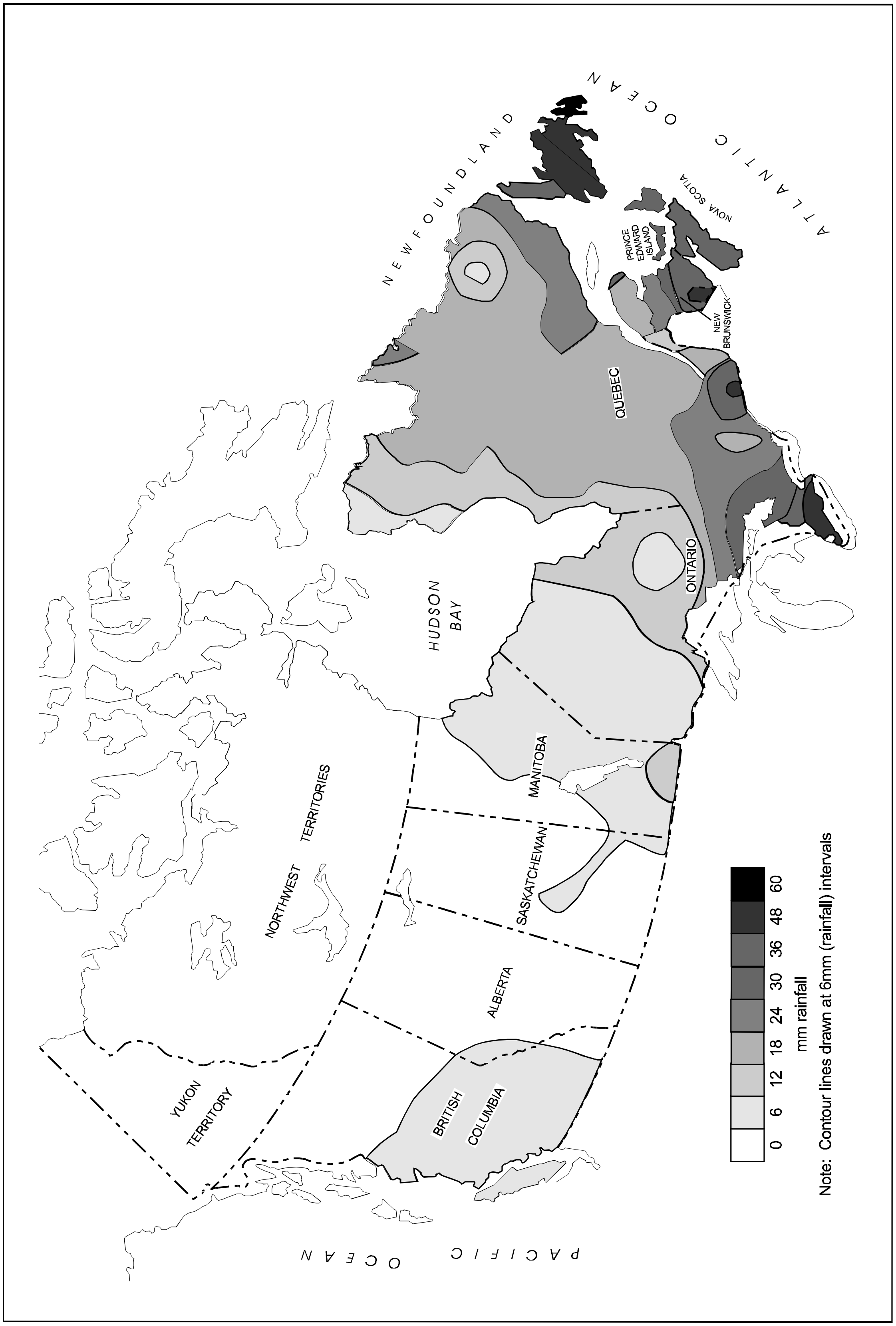

Figure R-5. Mean annual rainfall on frozen soil

K VALUES

Determination of K values for use with the Universal Soil Loss Equation and the Revised USLE

A K value for a soil is determined with the use of the soil-erodibility equation (Chapter 3) or the soil-erodibility nomograph. A detailed explanation of the information required for K value calculations as follows (from Cook et al., 1985):

a) Percent Silt, Very Fine Sand and Sand greater than 0.10mm

A mechanical analysis of the particle size distribution provides:

- estimates of % of silt **plus** very fine sand, and
- % of clay

If a mechanical analysis is not available **-**

- estimate K based on texture description (Figure K-4) and an estimated soil particle size distribution (Figures K-2 and K-3) (Note: % very fine sand should be added to the % of silt component.)

b) Organic Matter

The % organic matter of a soil is dependent upon soil moisture and also past land use and management practices. Within any one soil texture organic matter may vary due to past practices and is best determined by laboratory analysis. The level of organic matter in a soil is dependent on upon **addition of residues** (plants, manure, and other organic materials) and the **breakdown of these residuals** by microbes and other soil organisms.

If analysis is unavailable estimates based on soil texture and land use must be made.

c) Soil Structure

Soil structure refers to the aggregates of primary soil particles which are separated from adjoining aggregates by surfaces of weakness. An individual natural soil aggregate is called a ped. The classification of structure involves consideration of the shape and arrangement, the size and the distinctness of the visible aggregates or peds. The grade of soil structure is dependent upon soil moisture content and varies seasonally.

Soil structure information for specific soil series is available from provincial soil survey reports.

The comprehensive classification system presented in the Manual for Describing Soils in the Field - Canada Soil Information System (CanSIS) (Ontario Centre for Soil Resource Evaluation, 1993) has been reduced to match the nomograph classes of Wischmeier and Smith (1978) based upon aggregate size. The nomograph classes for soil structure are:

1 - Very fine granular (structureless)
2 - Fine granular
3 - Medium or coarse granular
4 - Blocky, platy or massive

Table K-1 provides a comparison of nomograph class, structure type, and aggregate size while Figure K-2 provides a guide to the general structure code based on textural classification (Cook et al., 1985).

Table K-1. Structure type - nomograph code criteria

Canadian Aggregate			United States Aggregate
Class	Size (mm)	Structure Type	Size (mm)
1	<1	Very fine granular or structureless	—
2	1-2	Fine granular	<2
3	2-10	Medium granular	2-5
	2-10	Coarse granular	5-10
4	>10	Blocky, platy, massive, prismatic	>10

(Cook et al., 1985)

Class 4 generally includes the fine textured soils, like clay, sandy clay, silty clay, clay loam and silty clay loam. The complete range of particle sizes (sands - clays) might be included in each of the codes 1, 2, or 3, depending upon the size of the aggregates. Evaluate aggregate sizes for each surface soil with respect to the organic matter content. All coarse, medium, fine sands; loamy fine sand, loamy very fine sand, fine and very fine sandy loam soils (<1 mm) will be included in structure class 1 if no significant aggregation occurred. Medium textured soils (loam, silt loam, and silt) will be generally classified into Class 2 or 3, but might sometimes meet Class 1 or 4 criteria (System of Soil Classification for Canada).

d) Permeability

The nomograph classes for permeability are:

1 - Rapid
2 - Moderate to rapid
3 - Moderate
4 - Slow to moderate
5 - Slow
6 - Very slow

Permeability refers to the entire soil profile, however, Wischmeier et al. (1971) suggest the soil horizon most impermeable within the top 2 feet (0.6 m) of the soil profile be considered for the permeability classification.

The following permeability criteria are suggested and Figure K-3 provides a guide for the general permeability codes based on textural classification (van Vliet, 1976):

Class 6 - Soils with impermeable layers (fragipan, clay pan, etc.)

Class 5 - More permeable surface soils than Class 6 and underlain by massive clay or silt clay (e.g. clay, silty clay, and sometimes clay loam soils)

Class 4 - Moderately permeability surface soils underlain by silty clay or silty clay loam having a weak subangular or angular blocky structure (e.g. clay loam, silty clay loam, sandy clay soils)

Class 3 - Subsoil structure grade moderate to strong or subsoil texture coarser than silty clay loam (e.g. loam, silt loam, sandy clay loam, sometimes sandy loam soils)

Class 2 - Subsoil structure grade weak to moderate, textures are sandy loam, loamy sands and very fine sands

Class 1 - Sands, gravels (coarse, medium and fine) and sometimes loamy sand soils

RUSLE-based changes to the permeability class to account for:

1. Rock fragments in the soil profile

Rock fragments within the soil profile can affect permeability, and hence the K value for a soil. The following adjustments are suggested to reflect these variations:

- soils with < 25% rock in the profile - **No change in class**
- 25 to 60% rock content - adjust **one step** to a **MORE permeable** class
- > 60% rock - adjust **one to two steps** to reflect **MORE permeability**

2. Presence of a restrictive layer

- Adjust the permeability rating to **a LESS permeable class**

Table K-2.Drainage classification and hydraulic conductivity values for soil textural classes

Textural Class	**Permeability Class**	**Hydraulic Conductivity**	
		cm/sec	**in/hr**
Gravels, coarse sands	rapid	>4.4 * 10-3	>6.3
Loamy sands and sandy loams	moderately rapid	1.4 to 4.4 * 10-3	2.0 to 6.3
Fine sandy loams, loams	moderately rapid	0.4 to 1.4 * 10-5	0.63 to 2.0
Loams, silt loams, clay loams	moderately slow	0.14 to 0.4 * 10-3	0.2 to 0.63
clay loams, clays,	slow	4 to 14 * 10-5	0.063 to 0.2
Dense, compacted	very slow	<4 * 10-5	<0.06

(Cook et al., 1985)

K value calculations have been done for a variety of soils, utilizing existing and recently collected soils information. This information is presented in Table K-3.

Table K-3. Soil erodibility values (K) for common surface textures

TEXTURAL CLASS	ORGANIC MATTER CONTENT		
	< 2 %	> 2 %	AVERAGE
Clay	0.032	0.028	0.029
Clay Loam	0.044	0.037	0.040
Coarse Sandy Loam	-	0.009	0.009
Fine Sand	0.012	0.008	0.011
Fine Sandy Loam	0.029	0.022	0.024
Heavy Clay	0.025	0.020	0.022
Loam	0.045	0.038	0.040
Loamy Fine Sand	0.020	0.012	0.015
Loamy Sand	0.007	0.005	0.005
Loamy Very Fine Sand	0.058	0.033	0.051
Sand	0.001	0.003	0.001
Sandy Clay Loam	-	0.026	0.026
Sandy Loam	0.018	0.016	0.017
Silt Loam	0.054	0.049	0.050
Silty Clay	0.036	0.034	0.034
Silty Clay Loam	0.046	0.040	0.042
Very Fine Sand	0.061	0.049	0.057
Very Fine Sandy Loam	0.054	0.044	0.046

These K estimations are based on the information obtained on approximately 1600 samples collected in Southern Ontario by Ontario Institute of Pedology surveyors.

If the organic matter content of a soil is unknown, use the value in the ‘average’ column. The other two columns refer to the values which can be used if the approximate organic matter content of a particular texture is known to be either greater or less than 2 percent.

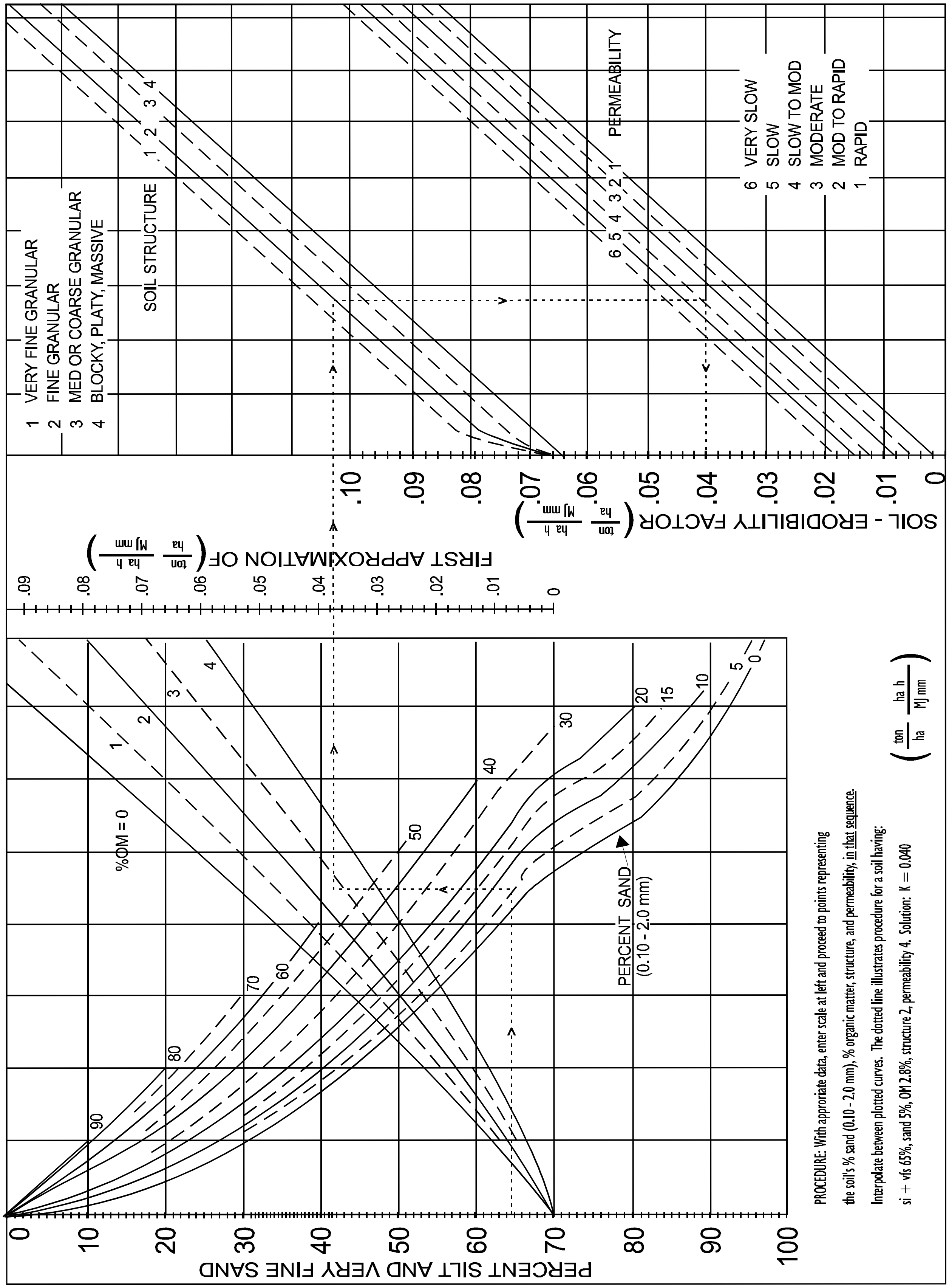

Figure K-1. The soil erodibility nomograph (Foster et al., 1981)

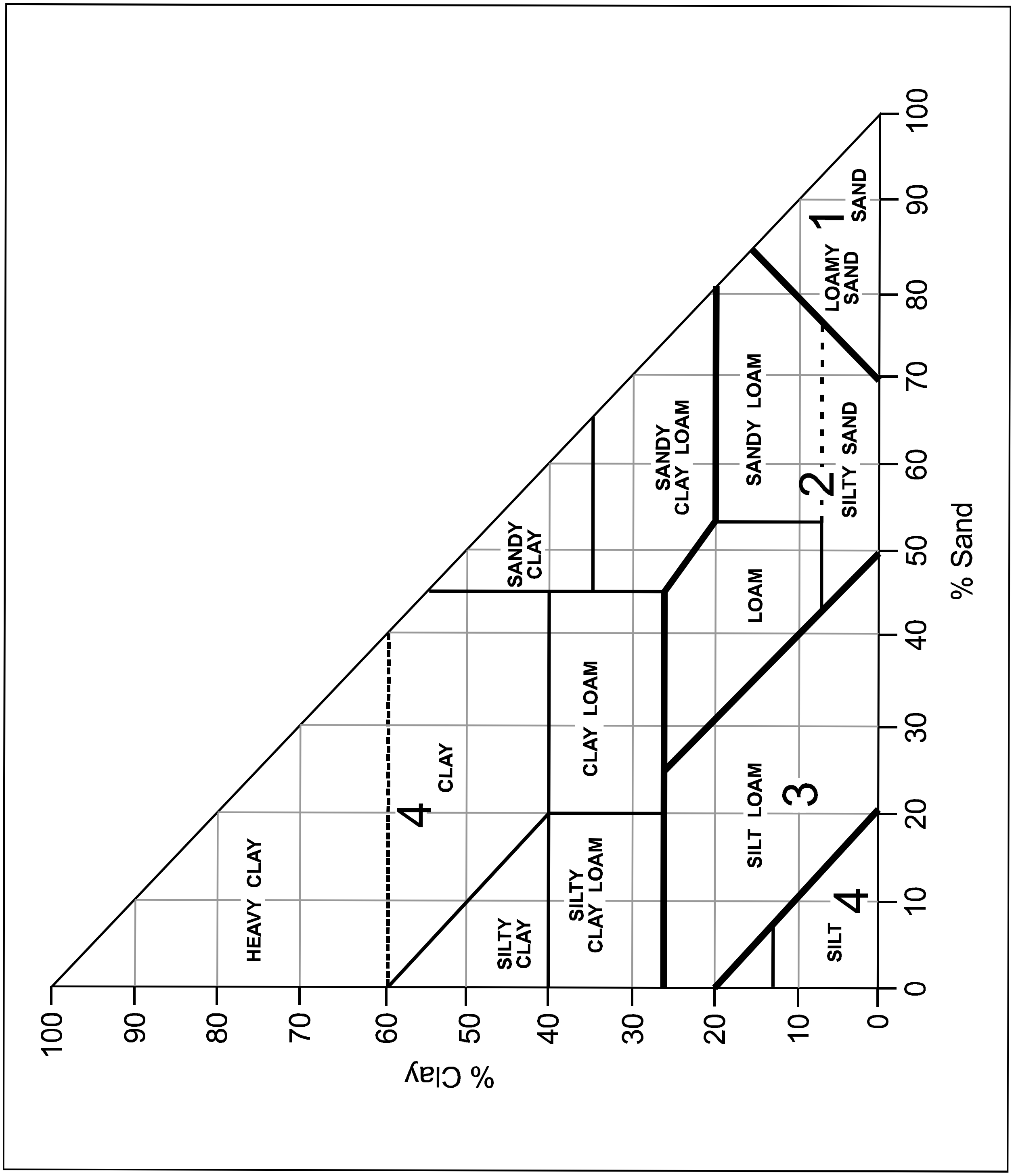

Figure K-2. Structure code based on textural classification (Ontario Centre for Soil Resource Evaluation, 1993)

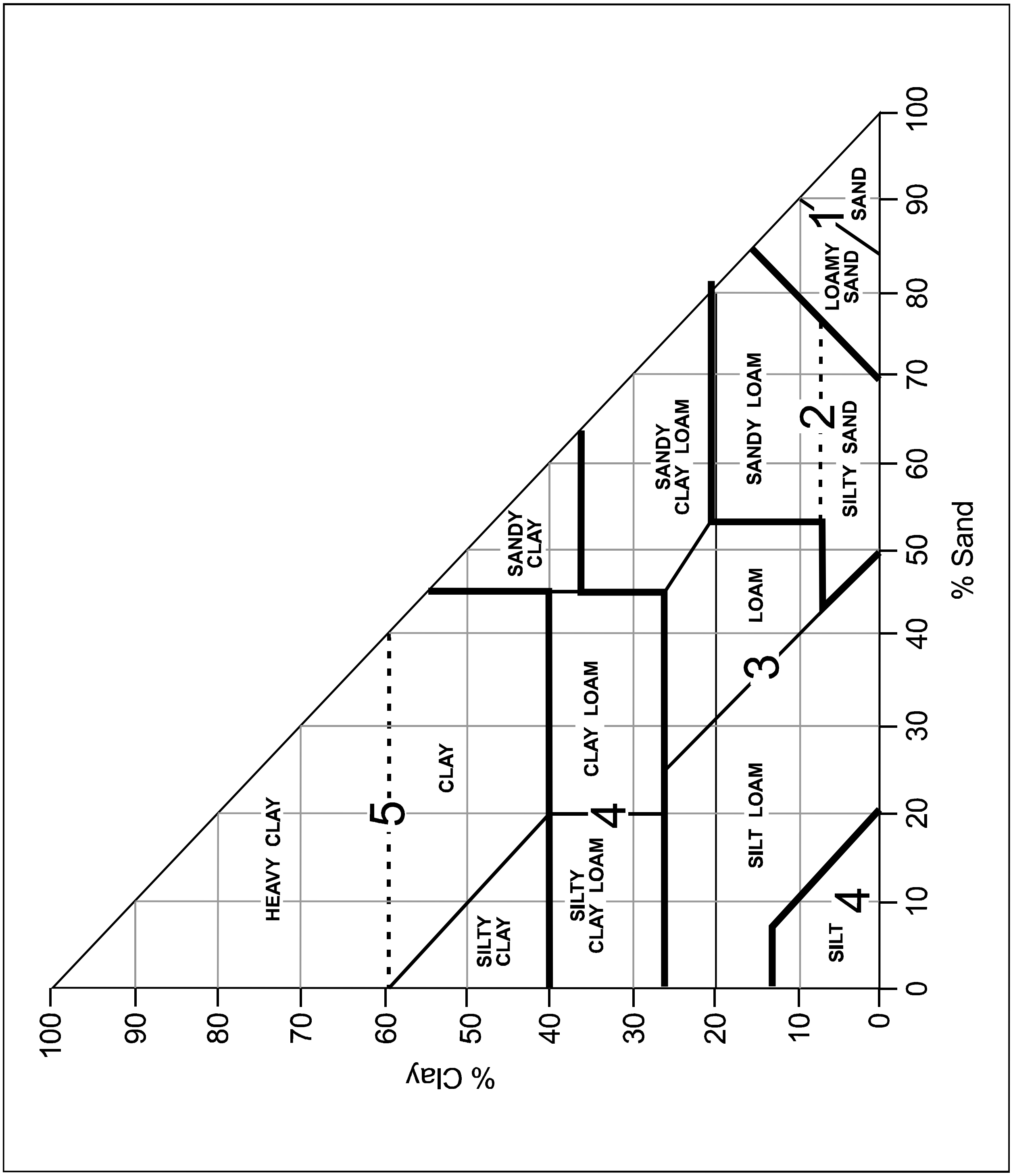

Figure K-3. Permeability code based on textural classification (Ontario Centre for Soil Resource Evaluation, 1993)

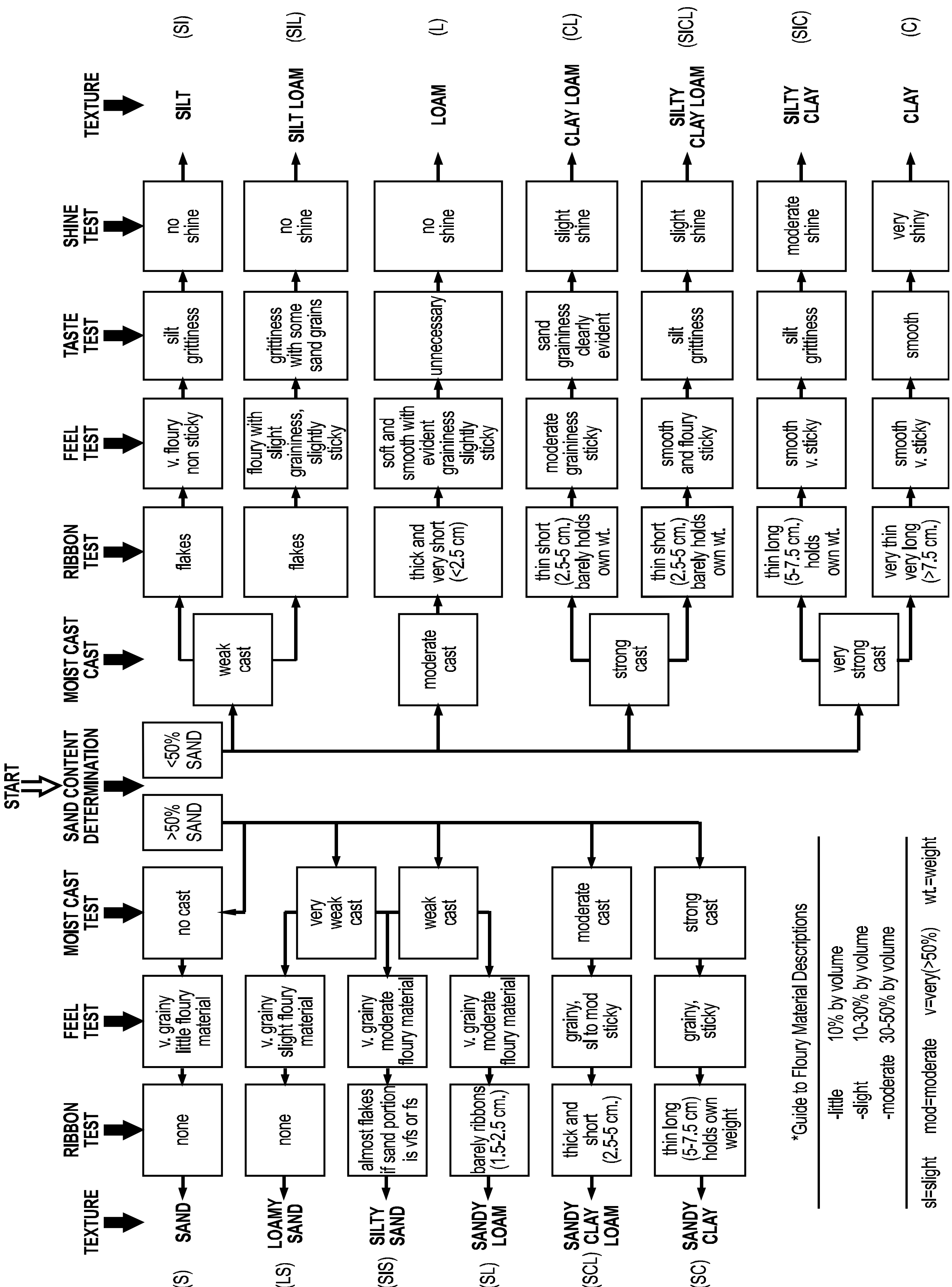

Figure K-4. Finger assessment of soil texture (Ontario Centre for Soil Resource Evaluation, 1993)

LS VALUES

Table LS-1. Values for topographic factor, LS, for low ratio of rill:inter-rill erosion, such as consolidated soil conditions with cover and rangeland (applicable to thawing soils where both inter-rill and rill erosion are significant)

Slope (%)	Slope length in meters											
	2	5	10	15	25	50	75	100	150	200	250	300
0.2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.5	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09
1	0.11	0.12	0.13	0.13	0.14	0.15	0.15	0.16	0.16	0.16	0.17	0.17
2	0.18	0.20	0.22	0.23	0.25	0.28	0.29	0.30	0.32	0.33	0.35	0.35
3	0.23	0.27	0.31	0.33	0.36	0.41	0.44	0.47	0.50	0.53	0.55	0.57
4	0.27	0.33	0.39	0.42	0.47	0.55	0.60	0.64	0.70	0.74	0.78	0.81
5	0.31	0.39	0.47	0.52	0.59	0.70	0.77	0.83	0.92	0.99	1.05	1.10
6	0.35	0.45	0.54	0.61	0.70	0.84	0.94	1.02	1.14	1.24	1.32	1.39
8	0.41	0.55	0.69	0.78	0.92	1.15	1.31	1.43	1.63	1.79	1.92	2.03
10	0.48	0.66	0.84	0.96	1.15	1.47	1.69	1.87	2.15	2.38	2.57	2.74
12	0.61	0.86	1.11	1.29	1.57	2.03	2.37	2.64	3.07	3.42	3.72	3.99
14	0.70	1.01	1.33	1.56	1.91	2.52	2.96	3.31	3.89	4.36	4.77	5.12
16	0.79	1.16	1.54	1.82	2.25	3.00	3.55	4.00	4.74	5.33	5.85	6.31
20	0.96	1.44	1.96	2.34	2.94	4.00	4.79	5.44	6.51	7.39	8.16	8.85
25	1.15	1.77	2.45	2.96	3.77	5.22	6.31	7.23	8.74	10.01	11.12	12.11
30	1.33	2.08	2.92	3.56	4.57	6.42	7.84	9.03	11.01	12.68	14.15	15.47
40	1.64	2.64	3.78	4.67	6.08	8.72	10.76	12.50	15.43	17.91	20.12	22.11
50	1.91	3.13	4.55	5.66	7.45	10.83	13.47	15.73	19.57	22.85	25.77	28.43
60	2.15	3.56	5.22	6.54	8.67	12.71	15.91	18.65	23.34	27.36	30.95	34.23

Table LS-2. Values for topographic factor, LS, for moderate ratio of rill:inter-rill erosion, such as for row-cropped agricultural soils, and other moderately consolidated conditions with little to moderate cover (not applicable to thawing soils)

Slope (%)	Slope length in meters											
	2	5	10	15	25	50	75	100	150	200	250	300
0.2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
0.5	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.10
1	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.20
2	0.14	0.17	0.20	0.22	0.25	0.30	0.33	0.36	0.39	0.42	0.45	0.47
3	0.17	0.22	0.28	0.31	0.37	0.46	0.52	0.56	0.64	0.70	0.75	0.79
4	0.19	0.27	0.34	0.40	0.48	0.61	0.71	0.79	0.91	1.01	1.10	1.17
5	0.30	0.31	0.41	0.49	0.60	0.79	0.93	1.04	1.23	1.38	1.50	1.62
6	0.24	0.35	0.48	0.57	0.71	0.96	1.14	1.29	1.54	1.75	1.92	2.08
8	0.28	0.43	0.60	0.74	0.94	1.31	1.60	1.83	2.23	2.56	2.85	3.11
10	0.32	0.51	0.73	0.90	1.17	1.68	2.07	2.41	2.97	3.45	3.87	4.25
12	0.40	0.66	0.97	1.21	1.60	2.33	2.91	3.41	4.25	4.98	5.62	6.21
14	0.46	0.78	1.16	1.46	1.95	2.89	3.64	4.28	5.39	6.35	7.21	8.00
16	0.52	0.89	1.34	1.70	2.30	3.45	4.37	5.18	6.56	7.77	8.86	9.85
20	0.64	1.12	1.71	2.19	3.00	4.59	5.89	7.03	9.01	10.75	12.33	13.80
25	0.76	1.37	2.14	2.77	3.84	5.98	7.75	9.32	12.07	14.51	16.74	18.81
30	0.88	1.62	2.55	3.33	4.66	7.35	9.60	11.60	15.15	18.31	21.21	23.91
40	1.10	2.06	3.31	4.37	6.20	9.95	13.13	15.99	21.10	25.68	29.91	33.88
50	1.29	2.46	4.00	5.31	7.59	12.33	16.38	20.04	26.62	32.56	38.07	43.25
60	1.46	2.81	4.60	6.13	8.82	14.45	19.29	23.68	31.60	38.79	45.46	51.77

Table LS-3. Values for topographic factor, LS, 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 (%)	Slope length in meters											
	2	5	10	15	25	50	75	100	150	200	250	300
0.2	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05
0.5	0.06	0.07	0.08	0.08	0.08	0.09	0.10	0.10	0.11	0.12	0.12	0.12
1	0.07	0.09	0.11	0.14	0.14	0.17	0.19	0.20	0.23	0.24	0.26	0.27
2	0.10	0.14	0.18	0.26	0.26	0.34	0.40	0.44	0.52	0.58	0.64	0.69
3	0.11	0.17	0.24	0.37	0.37	0.52	0.63	0.72	0.87	1.00	1.11	1.22
4	0.13	0.21	0.30	0.49	0.49	0.70	0.87	1.02	1.26	1.47	1.65	1.82
5	0.14	0.24	0.36	0.61	0.61	0.91	1.14	1.35	1.70	2.00	2.28	2.53
6	0.16	0.27	0.42	0.72	0.72	1.10	1.41	1.67	2.14	2.54	2.91	3.25
8	0.19	0.34	0.53	0.96	0.96	1.50	1.96	2.36	3.07	3.70	4.28	4.82
10	0.21	0.40	0.64	1.19	1.19	1.92	2.53	3.08	4.06	4.94	5.75	6.52
12	0.27	0.52	0.85	1.63	1.63	2.66	3.54	4.33	5.77	7.07	8.28	9.42
14	0.32	0.62	1.02	1.98	1.98	3.28	4.40	5.42	7.27	8.95	10.52	12.01
16	0.36	0.71	1.19	2.34	2.34	3.90	5.26	6.51	8.79	10.87	12.81	14.66
20	0.45	0.90	1.52	3.05	3.05	5.17	7.03	8.75	11.92	14.84	17.58	20.20
25	0.54	1.11	1.91	3.90	3.90	6.70	9.19	11.50	15.78	19.75	23.51	27.10
30	0.64	1.32	2.29	4.73	4.73	8.20	11.32	14.22	19.62	24.65	29.43	34.02
40	0.81	1.70	2.99	6.29	6.29	11.04	15.35	19.38	26.94	34.03	40.79	47.30
50	0.96	2.04	3.62	7.70	7.70	13.62	19.02	24.11	33.67	42.67	51.29	59.60
60	1.09	2.35	4.17	8.94	8.94	15.92	22.30	28.33	39.70	50.43	60.72	70.66

Table LS-4. Values for topographic factor, LS, for thawing soils where most of the erosion is caused by surface flow (using m=0.5)

Slope (%)	**Slope length in meters**											
	2	**5**	**10**	**15**	**25**	**50**	**75**	**100**	**150**	**200**	**250**	**300**
0.2	0.01	0.02	0.03	0.04	0.05	0.06	0.08	0.09	0.11	0.13	0.14	0.16
0.5	0.02	0.04	0.06	0.07	0.09	0.12	0.15	0.18	0.21	0.25	0.28	0.30
1	0.04	0.07	0.09	0.11	0.15	0.21	0.25	0.29	0.36	0.41	0.46	0.50
2	0.07	0.12	0.17	0.20	0.26	0.37	0.45	0.52	0.64	0.74	0.83	0.90
3	0.11	0.17	0.24	0.29	0.37	0.53	0.65	0.75	0.92	1.06	1.18	1.30
4	0.14	0.22	0.31	0.38	0.49	0.69	0.84	0.97	1.19	1.38	1.54	1.68
5	0.17	0.27	0.38	0.47	0.60	0.85	1.05	1.21	1.48	1.71	1.91	2.09
6	0.20	0.32	0.45	0.55	0.72	1.01	1.24	1.43	1.75	2.02	2.26	2.48
8	0.27	0.42	0.60	0.73	0.94	1.33	1.63	1.88	2.31	2.66	2.98	3.26
10	0.33	0.52	0.74	0.91	1.17	1.66	2.03	2.34	2.87	3.31	3.70	4.05
12	0.36	0.56	0.79	0.97	1.26	1.78	2.18	2.51	3.08	3.55	3.97	4.35
14	0.39	0.61	0.87	1.06	1.37	1.94	2.38	2.75	3.37	3.89	4.35	4.76
16	0.42	0.66	0.94	1.15	1.49	2.10	2.57	2.97	3.64	4.20	4.70	5.15
20	0.48	0.76	1.07	1.31	1.69	2.39	2.93	3.39	4.15	4.79	5.36	5.87
25	0.54	0.86	1.22	1.49	1.92	2.72	3.33	3.84	4.71	5.44	6.08	6.66
30	0.60	0.95	1.35	1.65	2.13	3.01	3.69	4.26	5.21	6.02	6.73	7.37
40	0.70	1.11	1.57	1.92	2.48	3.51	4.30	4.97	6.08	7.02	7.85	8.60
50	0.79	1.24	1.76	2.15	2.78	3.93	4.81	5.55	6.80	7.85	8.78	9.62
60	0.85	1.35	1.91	2.34	3.02	4.27	5.23	6.04	7.40	8.54	9.55	10.46

Table LS-5. Slope length exponents for a range of slopes and rill/interrill erosion classes

Slope Steepness (%)	Slope Length Exponent, m		
	Rill/Interrill Ratio â		
	Low*	Moderate†	High‡
0.2	0.02	0.04	0.07
0.5	0.04	0.08	0.16
1	0.08	0.15	0.26
2	0.14	0.24	0.39
3	0.18	0.31	0.47
4	0.22	0.36	0.53
5	0.25	0.40	0.57
6	0.28	0.43	0.60
8	0.32	0.48	0.65
10	0.35	0.52	0.68
12	0.37	0.55	0.71
14	0.40	0.57	0.72
16	0.41	0.59	0.74
20	0.44	0.61	0.76
25	0.47	0.64	0.78
30	0.49	0.66	0.79
40	0.52	0.68	0.81
50	0.54	0.70	0.82
60	0.55	0.71	0.83

* conditions where rill erosion is slight with respect to rill erosion; generally C factors would be less than 0.15
† conditions where rill and interrill erosion would be about equal on a 22.1m long slope in seedbed condition on a 9% slope
‡ conditions where rill erosion is great with respect to interrill erosion; generally C factors would be greater than 7.0

(Source: McCool et al., 1989)

Table LS-6. Soil Loss Factors for Irregular Slopes

# of Segments	Sequence # of Segment (i)	0.02	0.06	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.64	0.7	0.75	0.8	0.85	0.9
		Soil Loss Factor (SLF) value of m																		
2	1	0.99	0.96	0.93	0.90	0.87	0.84	0.81	0.78	0.76	0.73	0.71	0.68	0.66	0.64	0.62	0.59	0.57	0.55	0.54
	2	1.01	1.04	1.07	1.10	1.13	1.16	1.19	1.22	1.24	1.27	1.29	1.32	1.34	1.36	1.38	1.41	1.43	1.45	1.46
3	1	0.98	0.94	0.90	0.85	0.80	0.76	0.72	0.68	0.64	0.61	0.58	0.55	0.52	0.50	0.46	0.44	0.42	0.39	0.37
	2	1.01	1.02	1.02	1.03	1.04	1.05	1.05	1.05	1.06	1.06	1.06	1.05	1.05	1.05	1.04	1.04	1.03	1.02	1.02
	3	1.02	1.05	1.08	1.12	1.16	1.19	1.23	1.26	1.30	1.33	1.37	1.40	1.43	1.46	1.49	1.52	1.55	1.58	1.61
4	1	0.97	0.92	0.87	0.81	0.76	0.71	0.66	0.62	0.57	0.54	0.50	0.47	0.44	0.41	0.38	0.35	0.33	0.31	0.29
	2	1.00	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.91	0.90	0.88	0.87	0.85	0.84	0.82	0.80	0.78
	3	1.01	1.03	1.05	1.07	1.09	1.11	1.13	1.14	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.23	1.24	1.24
	4	1.02	1.05	1.09	1.13	1.17	1.21	1.25	1.29	1.33	1.36	1.40	1.44	1.48	1.50	1.55	1.58	1.62	1.65	1.68
5	1	0.97	0.91	0.85	0.79	0.72	0.67	0.62	0.57	0.53	0.48	0.45	0.41	0.38	0.36	0.32	0.30	0.28	0.25	0.23
	2	1.00	0.99	0.97	0.96	0.94	0.92	0.90	0.88	0.86	0.84	0.82	0.80	0.77	0.76	0.73	0.71	0.69	0.66	0.64
	3	1.01	1.02	1.03	1.04	1.04	1.05	1.05	1.06	1.06	1.06	1.06	1.06	1.05	1.05	1.05	1.04	1.03	1.03	1.02
	4	1.01	1.04	1.06	1.09	1.12	1.14	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.30	1.32	1.34	1.35	1.37	1.38
	5	1.02	1.05	1.09	1.13	1.17	1.22	1.26	1.30	1.34	1.38	1.42	1.46	1.50	1.53	1.58	1.62	1.65	1.69	1.73

Table LS-7. USLE values for LS for specific combinations of slope length and steepness

	slope length (m)											
%slope	**2**	**5**	**10**	**15**	**25**	**50**	**75**	**100**	**150**	**200**	**250**	**300**
0.2	0.046	0.055	0.063	0.069	0.076	0.088	0.095	0.101	0.109	0.116	0.121	0.125
0.5	0.055	0.066	0.076	0.083	0.092	0.105	0.114	0.121	0.131	0.139	0.145	0.151
0.8	0.065	0.078	0.090	0.098	0.108	0.124	0.135	0.143	0.155	0.164	0.172	0.178
2	0.089	0.117	0.144	0.162	0.189	0.233	0.263	0.287	0.324	0.353	0.377	0.399
3	0.127	0.167	0.205	0.232	0.270	0.333	0.376	0.410	0.463	0.504	0.539	0.570
4	0.134	0.194	0.256	0.301	0.369	0.487	0.573	0.643	0.756	0.848	0.928	0.998
5	0.137	0.217	0.306	0.375	0.484	0.685	0.839	0.969	1.187	1.370	1.532	1.678
6	0.172	0.272	0.385	0.472	0.609	0.861	1.054	1.217	1.491	1.722	1.925	2.109
8	0.254	0.401	0.568	0.695	0.898	1.270	1.555	1.795	2.199	2.539	2.839	3.110
10	0.351	0.554	0.784	0.960	1.240	1.753	2.147	2.479	3.037	3.506	3.920	4.294
12	0.462	0.731	1.033	1.265	1.633	2.310	2.829	3.267	4.001	4.620	5.165	5.658
14	0.588	0.929	1.314	1.609	2.078	2.938	3.598	4.155	5.089	5.876	6.570	7.197
16	0.727	1.149	1.626	1.991	2.570	3.635	4.452	5.140	6.296	7.270	8.128	8.903
18	0.880	1.391	1.967	2.409	3.110	4.398	5.386	6.219	7.617	8.795	9.833	10.772
20	1.045	1.652	2.336	2.861	3.694	5.223	6.397	7.387	9.047	10.447	11.680	12.795

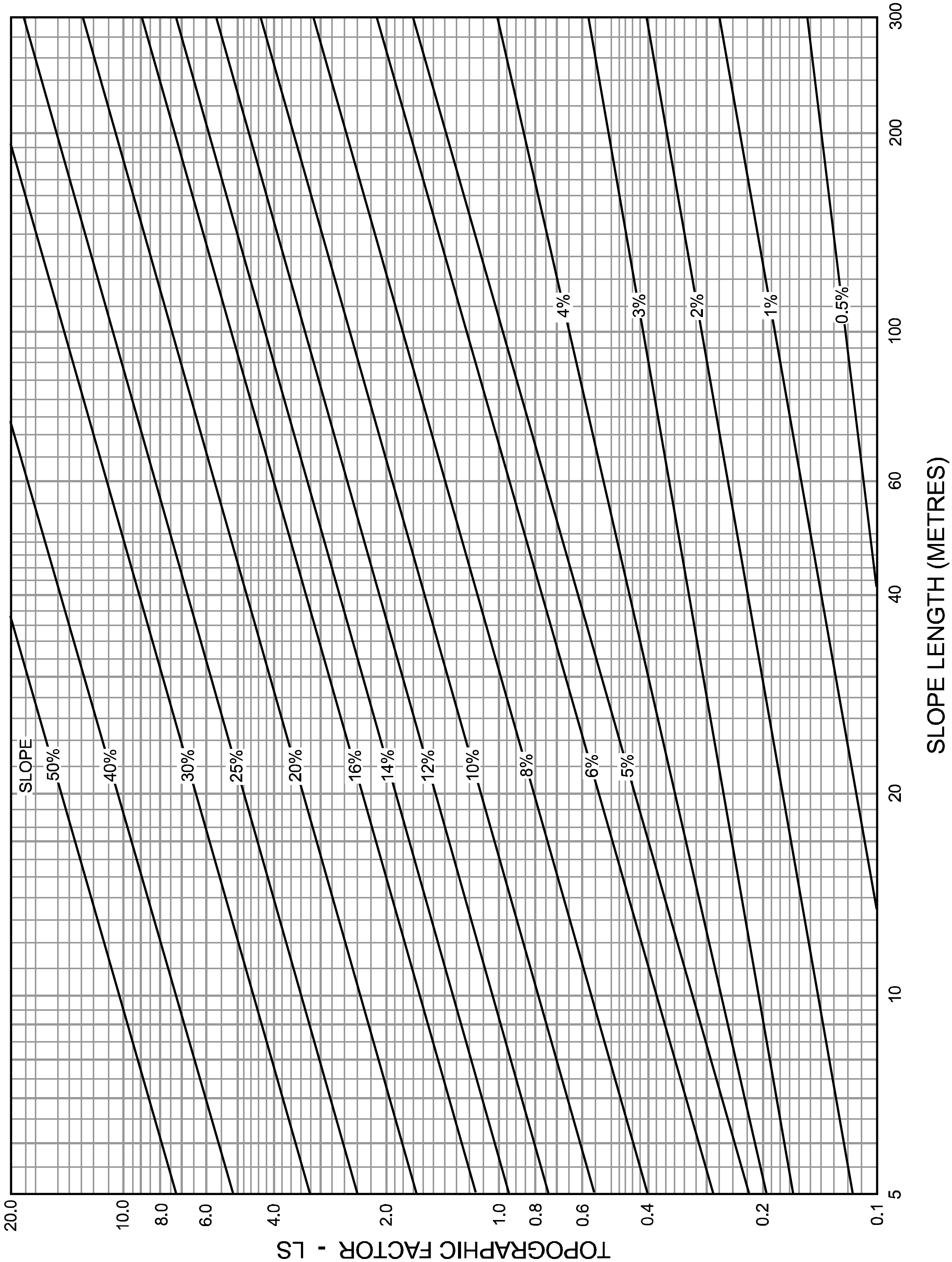

Figure LS-1. Slope effect chart in SI units (Wischmeier and Smith, 1978)

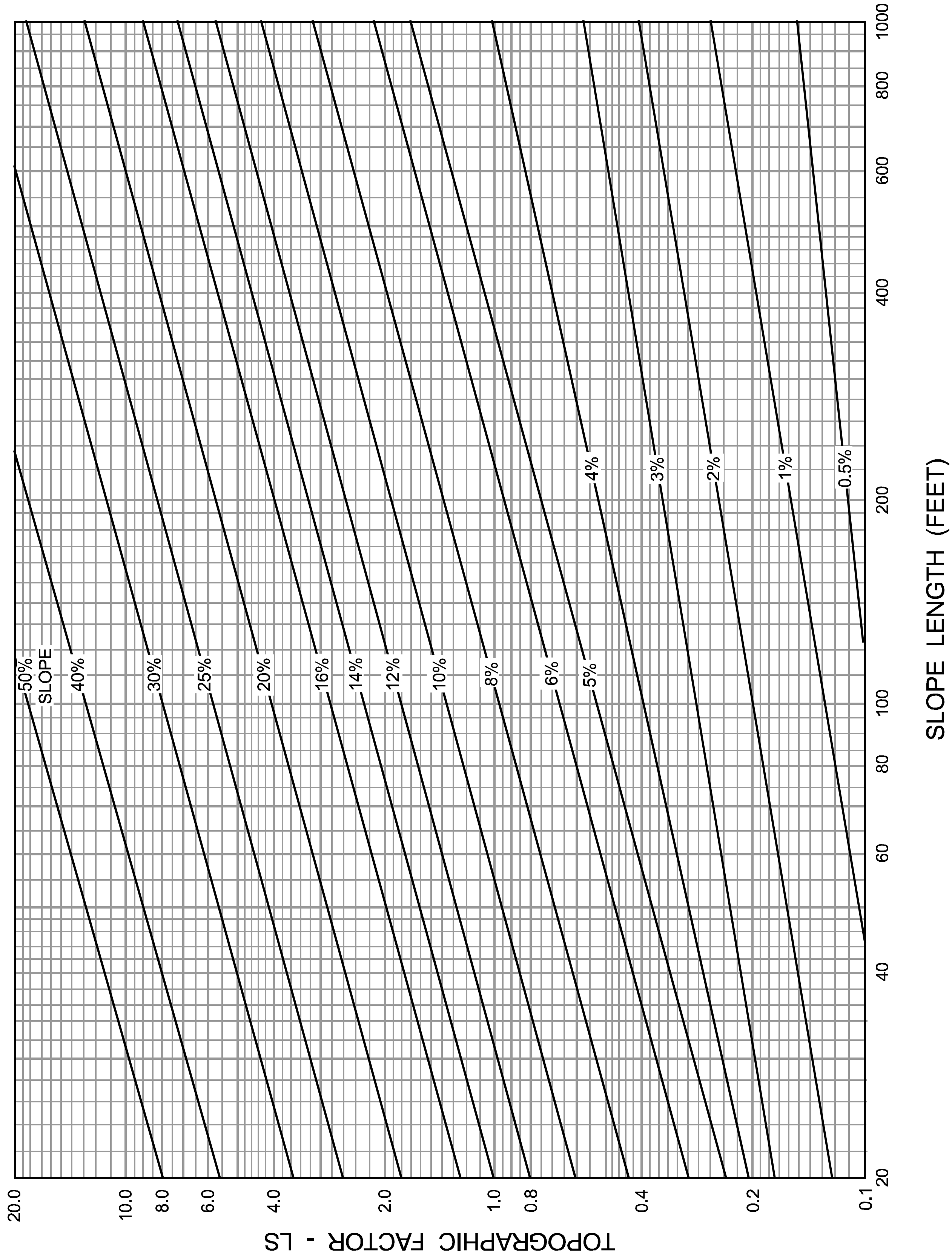

Figure LS-2. Slope effect chart in US customary units (Wischmeier and Smith, 1978)

C VALUES

DEFINITIONS

The following definitions are given for terms used in this section's C factor tables.

Management practices -

1. Tillage practices - refers to practices used in preparation for crop, prior to planting (primary / secondary)

Definitions of tillage practices are as follows:

Seasons:	**F** - fall	**S** - spring	
Tillage type:	**C** - cultivate	**MP** - moldboard plough	**TD** - tandem disc
	S - spring	**CH** - chisel	**NT** - no-till
	D - disc	**OD** - offset disc	**H** - harrow
	P - pack		

2. Cropping practices -
   Underseeded - refers to whether or not a forage crop is underseeded into the main crop
   Post-crop residue - residue treatment after harvest (left or removed)

3. Previous crop -
   Refers to crop grown immediately prior to main crop (2nd yr.after hay) - indicates that a hay crop was grown two years before current or main crop (some residual benefits of the hay stilll exist)

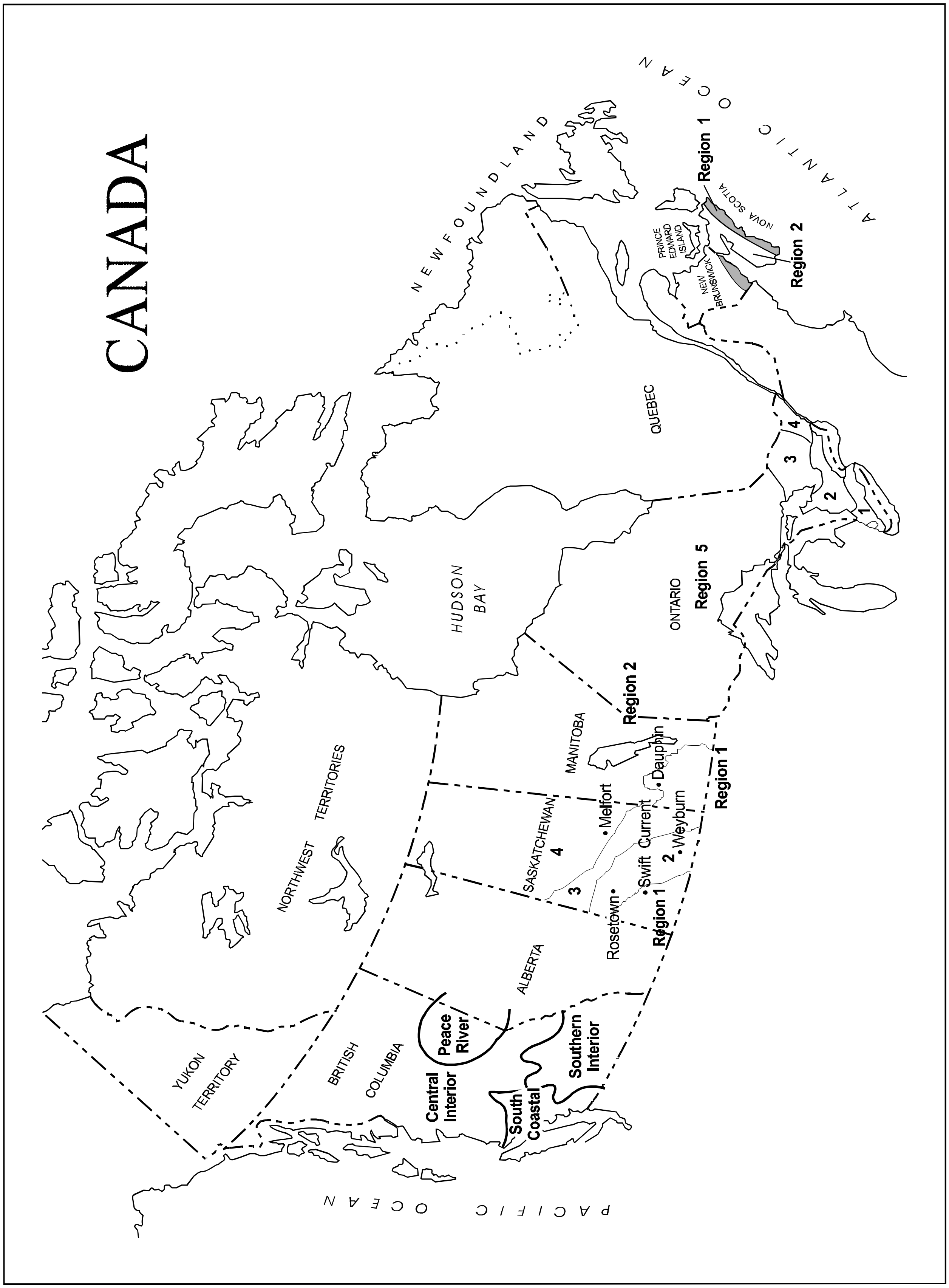

Figure C-1. C Regions of Canada

Table C-1. C Values for the Pacific Region. All Table C data from Huffman, 1985 unless otherwise stated.

Field Crop	Management Practice			Previous Crop	C Values				
	Tillage	Cropping			Coast	Interior		Peace River	
		underseeded	post-crop residue			Central	South	South	North
Barley,Oats	F MP	N	R	field crops	0.42	0.42			
	F MP	N	R	field crops (2nd yr. after hay)	0.37				
	F MP	N	L	field crops	0.31	0.35			
	F MP	N	L	field crops (2nd yr. after hay)		0.31			
	F MP	Y	L	field crops		0.20			
	F MP	Y	R	hay	0.23				
	F MP	N	L	hay	0.21	0.19			
	F MP	Y	L	hay	0.19	0.15			
	FD or CH	N	R	grain		0.38			
	FD or CH	N	R	grain (2nd yr. after hay)		0.32			
	FD or CH	N	L	grain		0.30			
	FD or CH	N	L	grain (2nd yr. after hay)		0.28			
	FD or CH	N	L	hay		0.15			
Barley	F C, S C (x2-3)	N	R	field crops				0.39	
(early crop,S.Peace River)	F C, S C (x2-3)	N	R	field crops (2nd yr. after hay)				0.37	
	F C, S C (x2-3)	N	L	field crops				0.29	
	F C, S C (x2-3)	N	L	field crops (2nd yr. after hay)				0.27	
	F C, S C (x2-3)	N	R	hay				0.27	
	F C, S C (x2-3)	N	L	hay				0.17	
Barley	F C, S C (x2-3)	N	R	field crops				0.41	0.43
(medium/late crop,S.Peace R.	F C, S C (x2-3)	N	R	field crops (2nd yr. after hay)				0.39	0.41
or Barley or oats, N. Peace R.)	F C, S C (x2-3)	N	L	field crops				0.31	0.31
	F C, S C (x2-3)	N	L	field crops (2nd yr. after hay)				0.29	0.29
	F C, S C (x2-3)	N	R	hay				0.24	0.29
	F C, S C (x2-3)	N	L	hay				0.14	0.18
Oats	F C, S C (x2-3)	N	L	field crops				0.29	
	F C, S C (x2-3)	N	L	field crops (2nd yr. after hay)				0.27	
	F C, S C (x2-3)	N	L	hay				0.17	
	S MP / S D (2-3x's)	N	R	grain			0.37		
	S MP / S D (2-3x's)	N	R	grain (2nd yr. after hay)			0.34		
	S MP / S D (2-3x's)	N	L	grain			0.32		
		N	L	grain (2nd yr. after hay)			0.29		
	- underseeded with	Y	L	grain			0.31		
	annual ryegrass	Y	L	grain (2nd yr. after hay)			0.28		
		L	R	hay			0.24		
		L	L	hay			0.19		
		Y	L	hay			0.17		
Double Crop	S MP / S D (2-3x's)		L	grain			0.27		
cereal	S MP / S D (2-3x's)		L	grain (2nd yr. after hay)			0.23		
silage corn	second crop / S D		L	hay			0.13		
Grain (dryland)	S C, D	N	L	grain			0.32		
	S C, D	N	L	grain (2nd yr. after hay)			0.30		
	S C, D	N	L	hay			0.17		

Table C-1 continued

	S C, D	N	L	fallow			0.43		
	S C, D	N	L	fallow (2nd yr. after hay)			0.38		
Canola (early crop)	F C	N	L	fallow				0.35	0.37
	F C	N	L	field crops				0.25	0.27
	F C	N	L	field crops (2nd yr. after hay)				0.24	0.26
	F C	N	L	hay				0.15	0.17
Canola (late crop)	F C	N	L	fallow				0.38	0.39
	F C	N	L	field crops				0.28	0.28
	F C	N	L	field crops (2nd yr. after hay)				0.25	0.29
	F C	N	L	hay				0.21	0.22
Corn (silage)	S D, C (2x's)	N	R	corn, grain	0.31				
	S D, C (2x's)	N	R	corn, grain (2nd yr. after hay)		0.28			
Fescue (establishing year)	F MP / S D	N	L	field crops				0.45	0.47
	F MP / S D	N	L	field crops (2nd yr. after hay)				0.40	0.43
	F MP / S D	N	L	hay				0.26	0.29
	F D, S C	N	L	field crops				0.39	0.45
	F D, S C	N	L	field crops (2nd yr. after hay)				0.37	0.41
	F D, S C	N	L	hay				0.23	0.25
Fescue (established crop)						0.10	0.12		
Hay or forage	F MP / S D, H	N		fallow (late seeding)				0.43	0.42
(establishing year)	F MP / S D, H	N		field crops	0.30	0.37	0.33	0.38	0.36
	F MP / S D, H	N		field crops (2nd yr. after hay)		0.33	0.26	0.33	0.31
	F D , S C	N		field crops				0.34	0.34
	F D , S C	N		field crops (2nd yr. after hay)				0.30	0.32
	S MP / S D, C	N		field crops	0.25	0.25	0.19		
	underseeded into prev. crop	Y		grain	0.05	0.20	0.16		
Green manure (red clover)	F D, S C	N		field crops				0.35	0.39
	F D, S C	N		field crops (2nd yr. after hay)				0.33	0.31
	underseeded into prev. crop	Y		grain				0.02	
Established forage crop	Alfalfa			hay	0.04	0.04	0.04	0.04	0.04
	Grass/Legume mix			hay	0.02	0.02	0.02	0.02	0.02
	Red Clover			hay	0.03	0.03	0.03	0.03	0.03
Wheat (spring)	F C, S C (2-3 x's)	N	R	field crops					0.48
	F C, S C (2-3 x's)	N	R	field crops (2nd yr. after hay)					0.44
	F C, S C (2-3 x's)	N	L	field crops				0.27	0.38
	F C, S C (2-3 x's)	N	L	field crops (2nd yr. after hay)				0.26	0.34
	F C, S C (2-3 x's)	N	R	hay					0.25
	F C, S C (2-3 x's)	N	L	hay				0.16	0.20
Fallow	c (4x's)	N		barley, canola, rye, wheat			0.45	0.60	0.60
				hay				0.45	0.45
HORTICULTURAL CROPS									
Beans (processing)	S MP / S D, C, P	N	L	beans, peas, other vegetables	0.41				
	S MP / S D, C, P	N	L	vegetables (2nd yr. after hay)	0.40				
	S MP / S D, C, P	N	L	corn, grain	0.38				
	S MP / S D, C, P	N	L	corn, grain (2nd yr. after hay)	0.37				
Table C-1 continued									
	S MP / S D, C, P	N	L	hay	0.28				

Broccoli, cauliflower	S MP / S D, C, P	N	L	vegetable crops	0.41		
	S MP / S D, C, P	N	L	vegetables (2nd yr. after hay)	0.40		
	S MP / S D, C, P	N	L	corn, grain	0.39		
	S MP / S D, C, P	N	L	corn, grain (2nd yr. after hay)	0.38		
	S MP / S D, C, P	N	L	hay	0.29		
Brussel Sprouts	S MP / S D, C, P	N	L	vegetables crops	0.39		
	S MP / S D, C, P	N	L	vegetables crops (2nd yr. after hay)	0.38		
	S MP / S D, C, P	N	L	corn, grain	0.36		
	S MP / S D, C, P	N	L	corn, grain (2nd yr. after hay)	0.35		
	S MP / S D, C, P	N	L	hay	0.27		
Carrots	S MP / D, C, P + bed shaping	N	L	vegetable crops	0.45		
	S MP / D, C, P + bed shaping	N	L	vegetable crops (2nd yr. after hay)	0.43		
	S MP / D, C, P + bed shaping	N	L	corn, grain	0.42		
	S MP / D, C, P + bed shaping	N	L	corn, grain (2nd yr. after hay)	0.40		
	S MP / D, C, P + bed shaping	N	L	hay	0.28		
	S MP; followed by winter cover			field crops	0.22		
Celery	S D or R	N	L	vegetable crops	0.46		
	S D or R	N	L	vegetable crops (2nd yr. after hay)	0.45		
	S D or R	N	L	hay	0.34		
Corn (sweet)	S SS, MP / D,C,P	N	L	field / vegetable crops	0.48		
	S SS, MP / D,C,P	N	L	field crops following hay	0.46		
	S SS, MP / D,C,P	N	L	hay	0.29		
Lettuce	S D or R	N	L	vegetable crops	0.47		
	S D or R	N	L	vegetables (2nd yr. after hay)	0.46		
	S D or R	N	L	hay	0.37		
Onions	S D or R	N	L	vegetable crops	0.46		
	S D or R	N	L	vegetables (2nd yr. after hay)	0.44		
	S D or R	N	L	hay	0.28		
Peas	S MP / D,C,P	N	L	vegetable crops	0.41		
	S MP / D,C,P	N	L	vegetables (2nd yr. after hay)	0.39		
	S MP / D,C,P	N	L	corn, grain	0.39		
	S MP / D,C,P	N	L	corn, grain (2nd yr. after hay)	0.38		
	S MP / D,C,P	N	L	hay	0.23		
Potatoes (early harvest)	S MP / D,C,P	N	L	field, vegetable crops	0.41	0.42	
	S MP / D,C,P	N	L	field, vegetable crops (2nd yr. after hay)	0.40	0.40	
	S MP / D,C,P	N	L	hay	0.28	0.24	
Potatoes (late harvest)	S MP; rotation with cover crop			field, vegetable crops	0.22		
	S MP / S D,C	N	L	field, vegetable crops	0.38		
Table C-1 continued							
FRUITS							
Grapes	cultivated between rows						0.39
	permanent cover between rows						0.22

Raspberries (Establishing year)	S MP	N	L	field, vegetable crops	0.60		
	S MP	N	L	field, vegetable crops (2nd yr. after hay)	0.55		
	S MP	N	L	hay	0.40		
Raspberries (Established crop and cultivated between rows)	S MP		L	raspberries	0.45		
Raspberries (Established crop with barley between rows)	S MP		L		0.15		
Strawberries (Establishing year)	S MP	N	L	vegetable crops	0.60		
	S MP	N	L	grain	0.55		
	S MP	N	L	grain (2nd yr. after hay)	0.50		
	S MP	N	L	hay	0.40		
Strawberries (Established crop, cultivated between row)	S MP		L	strawberries	0.46		
Strawberries (Established crop, with barley seeded bed)	S MP		L	strawberries	0.10		
Orchard	cultivated, bare soil				0.40	0.40	
	100% ground cover				0.02	0.02	
First year	10% canopy cover			permanent cover, except for 2-3 ft. strip			0.31
Second year	25% canopy cover			permanent cover, except for 2-3 ft. strip			0.20
Third + year(s)	50-60% canopy cover			permanent cover, except for 2-3 ft. strip			0.10
Additional C values*							
Beans						0.59	0.63
Canola						0.15	0.21
Corn (grain)					0.42	0.42	0.48
Corn (silage)					0.59	0.57	
Fall cereals					0.29	0.14	0.19
Fruit trees						0.05	
Grapes					0.20	0.20	
Nursery					0.20	0.20	0.20
Pasture					0.02	0.02	0.02
Potatoes						0.42	0.46
Root crops						0.40	0.44
Small fruits						0.27	0.44
Spring cereals					0.32		
Sod					0.02		0.02
Sugar beets					0.41	0.40	0.44
Vegetables						0.59	0.63
Woodland					0.01	0.01	0.01

* - from Huffman, 1985

Table C-1a. Generalized C Values for British Columbia.

Crop	Conventional Till	Conservation Till	No Till
Summerfallow	0.60	0.30	0.15

Fall Cereals	0.29	0.15	0.05
Spring Cereals[1]	0.37	0.19	0.09
Corn for Grain	0.31	0.16	0.08
Corn for Silage	0.46	0.23	0.12
Total Tame Hay[2]	0.14	0.07	0.04
Canola[3]	0.35	0.18	0.09
Potatoes	0.40	0.20	0.10
Dry Field Peas + Beans	0.41	0.21	0.10
Total Berries + Grapes	0.43	0.22	0.11
Total Fruit Trees	0.10	0.05	0.03
Total Vegetables	0.45	0.23	0.11

[1] Includes “oats for fodder”
[2] Includes “other fodder crops”
[3] Includes flaxseed

Note: The C-factor value for conservation tillage was arbitrarily set as 50% of the C-factor value for conventional tillage; the C-factor value for No Till was arbitrarily set as 25% of the C-factor value for conventional tillage.

Table C-2. C Values for the Prairie Region - Part 1

Field Crop	**Management Practices**			**Previous Crop**	**C-Values**					
	Tillage	Cropping			Alberta	Saskatchewan			Manitoba	
		underseeded	post-crop residue		Peace R.	Melfort	Rosetown	Swift Current	Weyburn	Dauphin
AVERAGE CONDITIONS										
Barley	FC, SC(x2)	N	L	fallow (following grain crop)	0.42					0.35
	FC, SC(x2)	N	L	fallow (following grain crop) (2nd yr. after hay)	0.40					0.27
	FC, SC(x2)	N	L	fallow (following row crop)	0.38					
	FC, SC(x2)	N	L	fallow (following row crop) (2nd yr. after hay)	0.36					
	FC, SC(x2)	N	L	barley, canola, peas	0.29					0.29
	FC, SC(x2)	Y	L	barley, canola, peas	0.27					
	FC, SC(x2)	N	L	barley, canola, peas (2nd yr. after hay)	0.27					0.22
	FC, SC(x2)	N	L	hay	0.17					0.10
	SOD or C,H,P	N	L	conventional fallow			0.26			
	SOD or C,H,P	N	L	conventional fallow (2nd yr. after hay)			0.22			
	SOD or C,H,P	N	L	conservation fallow			0.18			
	SOD or C,H,P	N	L	conservation fallow (2nd yr. after hay)			0.16			
	SOD or C,H,P	N	L	wheat			0.22			
	SOD or C,H,P	N	L	wheat (2nd yr. after hay)			0.18			
	SOD or C,H,P	N	L	hay			0.11			
Canary Grass	SOD, H, P	N	L	conventional fallow			0.38			
	SOD, H, P	N	L	conventional fallow (2nd yr. after hay)			0.32			
	SOD, H, P	N	L	conservation fallow			0.28			
	SOD, H, P	N	L	conservation fallow (2nd yr. after hay)			0.24			
Canola	FOD &/or C,SC, H, P	N	R	flax		0.57				
	FOD &/or C,SC, H, P	N	R	flax (2nd yr. after hay)		0.50				
	FOD &/or C,SC, H, P	N	L	cereal		0.41				
	FOD &/or C,SC, H, P	N	L	cereal (2nd yr. after hay)		0.37				
	FOD &/or C,SC, H, P	N	L	hay		0.25				
	FC, SC (x2)	N	L	fallow (following grain crop)	0.59					0.67
	FC, SC (x2)	N	L	fallow (following grain crop) (2nd yr. after hay)	0.47					0.51
	FC, SC (x2)	N	L	fallow (following row crop)	0.60					
	FC, SC (x2)	N	L	fallow (following row crop) (2nd yr. after hay)	0.48					
	FC, SC (x2)	N	L	barley, wheat	0.54					

Table C-2 continued

	FC, SC (x2)	N	L	barley, wheat (2nd yr. after hay)	0.49					
	FC, SC (x2)	N	L	hay	0.30					
	FTD(x2) SC(x2)	N	L	wheat						0.45
	FTD(x2) SC(x2)	N	L	wheat (2nd yr. after hay)						0.35
	FTD(x2) SC(x2)	N	L	hay						0.16
	SMP, C(x2), H, P(x2)	N	L	cereal		0.42				
	SMP, C(x2), H, P(x2)	N	L	cereal (2nd yr. after hay)		0.37				
	SMP, C(x2), H, P(x2)	N	L	hay		0.21				
	SC(2x), H, P(x2)	N	R	fallow		0.50				
	SC(2x), H, P(x2)	N	L	fallow		0.45				
Fallow	C(x4)	N		barley, canola, rye, wheat	0.40					
	C(x4)	N		hay	0.38					
- conventional	C(2x), RW(2x)		(30-40 % cover after fallow)	cereals, canary grass		0.50	0.40	0.40	0.52	0.40
- conservation	C(1x), RW(2x)		(40-50 % cover after fallow)	cereals, canary grass			0.34			
				lentils			0.52			
Flax	FOD, C; SC, H, P	N	L	cereal		0.54				
	FOD, C; SC, H, P	N	L	cereal (2nd yr. after hay)		0.47				
	FOD, C; SC, H, P	N	L	hay		0.26				
	FC, SC	N	R	fallow						0.68
	FC, SC	N	R	fallow (2nd yr. after hay)						0.52
	FTD(x2), SC(x2)	N	R	wheat						0.46
	FTD(x2), SC(x2)	N	R	wheat (2nd yr. after hay))						0.35
	FTD(x2), SC(x2)	N	R	hay						0.15
	S tillage (unspecified)	N	R			0.30				
Fall Rye, Winter Wheat	FMP, C, H, P	N	L	cereal		0.46				
	FMP, C, H, P	N	L	cereal (2nd yr. after hay)		0.32				
	FMP, C, H, P	N	L	hay		0.22				
Table C-2 continued										
Fall Rye, Winter Wheat	FC / SC, H, P	N	L	fallow (following grass)	0.42					

	FC / SC, H, P	N	L	fallow (following grass) (2nd yr. after hay)	0.39				
	FC / SC, H, P	N	L	fallow (following row crop)	0.37				
	FC / SC, H, P	N	L	fallow (following row crop) (2nd yr. after hay)	0.34				
	FC / SC, H, P	N	L	cereal	0.36	0.33			
	FC / SC, H, P	Y	L	cereal	0.34				
	FC / SC, H, P	N	L	cereal (2nd yr. after hay)	0.33	0.23			
	FC / SC, H, P	N	L	hay	0.17	0.16			
	F Hoe	N	L	conventional fallow				0.26	
	F Hoe	N	L	wheat				0.13	
	F Hoe	N	L	wheat (2nd yr. after hay)				0.12	
	F Hoe	N	L	hay				0.07	
Grain, wheat (spring)	FC, SC(x2)	N	L	fallow (following grain crop)	0.45				0.50
	FC, SC(x2)	N	L	fallow (following grain crop) (2nd yr. after hay)	0.40				0.36
	FC, SC(x2)	N	L	fallow (following row crop)	0.41				
	FC, SC(x2)	N	L	fallow (following row crop) (2nd yr. after hay)	0.36				
	FC, SC(x2)	N	L	barley, canola, peas	0.31				
	FC, SC(x2)	Y	L	barley, canola, peas	0.29				
	FC, SC(x2)	N	L	barley, canola, peas (2nd yr. after hay)	0.28				
	FC, SC(x2)	N	L	hay	0.10				
	FTD(x2), SC or Burn, FTD, SC	N	L or B	canola, wheat					0.39
	FTD(x2), SC or Burn, FTD, SC	N	L or B	canola, wheat (2nd yr. after hay)					0.20
	FTD(x2), SC or Burn, FTD, SC	N	L or B	hay					0.16
	SMP or C(x2) H, P(x2)	N	L	fallow (after row crop)		0.50			
	SMP or C(x2) H, P(x2)	N	L	fallow (after grain crop)		0.44			
	SMP or C(x2) H, P(x2)	N	R	cereal		0.56			
	SMP or C(x2) H, P(x2)	N	R	cereal (2nd yr. after hay)		0.47			
	SMP or C(x2) H, P(x2)	N	R	hay		0.26			
	SMP or C(x2) H, P(x2)	N	L	cereal		0.35			
	SMP or C(x2) H, P(x2)	N	L	cereal (2nd yr. after hay)		0.28			
	SMP or C(x2) H, P(x2)	N	L	hay		0.16			
	SMP or C(x2) H, P(x2)	Y	L	conventional fallow				0.42	
	SMP or C(x2)	Y	L	cereal		0.32		0.22	
	SMP or C(x2)	Y	L	cereal (2nd yr. after hay)		0.26		0.18	
	SMP or C(x2)	Y	L	hay		0.14		0.10	
	SOD or C, H, P	N	L	conventional fallow			0.30		0.45
Table C-2 continued									
	SOD or C, H, P	N	L	conventional fallow (2nd yr. after hay)			0.25		
	SOD or C, H, P	N	L	conservation fallow			0.20		

	SOD or C, H, P	N	L	conservation fallow (2nd yr. after hay)			0.17	
Grain, wheat (spring) (cont'd)	SOD or C, H, P	N	L	wheat, mustard, flax			0.24	0.29
	SOD or C, H, P	N	L	wheat, mustard, flax (2nd yr. after hay)			0.20	0.24
	SOD or C, H, P	N	L	hay			0.12	0.13
Hay (alfalfa)	SC(x2), H, P	N	L	cereal		0.40		
(Establishing year)	SC(x2), H, P	N	L	cereal (2nd yr. after hay)		0.35		
(Established or		alfalfa			0.02	0.02		
underseeded)		grass /leg-ume -2 to 3 t hay				0.01		
						0.01		
		-1 t hay						
		alsike, red clover			0.02			
		sweet clover			0.03			
Lentils	FOD, C; SD, H, P	N	L	cereals, peas		0.54		
	FOD, C; SD, H, P	N	L	cereals, peas (2nd yr. after hay)		0.50		
	FOD, C; SD, H, P	N	L	hay		0.27		
	SOD, H, P	N	L	conservation fallow			0.40	
	SOD, H, P	N	L	conservation fallow (2nd yr. after hay)			0.34	
	SOD, H, P	N	L	hay			0.20	
Peas, beans	FOD, C; SC, H, P	N	L	beans, peas		0.55		
	FOD, C; SC, H, P	N	L	beans, peas (2nd yr. after hay)		0.50		
	FOD, C; SC, H, P	N	L	cereal		0.42		
	FOD, C; SC, H, P	N	L	cereal (2nd yr. after hay)		0.38		
	FOD, C; SC, H, P	N	L	hay		0.24		
	FC, SC(x2),	N	L	fallow (following grain crop)	0.54			
	FC, SC(x2),	N	L	fallow (following grain crop) (2nd yr. after hay)	0.41			
	FC, SC(x2),	N	L	fallow (following row crop)	0.55			
	FC, SC(x2),	N	L	fallow (following row crop) (2nd yr. after hay)	0.42			
	FC, SC(x2),	N	L	barley, wheat	0.48			
Table C-2 continued								
	FC, SC(x2),	N	L	barley, wheat (2nd yr. after hay)	0.42			
	FC, SC(x2),	N	L	hay	0.22			
DRY CONDITIONS								

Barley	SOD, H, P	N	L	conventional fallow	0.31		
	SOD, H, P	N	L	fallow (2nd yr. after hay)	0.26		
	SOD, H, P	N	L	conservation fallow	0.29		
	SOD, H, P	N	L	fallow (2nd yr. after hay)	0.25		
	SOD, H, P	N	L	wheat	0.24		
	SOD, H, P	N	L	wheat (2nd yr. after hay)	0.21		
	SOD, H, P	N	L	hay	0.12		
	FC, SC	N	L	fallow			0.38
	FC, SC	N	L	fallow (2nd yr. after hay)			0.29
	FTD(x2), SC or burn , FTD, SC	N	L or B	canola, wheat			0.30
	FTD(x2), SC or burn , FTD, SC	N	L or B	canola, wheat (2nd yr. after hay)			0.24
	FTD(x2), SC or burn , FTD, SC	N	L or B	hay			0.12
Wheat	SD or C, H, P	N	L	conventional fallow	0.39	0.54	
	SD or C, H, P	N	L	fallow (2nd yr. after hay)	0.34		
	SD or C, H, P	N	L	conservation fallow	0.32		
	SD or C, H, P	N	L	fallow (2nd yr. after hay)	0.27		
	SD or C, H, P	N	L	wheat, mustard, flax	0.27	0.33	
	SD or C, H, P	N	L	wheat, mustard, flax (2nd yr. after hay)	0.22	0.28	
	SD or C, H, P	N	L	hay	0.13	0.16	
	FC, SC	N	L or B	fallow			0.59
	FC, SC	N	L or B	fallow (2nd yr. after hay)			0.46
	FTD(x2), JC or Burn, FTD, SC	N	L or B	canola, wheat			0.32
	FTD(x2), JC or Burn, FTD, SC	N	L or B	canola, wheat (2nd yr. after hay)			0.25
	FTD(x2), JC or Burn, FTD, SC	N	L or B	hay			0.13
Lentils	SOD, H, P	N	L	conventional fallow	0.53		
	SOD, H, P	N	L	fallow (2nd yr. after hay)	0.46		
	SOD, H, P	N	L	hay	0.27		
Canary Grass	SD, H, P	N	R	conventional fallow	0.48		
	SD, H, P	N	R	fallow (2nd yr. after hay)	0.40		
	SD, H, P	N	R	conservation fallow	0.42		
	SD, H, P	N	L	fallow (2nd yr. after fallow)	0.24		
Fallow							
- conventional	C(x2), RW(2x)		(20-25 % cover after fallow)	cereals, canary grass	0.43	0.56	0.50
Table C-2 continued							
- conservation	C(1x), RW(2x)		(25-30 % cover after fallow)	cereals, canary grass	0.39		

			(20-25 % cover after fallow)	lentils	0.56		
Canola	FC, SC	N	L or B	fallow			0.68
	FC, SC	N	L or B	fallow (2nd yr. after hay)			0.54
	FTD(x2), SC	N	L or B	wheat			0.51
	FTD(x2), SC	N	L or B	wheat (2nd yr. after hay)			0.40
	FTD(x2), SC	N	L or B	hay			0.21
Flax	FTD(x2), SC	N	L or B	fallow			0.69
	FTD(x2), SC	N	L or B	fallow (2nd yr. after hay)			0.54
	FTD(x2), SC	N	L or B	wheat			0.47
	FTD(x2), SC	N	L or B	wheat (2nd yr. after hay)			0.36
	FTD(x2), SC	N	L or B	hay			0.18
DRY CONDITIONS, SOLONETZIC SOIL							
Wheat, durum	SD, C	N	L	fallow		0.55	
	SD, C	N	L	flax, mustard, wheat		0.37	
	SD, C	N	L	flax, mustard, wheat (2nd yr. after hay)		0.32	
	SD, C	N	L	hay		0.18	
Fallow							
- conventional	C(x4)			cereals		0.58	

Table C-2: Values for the Prairie Region - Part 2

Typical Rotations	Number of Crop Years in Rotation	C - value
Weyburn		
1. Barley - summer fallow	2	0.47
2 Barley - summer fallow - canola	3	0.45
3. Barley - wheat - fallow	3	0.42
4. Wheat - barley - forage (3 yrs.)	5	0.13

ADDITIONAL CROPS

(from Huffman, 1985)

	C - value		
General values	Alberta	Saskatchewan	Manitoba
Beans, peas	.53 - .56	.53 - .60	.54 - .60
Canola, mustard, flax	.25 - .34	.24 - .34	.25 - .34
Corn (grain)	.51	.51 - .54	.52 - .55
Corn (silage)	.57	.55 - .58	.56 - .59
Fallow	.43 - .73	.39 - .77	.52 - .78
Spring grains	.26 - .35	.24 - .34	.24 - .51
Sugar beets	.50	.55 - .58	.56 - .59
Sunflower	.51	.51 - .54	.52 - .55
Potatoes	.42	.39 - .42	.40 - .43
Winter grains	.14	.14	.14

ADDITIONAL C VALUES

(from Tajek et al., 1985)

	Peace River	Foothills	Central Alberta	Dark Brown Zone	Brown Zone
Cereals	0.3 (0.26*)	0.28	0.27	0.30	0.39**
W. Wheat	-	-		0.27	0.29
Canola	0.42	-	0.34	0.39	-
Row Crop	-		0.45	0.45	0.45

Summerfallow 0.69 depending on the residue

Notes: * with clover or alfalfa in rotation
** cereal summerfallow rotation

The C-factor values for various geographical regions of Alberta are based on common agricultural practices, average time sequence of various operations and annual distribution of the RT factor in a given region.

a) a 2 yr. rotation in the Brown Zone
b) a 3 yr. rotation in the Dark Brown Zone
c) a 5 yr. rotation for the remainder

Table C-2a. Generalized C Values for Alberta

Crop	Conventional Till	Conservation Till	No Till
Spring Cereals	0.29	0.22	0.15
Fall Cereals	0.14	0.11	0.07
Oil Seeds	0.29	0.22	0.15
Legumes	0.29	0.22	0.15
Buckwheat	0.31	0.23	0.16
Sunflower	0.51	0.38	0.26
Corn Grain	0.53	0.40	0.27
Corn Silage	0.57	0.43	0.29
Potatoes	0.42	0.32	0.21
Sugar Beets	0.50	0.38	0.25
Tame Hay	0.01	0.01	0.01
Mixed Grain	0.31	0.23	0.16
Summer fallow	0.69		
Other Fodder Crops	0.30	0.23	0.15

Notes: The C-factor value for conservation tillage was arbitrarily set as 75 % of the C-factor value for conventional tillage; the C-factor value for No Till was arbitrarily set as 50% of the C-factor value for conventional tillage.

Table C-2b. Generalized C Values for Manitoba

Crop	Region 1 (Black)			Region 2 (Grey)		
	Conventional Till	Conservation Till	No Till	Conventional Till	Conservation Till	No Till
Spring Cereals	0.27	0.20	0.14	0.40	0.30	0.20
Fall Cereals	0.14	0.11	0.10	0.14	0.11	0.10
Grain Corn and Sunflowers	0.53	0.40	0.27	0.54	0.41	0.27
Canola, Flax, Mustard, & Soybeans and Buckwheat	0.26	0.20	0.13	0.30	0.23	0.15
Peas, Beans, Sugar Beets & Silage Corn	0.56	0.42	0.28	0.58	0.43	0.29
Potatoes	0.40	0.30	0.20	0.42	0.32	0.21
Hay	0.13	-*	-	0.13	-	-
Summerfallow	0.55	0.41	-	0.69	0.52	-
Improved Pasture	0.10	-	-	0.10	-	-

* - not applicable

Note: The C-factor value for conservation tillage was arbitrarily set as 75% of the C-factor value for conventional tillage; the C-factor value for No Till was arbitrarily set as 50% of the C-factor value for conventional tillage.

Table C-2c. Generalized C Values for Saskatchewan

Crop	Region 1 -Mixed Grassland			Moist-Mixed Grassland			Aspen Parkland			Boreal Trans-Mid Boreal		
	Conv. Till	Cons. Till	No Till	Conv. Till	Cons. Till	No Till	Conv. Till	Cons. Till	No Till	Conv. Till	Cons. Till	No Till
Fall Cereals	0.14	0.12	0.11	0.14	0.12	0.11	0.14	0.12	0.11	0.14	0.12	0.11
Forages	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Fallow	0.39	0.33	0.29	0.52	0.44	0.39	0.61	0.52	0.46	0.70	0.60	0.53
Spring Cereals	0.26	0.22	0.20	0.24	0.20	0.18	0.34	0.29	0.26	0.30	0.26	0.23
Corn/Sunflower	0.51	0.43	0.38	0.52	0.44	0.39	0.54	0.46	0.41	0.54	0.46	0.41
Oilseeds	0.24	0.20	0.18	0.32	0.27	0.24	0.34	0.29	0.26	0.30	0.26	0.23
Peas/Beans	0.53	0.45	0.40	0.54	0.46	0.41	0.60	0.51	0.45	0.58	0.49	0.44

Note: The C-factor value for conservation tillage was arbitrarily set as 85% of the C-factor value for conventional tillage; the C-factor value for No Till was arbitrarily set as 50% of the C-factor value for conventional tillage.

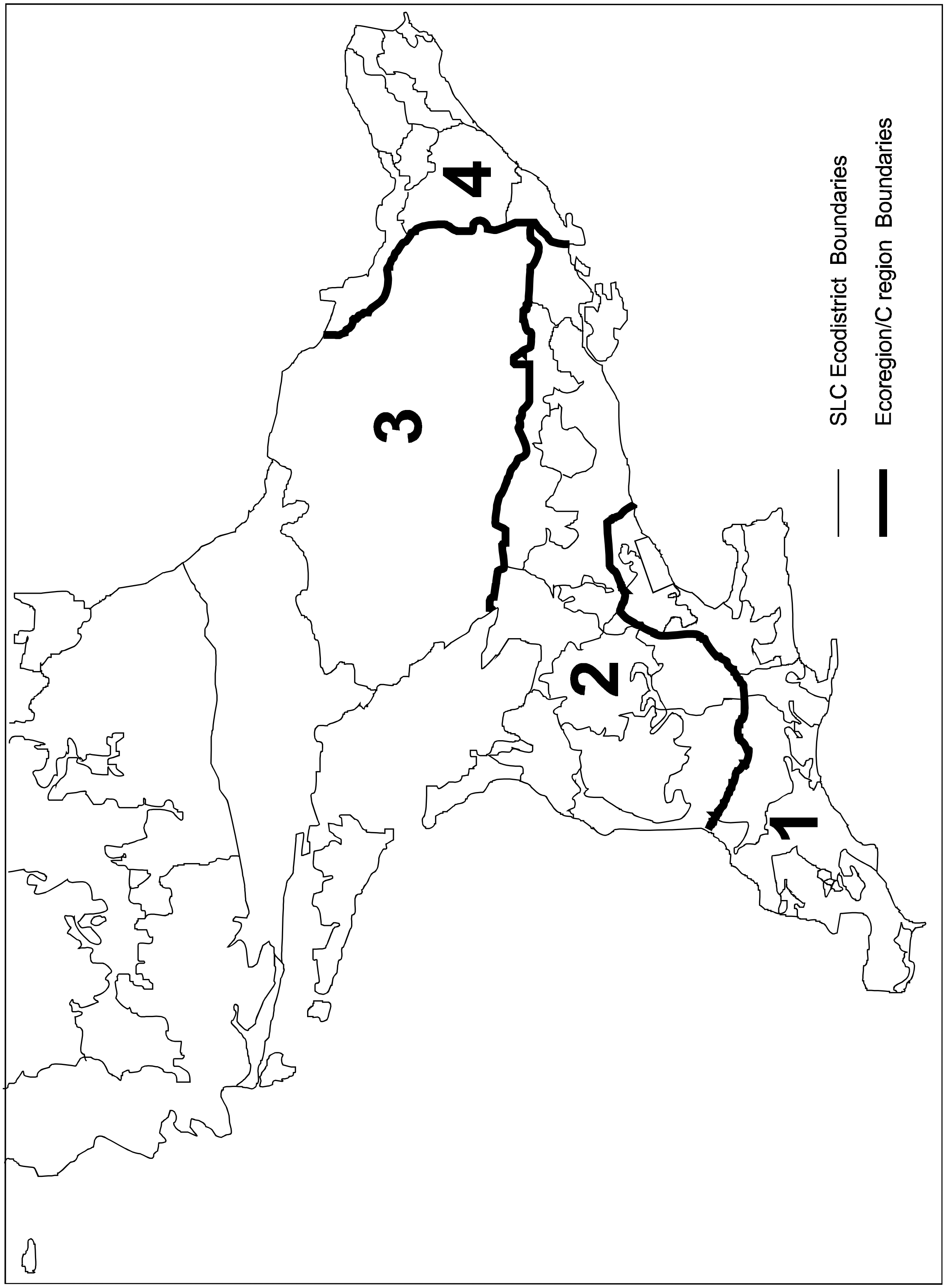

Figure C-2. C Factor Regions for Ontario

Table C-3. C Values for the Great Lakes/St. Lawrence Region - Part 1

Field Crop	Management Practices: Tillage	Cropping: underseeded	Cropping: post-crop residue	Previous Crop	C Values, Region 1	2	3	4	Quebec
Beans (white)	F MP	N	L	beans, canola				0.62	0.62
	F MP	N	L	corn, grain				0.54	0.54
Canola (spring)	F MP / S C (x2-3)	N	L	beans				0.43	0.43
	F MP / S C (x2-3)	N	L	corn, grain				0.39	0.39
	- followed by no-till	N	L	field crops			0.45		
	- followed by no-till	N	L	Field crops (2nd yr. after hay)			0.41		
	- followed by no-till	N	L	hay			0.23		
	- followed by F MP	N	L	field crops			0.53		
	- followed by F MP	N	L	Field crops (2nd yr. after hay)			0.49		
	- followed by F MP	N	L	hay			0.29		
Canola (winter)	F MP	N	L	field crops		0.24			
	F MP	N	L	Field crops (2nd yr. after hay)		0.20			
	F MP	N	L	hay		0.13			
Corn (grain)	F MP / S C (x2-3)	N	L	soybeans	0.48	0.46		0.43	0.43
	F MP / S C (x2-3)	N	L	soybeans (2nd yr. after hay)	0.46	0.43		0.41	0.41
	F MP / S C (x2-3)	N	L	field crops			0.43		
	F MP / S C (x2-3)	N	L	Field crops (2nd yr. after hay)			0.40		
	F MP / S C (x2-3)	N	L	corn,grain	0.41	0.38		0.37	0.37
	F MP / S C (x2-3)	N	L	corn, grain (2nd yr. after hay)	0.37	0.36		0.34	0.34
	F MP / S C (x2-3)	N	L	winter wheat	0.36	0.36			
	F MP / S C (x2-3)	N	L	hay	0.22	0.23	0.20	0.23	0.23
	F CH	N	L	soybeans		0.39			
	F CH	N	L	corn,grain		0.33			
	F CH	N	L	field crops	0.36				
	F CH	N	L	Field crops (2nd yr. after hay)		0.31			
	F CH	N	L	hay		0.18			
	S MP	N	L	soybeans	0.41	0.41			
	S MP	N	L	corn, grain	0.31	0.32			
	S MP	N	L	winter wheat	0.30				
	S MP	N	L	field crops	0.30				
	S MP	N	L	Field crops (2nd yr. after hay)		0.28			
	S MP	N	L	corn, grain(2nd yr, after hay)	0.28				
	S MP	N	L	winter wheat (2nd yr. after hay)	0.28				
	S MP	N	L	field crops	0.24				
	S MP	N	L	hay	0.15	0.14			
	S CH	N	L	soybeans	0.38	0.38			
	S CH	N	L	corn,grain	0.30	0.30			
	S D/C	N	L	soybeans	0.30				
	S D/C	N	L	field crops		0.28			
	S D/C	N	L	corn,grain	0.23				
	N T	N	L	soybeans	0.24	0.24			
	N T	N	L	corn, grain	0.14	0.16			
Corn (silage)	F MP / S C (x2-3)	N	R	corn,grain	0.55	0.53			
	F MP / S C (x2-3)	N	R	corn ,grain (2nd yr. after hay)	0.50	0.51			

Table C-3. C Values for the Great Lakes/St. Lawrence Region continued

Corn (silage) (cont'd)	F MP / S C (x2-3)	N	R	field crops			0.63	0.50	0.50

	F MP / S C (x2-3)	N	R	Field crops (2nd yr. after hay)			0.59	0.47	0.47
	F MP / S C (x2-3)	N	R	winter wheat	0.46	0.53			
	F MP / S C (x2-3)	N	R	hay	0.29	0.30	0.32	0.27	0.27
	S MP	N	R	field crops	0.43	0.44			
	S MP	N	R	Field crops (2nd yr. after hay)	0.41	0.41			
	S MP	Y (B)	R	field crops	0.36				
	S MP	Y (G&L)	R	field crops	0.28				
	S MP	N	R	hay	0.23	0.24			
	S D/C	N	R	soybeans	0.32	0.32			
	N T	N	R	soybeans	0.25	0.24			
Grain (mixed)	F MP/ S C (2x-3)	N	R	field crops	0.43	0.43		0.41	0.41
	F MP/ S C (2x-3)	N	R	Field crops (2nd yr. after hay)	0.41	0.41			
	F MP/ S C (2x-3)	Y	R	field crops			0.42	0.38	0.38
	F MP/ S C (2x-3)	Y	R	Field crops (2nd yr. after hay)			0.37		
	F MP/ S C (2x-3)	N	L	field crops	0.31	0.34		0.30	0.30
	F MP/ S C (2x-3)	N	L	Field crops (2nd yr. after hay)	0.27	0.33			
	F MP/ S C (2x-3)	Y (G&L)	L	grain	0.29	0.29	0.32	0.28	0.28
	F MP/ S C (2x-3)	Y (G&L)	L	grain (2nd yr. after hay)			0.28		
	F MP/ S C (2x-3)	N	R	hay	0.17		0.19		
	F CH	N	R	field crops				0.36	0.36
	F CH	Y	R	field crops				0.34	0.34
	F CH	N	L	field crops	0.29			0.25	0.25
	F CH	Y	L	field crops				0.23	0.23
	S MP	N	L	field crops	0.34	0.34			
	S MP	N	L	Field crops (2nd yr. after hay)	0.26	0.26			
	S MP	N	L	hay		0.16			
	S D/C	N	L	field crops	0.17	0.18			
	S D/C	N	L	Field crops (2nd yr. after hay)	0.15	0.15			
	S D/C	N	L	hay		0.10			
Hay(Establishing year)	F MP/ S C (2x-3)	N	L	field crops	0.23	0.27	0.31		
- September seeded	F MP/ S C (2x-3)	N	L	field crops				0.25	0.25
- October seeded	F MP/ S C (2x-3)	N	L	field crops				0.17	0.17
	F CH	N	L	field crops	0.15	0.20			
	S MP	N	L	field crops	0.08	0.13			
	S MP	Y	L	grain	0.04	0.04			
Hay (Established forage crop)	Alfalfa		L	hay	0.02	0.02	0.02	0.02	0.02
	Grass/legume mix		L	hay	0.01	0.01	0.01	0.01	0.01
	Red clover		L	hay	0.02	0.02	0.02	0.02	0.02
Peas	F MP	N	L	beans		0.55			
	F MP	N	L	corn, grain		0.49			
Soybeans	F MP	N	L	soybeans	0.56	0.47		0.54	0.54
	F MP	N	L	soybeans(2nd yr. after hay)		0.45			
	F MP	N	L	corn, grain	0.53	0.41	0.49	0.46	0.46
	F MP	N	L	corn, grain (2nd yr. after hay)		0.38	0.45		
	F MP	N	L	winter wheat	0.41				
	F MP	N	L	hay		0.21	0.25		
	F &/or S CH	N	L	soybeans	0.54	0.42		0.45	0.45
	F &/or S CH	Y	L	corn, grain	0.39	0.40		0.40	0.40
Table C-3. C Values for the Great Lakes/St. Lawrence Region continued									
	F & S C	N	L	field crops	0.38	0.32			
	F & S C	N	L	field crops	0.24				
	S MP	N	L	field crops		0.32			

	S MP	N	L	soybeans	0.35				
	S MP	N	L	corn, grain	0.35				
	S CH & D	N	L	field crops		0.33			
	S CH & D	Y	L	soybeans	0.31				
	S CH & D	Y	L	corn, grain	0.29				
	S CH & D	N	L	soybeans	0.22				
	S CH & D	N	L	corn, grain	0.19				
	N T	N	L	field crops	0.30				
	N T	N	L	soybeans		0.32			
	N T	N	L	soybeans (2nd yr. after hay)		0.30			
	N T	N	L	corn, grain		0.29			
	N T	N	L	corn, grain (2nd yr. after hay)		0.27			
	N T	N	L	hay		0.21			
Winter wheat	F MP	N	R	field crops		0.31		0.27	0.27
	F MP	Y	R	field crops		0.25			
	F MP	N	R	Field crops (2nd yr. after hay)		0.25			
	F MP	N	L	field crops	0.31	0.29			
	F MP	Y	L	field crops		0.19	0.25	0.22	0.22
	F MP	Y	L	Field crops (2nd yr. after hay)		0.15			
	F MP	N	L	Field crops (2nd yr. after hay)	0.28	0.22			
	F MP	N	L	hay	0.13	0.10			
	F CH	N	L	soybeans	0.24			0.22	0.22
	F CH	N	L	corn, grain	0.30				
	F CH	N	L	hay	0.14				
	F CH	N	L	corn, grain (2nd yr. after hay)	0.26				
	F CH	Y	L	field crops				0.17	0.17
HORTICULTURAL CROPS									
Asparagus	15 -20 yrs. continuous				0.55	0.55			
Beans	F MP			field crops	0.50				
- processing	S MP			field crops	0.40				
Cabbage or cauliflower	F MP			field crops	0.56	0.55			
	F MP; followed by winter cover crop			field crops	0.26				
	(Average annual C value for 2 yr. rotation)								
	S MP			field crops	0.49				
Carrots	F MP			field crops	0.48				
	F MP; followed by winter cover crop			field crops	0.27				
	(Average annual C value for 2 yr. rotation)								
Celery	F MP			field crops	0.57				
	S MP			field crops	0.50				
Corn (sweet)	F MP			field crops	0.53				
	F MP; followed by a winter cover crop			field crops	0.29				
	S MP			field crops	0.44				
	S MP			hay	0.23				
	S MP			field crops (2nd yr. after hay)	0.40				
	S CH			field crops	0.27				

Table C-3. C Values for the Great Lakes/St. Lawrence Region continued

Cucumber	S MP			field crops	0.22	0.20			
	S D			field crops	0.20				
Lettuce	S D			field crops	0.35				
Onions	F MP				0.50	0.50			

Onions (Spanish)	S MP; followed by winter cover crop		0.31	0.31
Peas	F MP		0.61	0.52
	S MP		0.53	
Peanuts	F & S D	peanuts	0.55	0.55
	S MP	grain	0.31	0.30
Peppers	F MP	field crops	0.51	0.50
	S MP	field crops	0.45	0.45
Potatoes	F MP or F C	field crops	0.45	0.45
	F MP; rotation with cover crop	field crops (2yr. average)	0.26	0.25
	S MP	field crops	0.43	
	S MP	hay	0.30	
Pumpkins	S MP	field crops	0.20	
Rutabagas	F MP or F C	field crops	0.50	0.50
	S C	field crops	0.16	
Tobacco	F MP			0.46
	S MP	field crops	0.49	0.31
	F MP; in rotation with winter wheat or rye (rotational average)		0.46	0.46
	S MP; rotational average with grain /wheat		0.31	
	S MP; (rotational average), D only before grain/wheat		0.27	
Tomatoes	F MP	field crops	0.51	0.50
	F MP; followed by winter cover crop	field crops	0.41	
	S MP	field crops	0.26	0.35
FRUITS				
Orchard	cultivated bare ground			0.40
	100% ground cover			0.00
Apples	First 3 yrs. - no ground cover		0.38	
	After 3 yrs. - Permanent sod, herbicide strip		0.03	
Cherries	Permanent sod, herbicide strip		0.03	
Grapes	No ground cover		0.36	
	Winter rye cover crop		0.31	
	Permanent sod		0.01	
Peaches	No ground cover		0.38	
	Winter rye cover crop		0.09	
Pears	Permanent sod, herbicide strip		0.03	
Plums	Permanent sod, no herbicide strip		0.00	

Table C-3. C Values for the Great Lakes/St. Lawrence Region continued

Raspberries	10-15 yrs. continuous, bare soil, 50-75% canopy cover		0.26	0.25

	10-15 yrs. continuous, 50-75% ground cover,50-75% canopy cover	0.11	0.10		
Strawberries	4-5 yrs. continuous, straw cover over winter	0.30	0.30		
Additional C- values *					
Grapes			0.05	0.05	0.05
Nursery				0.20	0.20
Pasture				0.02	
Potatoes				0.37	0.37
Root crops				0.37	0.37
Small fruits				0.10	0.10
Sod		0.02		0.02	0.02
Sugar beets		0.36	0.37	0.37	0.37
Vegetables		0.71			0.71
Woodland		0.01			

* from Fox *et al*., 1985

Table C-3. C Values for the Great Lakes/St. Lawrence Region - Part 2

TYPICAL ROTATIONS	Number of Crop Years in Rotation	Average C-Value
Region 1		
1. Corn (4yrs.) - spring grain or wheat		0.40
2. Corn - corn - soybeans- soy.-winter wheat-red clover		0.34
3. Corn-spring grain-winter wheat-red clover		0.23
4. Corn-corn-spring grain-(underseeded)-forage (3 yrs.)		0.13
Region 2		
1. Corn-corn-beans-winter wheat	4	
2. Corn-corn-grain-hay (3 yrs.)	6	
Region 3		
1. Barley (3 yrs.)-hay (4-6 yrs.)	7-9	
2. Corn (1-2 yrs.)-grain-hay (4 yrs.)	6-7	
3. Corn (1-2 yrs.) -soybeans - wheat and red clover	3-4	
4. Canola-barley (1-2 yrs.) -hay (4-5 yrs.)	6-8	
Region 4		
1. Corn-soybeans		0.45
2. Corn-winter wheat		0.32
3. Corn-canola or peas		0.41
4. Corn (3 yrs.)-grain-red clover (2 yrs.)		0.26
5. Corn (3 yrs.) -grain -alfalfa (4 yrs.)		

Table C-3a. Generalized C Values for Ontario

Crop	Region 1	Region 2	Region 3	Region 4

	Conv. Till	Cons. Till	No Till	Conv. Till	Cons. Till	No Till	Conv. Till	Cons. Till	No Till	Conv. Till	Cons. Till	No Till
Grain Corn	0.41	0.30	0.14	0.38	0.30	0.16	0.43	0.30	0.16	0.37	0.30	0.16
Silage Corn	0.55	0.32	0.25	0.53	0.32	0.24	0.47	0.32	0.24	0.50	0.32	0.24
Beans	0.56	0.32	0.31	0.47	0.33	0.32	0.49	0.33	0.32	0.46	0.33	0.32
Spring Grains	0.43	0.29	0.18	0.43	0.26	0.18	0.42	0.25	0.18	0.41	0.25	0.18
Fall Grains	0.34	0.17	0.12	0.34	0.18	0.12	0.31	0.16	0.12	0.25	0.13	0.12
Alfalfa/Hay	0.02	-*	-	0.02	-	-	0.02	-	-	0.02	-	-
Sod	0.02	-	-	0.02	-	-	0.02	-	-	0.02	-	-
Tobacco	0.47	0.31	0.27	0.46	0.31	-	-	-	-	-	-	-
Berries	0.28	0.11	-	0.28	0.10	-	-	-	-	-	-	-
Grapes	0.36	0.31	0.01	-	-	-	-	-	-	-	-	-
Fruit Trees	0.38	0.09	0.03	0.40	0.02	-	-	-	-	-	-	-
Nurseries	0.20	-	-	0.20	-	-	0.20	-	-	0.20	-	-
Potatoes	0.44	0.26	-	0.45	0.25	-		-	-	-	-	-
Fallow	0.50	0.34	-	0.50	0.34	-	0.50	0.34	-	0.50	0.34	-
Other Field Crops	0.46	0.28	0.20	0.43	0.28	0.20	0.42	0.27	0.20	0.40	0.27	0.20

*- not applicable

Table C-3b. Generalized C Values for Quebec

Crop	Conventional Till	Conservation Till	No Till
Spring Grain	0.41	0.36	0.15
Fall Grain	0.27	0.22	-*
Corn (grain)	0.37	0.32	0.15
Corn (silage)	0.51	0.44	0.21
Soybeans, buckwheat, dry peas, dry beans	0.46	0.40	0.28
Hay (alfalfa)	0.02	0.02	0.02
Hay (all other)	0.004	0.004	0.004
Potatoes	0.45	0.40	-
Tobacco	0.49	0.44	-
Vegetables	0.56	0.42	-
Tree fruits	0.04	0.04	0.04
Berries, grapes	0.36	0.10	-
Nursery products	0.20	0.20	0.20

* - not applicable

Table C-4. C Values for The Atlantic Region

Field Crop	Management Practices: Tillage	Cropping: under-seeded	Cropping: post-crop residue	Previous Crop	C Values: NB	Nfld.	Nova Scotia Region 1	Nova Scotia Region 2	PEI
Barley, oats	F MP / S C, D	N	R	field crops			0.44	0.45	0.52
	F MP / S C, D	N	R	field crops (2nd yr. after hay)			0.42	0.42	0.47
	F MP / S C, D	N	L	field crops			0.40	0.40	0.41
	F MP / S C, D	Y	L	field crops			0.38	0.37	0.39
	F MP / S C, D	N	L	field crops (2nd yr. after hay)			0.33	0.37	0.37
	F MP / S C, D	Y	L	field crops (2nd yr. after hay)			0.29	0.35	
	F MP / S C, D	N	R	hay			0.28	0.30	0.24
	F MP / S C, D	N	L	hay			0.22	0.29	0.21
	F CH / S C ,D	N	R	field crops			0.35		
	F CH / S C ,D	N	R	field crops (2nd yr. after hay)			0.28		
	F CH / S C ,D	N	L	field crops			0.25		0.33
	F CH / S C ,D	Y	L	field crops			0.24		0.31
	F CH / S C ,D	N	L	field crops (2nd yr. after hay)			0.23		0.29
	F CH / S C ,D	Y	L	field crops (2nd yr. after hay)			0.22		
	F CH / S C ,D	N	R	hay			0.15		
	F CH / S C ,D	N	L	hay			0.13		0.17
	F CH*			potatoes	0.20				
	F CH*	Y		potatoes	0.12				
	S MP / S C, D	N	R	field crops		0.44	0.42	0.29	
	S MP / S C, D	N	R	field crops (2nd yr. after hay)		0.40	0.38	0.27	
	S MP / S C, D	Y	R	field crops		0.32		0.24	
	S MP / S C, D	Y	R	field crops (2nd yr. after hay)		0.29		0.22	
	S MP / S C, D	N	L	field crops		0.27	0.33	0.22	0.24
	S MP / S C, D	N	R	hay		0.25		0.20	
	S MP / S C, D	N	L	field crops (2nd yr. after hay)		0.24	0.25	0.17	0.22
	S MP / S C, D	Y	L	field crops		0.19	0.30	0.15	0.22
	S MP / S C, D	Y	R	hay		0.18			0.19
	S MP / S C, D	Y	L	field crops (2nd yr. after hay)		0.17	0.21		
	S MP / S C, D	N	R	hay			0.12		0.13
	S MP / S C, D	N	L	hay		0.15	0.10		0.09
	S MP / S C, D	Y	L	hay		0.10			
	S CH / S C, D	N	R	field crops			0.25		
	S CH / S C, D	N	R	field crops (2nd yr. after hay)			0.22		
	S CH / S C, D	N	L	field crops			0.20		0.23
	S CH / S C, D	Y	L	field crops			0.18		0.19
	S CH / S C, D	N	L	field crops (2nd yr. after hay)			0.17		0.21
	S CH / S C, D	Y	L	field crops (2nd yr. after hay)			0.15		0.17
	S CH / S C, D	N	R	hay			0.11		0.13
	S CH / S C, D	N	L	hay			0.09		0.10
	S CH*	Y		potatoes	0.09				
beans	F PLOUGH*	N	L	row crops	0.40				
	F PLOUGH*	N	L	row crops, beans followed by winter cover	0.32				

Table C-4. C Values for The Atlantic Region, continued

	F PLOUGH*	N	L	small grain	0.28				
	F PLOUGH*	N	L	hay	0.26				
	S PLOUGH*	N	L	row crops	0.31				
	S PLOUGH*	N	L	row crops, beans followed by winter cover	0.28				
	S PLOUGH*	N	L	small grain	0.23				
	S PLOUGH*	N	L	hay	0.21				
corn (grain)	F MP / S C, D or CH	N	L	beans, peas	0.45		0.38	0.44	
	F MP / S C, D or CH	N	L	beans, peas (2nd yr. after hay)	0.42		0.36	0.42	
	F MP / S C, D or CH	N	L	field crops					0.39
	F MP / S C, D or CH	N	L	field crops (2nd yr. after hay)					0.35
	F MP / S C, D or CH	N	L	corn, grain			0.36	0.42	
	F MP / S C, D or CH	N	L	corn, grain (2nd yr. after hay)			0.34	0.40	
	F MP / S C, D or CH	N	L	hay	0.25		0.21	0.23	0.19
	F PLOUGH*	N	L	small grain	0.28				
	F PLOUGH*	N	L	row crops	0.24				
	F PLOUGH*	N	L	hay	0.18				
	F OD / S C	N	L	beans, peas				0.40	
	F OD / S C	N	L	beans, peas (2nd yr. after hay)				0.38	
	F OD / S C	N	L	field crops					0.38
	F OD / S C	N	L	field crops (2nd yr. after hay)					0.35
	F OD / S C	N	L	corn, grain	0.38			0.37	
	F OD / S C	N	L	corn, grain (2nd yr. after hay)	0.35			0.35	
	F OD / S C	N	L	hay					
	S MP / C, D	N	L	beans, peas			0.33	0.33	
	S MP / C, D	N	L	beans, peas (2nd yr. after hay)			0.30	0.31	
	S MP / C, D	N	L	field crops					0.32
	S MP / C, D	N	L	field crops (2nd yr. after hay)					0.29
	S MP / C, D	N	L	corn, grain	0.32		0.28	0.30	
	S MP / C, D	N	L	corn, grain (2nd yr. after hay)	0.29		0.26	0.28	
	S MP / C, D	N	L	hay	0.17		0.16	0.17	0.17
	S PLOUGH*			spring grain	0.21				
	S PLOUGH*			small grain, 10% cover left after planting	0.15				
	S PLOUGH*			small grain, 30% cover left after planting	0.08				
	S PLOUGH*			row crops	0.18				
	S PLOUGH*			row crops, 10% cover left after planting	0.10				
	S PLOUGH*			row crops, 30% cover left after planting	0.07				
	S PLOUGH*			manure applied	0.13				
	S PLOUGH*			hay	0.11				
	S OD / S C, D	N	L	beans, peas			0.31	0.34	
	S OD / S C, D	N	L	beans, peas (2nd yr. after hay)			0.28	0.32	
	S OD / S C, D	N	L	field crops					0.23
	S OD / S C, D	N	L	field crops (2nd yr. after hay)					0.20
	S OD / S C, D	N	L	corn, grain			0.28	0.30	
	S OD / S C, D	N	L	corn, grain (2nd yr. after hay)			0.26	0.28	
	S OD / S C, D	N	L	hay			0.14	0.17	0.11

Table C-4. C Values for The Atlantic Region, continued

corn (silage)	F PLOUGH*			row crops	0.34				

	F PLOUGH*			small grain	0.33		
	F PLOUGH*			hay	0.20		
	S PLOUGH*			silage corn, intercropped with ryegrass	0.19		
	S PLOUGH*			silage corn & ryegrass, intercropped with ryegrass	0.12		
	S PLOUGH*			silage+ryegrass, intercropped with ryegrass+manure	0.09		
	S PLOUGH*			small grain	0.30		
	S PLOUGH*			small grain, corn followed by winter cover	0.26		
	S PLOUGH*			small grain, 10% cover after planting	0.23		
	S PLOUGH*			small grain, 30% cover after planting	0.12		
	S PLOUGH*			small grain, intercropped with ryegrass	0.17		
	S PLOUGH*			row crops	0.30		
	S PLOUGH*			row crops, corn followed by winter cover	0.24		
	S PLOUGH*			row crops, 10% cover after planting	0.21		
	S PLOUGH*			same as above, corn followed by winter cover	0.17		
	S PLOUGH*			row crops, 30% cover after planting	0.17		
	S PLOUGH*			row crops, manure applied	0.24		
	S PLOUGH*			row crops, manure applied, winter cover	0.16		
	S PLOUGH*			hay, manure applied	0.18		
	NO-TILL*			third year or more after sod	0.18		
	NO-TILL*			second year after sod	0.15		
	NO-TILL*			planted into winter cover	0.11		
	NO-TILL*			planted into well established sod	0.05		
corn (sweet)	S PLOUGH*	N	L	stalks left standing after harvest	0.32		
	S PLOUGH*	N	L	late crop; residue mowed, left on surface	0.24		
	S PLOUGH*	N	L	early crop; residue mowed, left on surface	0.20		
	S PLOUGH*		L	early crop with winter cover	0.18		
	S PLOUGH*		L	late crop with winter cover	0.13		
	S PLOUGH*		L	early or late crop after sod	0.11		
	S PLOUGH*		L	early crop after sod with winter cover	0.14		
	S PLOUGH*		L	late crop after sod with winter cover	0.10		
Hay (Establishing year)	F MP / S D, H	N	L	field crops			0.25
	F MP / S D, H	N	L	field crops (2nd yr. after hay)			0.21
	F CH	N	L	field crops			0.16
	F CH	N	L	field crops (2nd yr. after hay)			0.14
- early planting	S MP / S D, C	N	L	field crops		0.15	0.09
	S MP / S D, C	N	L	field crops (2nd yr. after hay)		0.10	0.06
Table C-4. C Values for The Atlantic Region, continued							
- late planting	S MP / S D, C	N	L	field crops		0.20	
	S MP / S D, C	N	L	field crops (2nd yr. after hay)		0.14	

	S CH	N	L	field crops					0.06
	S CH	N	L	field crops (2nd yr. after hay)					0.05
- alfalfa, red clover	F MP / S D, H	N	L	field, vegetable crops			0.20	0.20	
	S MP / S D, H	N	L	field, vegetable crops			0.17	0.14	
- grass, legume	F MP / S D, H	N	L	field, vegetable crops			0.19	0.19	
	S MP / S D, H	N	L	field, vegetable crops			0.16	0.13	
Hay (Established crop)	Alfalfa					0.02	0.02	0.02	0.02
	Grass / legume mix					0.00	0.01	0.01	0.01
	Red clover					0.02	0.02	0.02	0.02
Peas, soybeans	F MP / S C, D	N	L	legume, non-legume vegetables			0.51	0.44	
	F MP / S C, D	N	L	vegetables (2nd yr. after hay)			0.48	0.48	
	F MP / S C, D	N	L	corn, grain			0.42	0.42	0.46
	F MP / S C, D	N	L	corn, grain (2nd yr. after hay)			0.40	0.39	0.41
	F MP / S C, D	N	L	hay			0.24	0.22	0.22
	F CH or OF / S C, D	N	L	field crops			0.40	0.40	0.21
	F CH or OF / S C, D	N	L	field crops (2nd yr. after hay)			0.33	0.33	0.19
	F CH or OF / S C, D	N	L	hay			0.22	0.23	0.10
	S MP / S D, C	N	L	legume, non-legume vegetables			0.49	0.43	
	S MP / S D, C	N	L	vegetables (2nd yr. after hay)			0.41	0.41	
	S MP / S D, C	N	L	corn, grain			0.46	0.38	0.30
	S MP / S D, C	N	L	corn, grain (2nd yr. after hay)			0.38	0.36	0.26
	S MP / S D, C	N	L	hay			0.21	0.22	0.14
	S CH / S C, D	N	L	corn, grain					0.19
	S CH / S C, D	N	L	corn, grain (2nd yr. after hay)					0.17
	S CH / S C, D	N	L	hay					0.10
	S OD / S D, C	N	L	field crops			0.38	0.37	
	S OD / S D, C	N	L	field crops (2nd yr. after hay)			0.31	0.30	
	S OD / S D, C	N	L	hay			0.20	0.20	
Potatoes	F MP / S C, D*	N	R	row crops	0.43				
	F MP / S C, D	N	R	field crops			0.42	0.42	0.41
	F MP / S C, D	N	R	field crops (2nd yr. after hay)			0.41	0.40	0.39
	F MP / S C, D*	N	R	small grain	0.29				
	F MP / S C, D	N	R	hay			0.27	0.24	0.23
(contoured rows,ridged)	F MP / S C, D	N	R	field crops					0.40
(contoured rows,ridged)	F MP / S C, D	N	R	field crops (2nd yr. after hay)					0.37
(contoured rows,ridged)	F MP / S C, D*	N	R	hay	0.22				0.23
(contoured rows,ridged)	F MP / S C, D*	Y	R	hay, potatoe crop followed by winter cover	0.20				
	F CH*			potatoes, peas	0.48				
	F CH*			grain, residue removed	0.35				
	F CH*	Y		grain (underseeded), residue removed	0.31				
	F CH*			hay, grain	0.28				
	F CH*	Y		grain (underseeded)	0.25				
Potatoes	S MP / S C,D	N	R	barley, beans, peas		0.45	0.40		0.34

Table C-4. C Values for The Atlantic Region, continued

	S MP / S C,D	N	R	barley, beans, peas, followed by winter cover			0.35		0.31
	S MP / S C,D*	N	R	row crops	0.44				
	S MP / S C,D	N	R	field crops (2nd yr. after hay)		0.43	0.38		0.19

	S MP / S C,D*	N	R	small grain	0.36				
	S MP / S C,D*	Y	R	small grain, underseeded with 10% cover	0.36				
	S MP / S C,D*	Y	R	row crops, underseeded with 10% cover	0.36				
	S MP / S C,D*	Y	R	row crops, followed by winter cover	0.31				
	S MP / S C,D*	Y	R	small grain, followed by winter cover	0.29				
	S MP / S C,D*	Y	R	small grain, underseeded with 30% cover	0.20				
	S MP / S C,D*	Y	R	hay, potatoe crop followed by winter cover	0.17				
	S MP / S C,D*	N	R	hay	0.16	0.27	0.25		
	S CH*			potatoes, peas	0.41				
	S CH*		R	grain (residue removed)	0.31				
	S CH*	Y		grain (underseeded)	0.27				
	S CH*			hay	0.25				
Rye, winter wheat	F MP or CH / S D, C	N	L	field crops			0.31	0.34	0.26
	F MP or CH / S D, C	N	L	field crops (2nd yr. after hay)			0.27	0.26	0.20
	F MP or CH / S D, C	N	L	hay			0.17	0.10	0.13
HORTICULTURAL CROPS									
Root crops									
Carrots	S MP / H,D,C	N	R	field crops		0.50			
	S MP / H,D,C	N	R	field crops (2nd yr. after hay)		0.45			
	S MP / H,D,C	N	R	hay		0.30			
Rutabagas	S MP / H,D,C	N	R	field crops		0.43			
	S MP / H,D,C	N	R	field crops (2nd yr. after hay)		0.41			
	S MP / H,D,C	N	R	hay		0.25			
(general - Nova Scotia)	F MP / S D, C	N	R	field crops			0.52	0.49	
	F MP / S D, C	N	R	field crops (2nd yr. after hay)			0.51	0.46	
	F MP / S D, C	N	R	hay			0.31	0.27	
	S MP / S D, C	N	R	corn, grain			0.52	0.45	
	S MP / S D, C	N	R	corn, grain (2nd yr. after hay)			0.44	0.40	
	S MP / S D, C	N	R	hay			0.26	0.26	
(general - P.E.I.) -early crop	F MP or CH / S C, D	N	R	field crops					0.48
	F MP or CH / S C, D	N	R	field crops (2nd yr. after hay)					0.45
	F MP or CH / S C, D	N	R	hay					0.26
(general - P.E.I) - late crop	F MP or CH / S C, D	N	R	field crops					0.54
	F MP or CH / S C, D	N	R	field crops (2nd yr. after hay)					0.47
	F MP or CH / S C, D	N	R	hay					0.28
(general - P.E.I) -early crop	S MP / S D, C	N	R	field crops					0.48
	S MP / S D, C	N	R	field crops (2nd yr. after hay)					0.43
	S MP / S D, C	N	R	hay					0.26
(general - P.E.I) - late crop	S MP / S D, C	N	R	field crops					0.49
	S MP / S D, C	N	R	field crops (2nd yr. after hay)					0.45
Table C-4. C Values for The Atlantic Region, continued									
	S MP / S D, C	N	R	hay					0.24
small grains	S TILLAGE*	N	R	low residue crop (silage corn, potatoes)	0.18				
	S TILLAGE*	N	L	low residue crop (silage corn, potatoes)	0.15				

	S TILLAGE*	N	R	high residue crop (grain corn, hay)	0.13			
	S TILLAGE*	Y	L	low residue crop (silage corn, potatoes)	0.10			
	S TILLAGE*	N	L	high residue crop (grain corn, hay)	0.09			
	S TILLAGE*	Y	L	low residue crop (silage corn, potatoes)	0.04			
VEGETABLE CROPS								
Broccoli	F TILLAGE*			tillage after harvest, 50% ground cover	0.34			
	S TILLAGE*				0.29			
Cabbage, cauliflower	S MP /H,D,C	N	R	vegetables	0.22			
(early harvest)	S MP /H,D,C	N	R	vegetables (2nd yr. after hay)	0.35			
	S MP /H,D,C	N	R	grain	0.28			
	S MP /H,D,C	N	R	grain (2nd yr. after hay)	0.25			
	S MP /H,D,C	N	R	hay	0.24			
Cabbage, cauliflower	S MP /H,D,C	N	R	vegetables	0.23			
(late harvest)	S MP /H,D,C	N	R	vegetables (2nd yr. after hay)	0.22			
	S MP /H,D,C	N	R	grain	0.15			
	S MP /H,D,C	N	R	grain (2nd yr. after hay)	0.13			
	S MP /H,D,C	N	R	hay				
Lettuce	S MP /H,D,C	N	L	vegetables				
	S MP /H,D,C	N	L	vegetables (2nd yr. after hay)				
	S MP /H,D,C	N	L	grain				
	S MP /H,D,C	N	L	grain (2nd yr. after hay)				
	S MP /H,D,C	N	L	hay				
Mixed vegetables	S TILLAGE*				0.50			
	S TILLAGE*			with winter cover	0.42			
Vegetable crops (general)(Nova Scotia)	F MP / S C, D	N	L	vegetables		0.65	0.73	
	F MP / S C, D	N	L	vegetables (2nd yr. after hay)		0.63	0.68	
	F MP / S C, D	N	L	grain		0.59	0.57	
	F MP / S C, D	N	L	grain (2nd yr. after hay)		0.56	0.49	
	F MP / S C, D	N	L	hay		0.40	0.34	
	S MP / S C, D	N	L	vegetables		0.55	0.59	
	S MP / S C, D	N	L	vegetables (2nd yr. after hay)		0.45	0.52	
	S MP / S C, D	N	L	grain		0.51	0.45	
	S MP / S C, D	N	L	grain (2nd yr. after hay)		0.43	0.33	
	S MP / S C, D	N	L	hay		0.29	0.26	
	CH / S C, D	N	L	field crops		0.42	0.44	
	CH / S C, D	N	L	field crops (2nd yr. after hay)		0.36	0.39	
Table C-4. C Values for The Atlantic Region, continued								
	CH / S C, D	N	L	hay		0.21	0.24	
Vegetable crops								
PEI (general crops)								
- early crop	F MP / S D, C	N	L	field crops				0.65
	F MP / S D, C	N	L	field crops (2nd yr. after hay)				0.61
	F MP / S D, C	N	L	hay				0.36

- late crop	F MP / S D, C	N	L	field crops				0.66
	F MP / S D, C	N	L	field crops (2nd yr. after hay)				0.61
	F MP / S D, C	N	L	hay				0.33
- early crop	S MP / S D, C	N	L	field crops				0.55
	S MP / S D, C	N	L	field crops (2nd yr. after hay)				0.49
	S MP / S D, C	N	L	hay				0.28
- late crop	S MP / S D, C	N	L	field crops				0.63
	S MP / S D, C	N	L	field crops (2nd yr. after hay)				0.54
	S MP / S D, C	N	L	hay				0.32
- early crop	CH / S C, D	N	L	field crops				0.53
	CH / S C, D	N	L	field crops (2nd yr. after hay)				0.29
	CH / S C, D	N	L	hay				0.49
- late crop	CH / S C, D	N	L	field crops				0.40
	CH / S C, D	N	L	field crops (2nd yr. after hay)				0.35
	CH / S C, D	N	L	hay				0.21
Tobacco	F MP / S C, D	N	L	grain, winter cover crop		0.59	0.65	0.47
	F MP / S C, D	N	L	field crops (2nd yr. after hay)		0.57	0.60	0.40
	F MP / S C, D	N	L	hay		0.37	0.35	0.30
	S MP / S C, D	N	L	grain, winter cover crop		0.57	0.60	0.40
	S MP / S C, D	N	L	field crops (2nd yr. after hay)		0.52	0.55	0.35
	S MP / S C, D	N	L	field crops; followed by winter wheat		0.43	0.45	
	S MP / S C, D	N	L	hay		0.31	0.30	0.25
FRUITS								
Blueberries	continuous	N	L	blueberries		0.15		0.15
Raspberries	continuous	N	L	raspberries		0.25		
Strawberries	S MP / H or D	N	L	vegetable crops	0.50			
(establishing year)	S MP / H or D	N	L	grain	0.45			
	S MP / H or D	N	L	grain crops (2nd yr. after hay)	0.40			
	S MP / H or D	N	L	hay	0.30			
(established crop)								
- cultivated between rows		N	L	strawberries	0.30	0.30		
- straw mulch between rows		N	L	strawberries	0.10			
ADDITIONAL C values								
Beans/peas					0.51			
Corn(grain)					0.28			
Corn (silage)					0.39		0.48	0.43
Fall cereal					0.22			
Fruit trees					0.05		0.05	0.05
Grapes							0.05	0.05
Table C-4. C Values for The Atlantic Region, continued								
Nursery					0.20		0.20	0.20
Pasture					0.02		0.02	0.02
Sod					0.02		0.02	
Spring cereal					0.28			
Sugar beets					0.36		0.37	0.36
Woodland							0.01	

* from Daigle; Jones, 1995

Table C-4a. Generalized C Values for New Brunswick

Crop	Potato Belt		Non-Potato Belt	
	Conventional Till	Conservation Till	Conventional Till	Conservation Till
Corn for Silage	0.37	0.37	-*	-
Tame Hay	0.02	0.02	-	-
Other Fodder Crops	0.06	0.06	-	-
Potatoes	0.36	0.28	0.28	-
Soybeans	0.40	-	-	
Total Berries and Grapes	0.14	0.14	-	-
Total Fruit Trees	0.05	0.05	-	-
Total Vegetables	0.50	0.35	-	-
Spring Grain	0.18	0.06	-	-
Fall Grains	0.15	0.05	-	-

* - not applicable

Table C-4b. Generalized C Values for Nova Scotia

Crop	Conventional Till	Conservation Till
Corn for Grain	0.28 - 0.30	-*
Corn for Silage	0.37 - 0.41	-
Tame Hay	0.02	-
Other Fodder Crops	0.08	-
Potatoes	0.45	0.35
Total Berries and Grapes	0.14	-
Total Fruit Trees	0.05	-
Total Vegetables	0.50	0.40
Spring Grain	0.08	-
Fall Grain	0.06	-

* - not applicable

Table C-4c. Generalized C Values for Prince Edward Island

Crop	Conventional Till	Conservation Till
Corn for Silage	0.40	-*
Tame Hay	0.02	-
Other Fodder Crops	0.06	-
Soybeans	0.35	-
Potatoes	0.34	0.26
Tobacco	0.47	-
Total Berries and Grapes	0.14	-
Total Vegetables	0.45	-
Spring Grain:		
- after potatoes	0.14	-
- after hay	0.08	-
Fall Grain	0.12	-

* - not applicable

Table C-5. C Values For Permanent Pasture, Range, and Idle Land

Vegetative Canopy Type and Height	Percent cover	Type	Cover that contacts the soil surface Percent ground cover					
			0	20	40	60	80	95+
No appreciable canopy		G	0.45	0.20	0.10	0.04	0.01	0.00
		W	0.45	0.24	0.15	0.09	0.04	0.01
Tall weeds or short brush with average drop fall height of 20 inches	25	G	0.36	0.17	0.09	0.04	0.01	0.00
		W	0.36	0.20	0.13	0.08	0.04	0.01
	50	G	0.26	0.13	0.07	0.35	0.01	0.00
		W	0.26	0.16	0.11	0.08	0.04	0.01
	75	G	0.17	0.10	0.06	0.03	0.01	0.00
		W	0.17	0.12	0.09	0.07	0.04	0.01
Appreciable brush or bushes, with average drop fall height of 6 1/2 feet	25	G	0.40	0.18	0.09	0.04	0.01	0.00
		W	0.40	0.22	0.14	0.09	0.04	0.01
	50	G	0.34	0.16	0.08	0.04	0.01	0.00
		W	0.34	0.19	0.13	0.08	0.04	0.01
	75	G	0.28	0.14	0.08	0.04	0.01	0.00
		W	0.28	0.17	0.13	0.08	0.04	0.01
Trees, but no appreciable low brush. Average drop fall of 13 feet	25	G	0.42	0.19	0.10	0.04	0.01	0.00
		W	0.42	0.23	0.14	0.09	0.04	0.01
	50	G	0.39	0.18	0.09	0.04	0.01	0.00
		W	0.39	0.21	0.14	0.09	0.04	0.01
	75	G	0.36	0.17	0.09	0.04	0.01	0.00
		W	0.36	0.20	0.13	0.08	0.04	0.01

Vegetation and mulch randomly distributed over area; G - grasses, W - broadleaf weeds; Canopy height - average drop fall height of water falling from canopy to ground (negligible if height greater than 33 feet)

Table C-6. C Values For Undisturbed Forest Land

Percent of area covered by canopy of trees and undergrowth	Percent of area covered by duff at least 2 inches deep	C factor
100-75	100-90	0.0001-0.001
70-45	85-75	0.002-0.004
40-20	70-40	0.003-0.009

Table C-7. C Values For Mechanically Prepared Woodland Sites

Site Preparation	Mulch Cover (%)	Soil Condition and weed cover							
		Excellent		Good		Fair		Poor	
		NC	WC	NC	WC	NC	WC	NC	WC
Disked, raked, bedded	0	0.52	0.20	0.72	0.27	0.85	0.32	0.94	0.36
	10	0.33	0.15	0.46	0.20	0.54	0.24	0.60	0.26
	20	0.24	0.12	0.34	0.17	0.40	0.20	0.44	0.22
	40	0.17	0.11	0.23	0.14	0.27	0.17	0.30	0.19
	60	0.11	0.08	0.15	0.11	0.18	0.14	0.20	0.15
	80	0.05	0.04	0.07	0.06	0.09	0.08	0.10	0.09
burned	0	0.25	0.10	0.26	0.10	0.31	0.12	0.45	0.17
	10	0.23	0.10	0.24	0.10	0.26	0.11	0.36	0.16
	20	0.19	0.10	0.19	0.10	0.21	0.11	0.27	0.14
	40	0.14	0.09	0.14	0.09	0.15	0.09	0.17	0.11
	60	0.08	0.06	0.09	0.07	0.10	0.08	0.11	0.08
	80	0.04	0.04	0.05	0.04	0.05	0.04	0.06	0.05
drum chopped	0	0.16	0.07	0.17	0.07	0.20	0.08	0.29	0.11
	10	0.15	0.07	0.16	0.07	0.17	0.08	0.23	0.10
	20	0.12	0.06	0.12	0.06	0.14	0.07	0.18	0.09
	40	0.09	0.06	0.09	0.06	0.10	0.06	0.11	0.07
	60	0.06	0.05	0.06	0.05	0.07	0.05	0.07	0.05
	80	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04

NC - no live vegetation; WC - 75% cover of grass, weeds with average drop fall height of 20 inches

Table C-8. Mulch Values and Length Limits for Construction Slopes

Type of mulch	Mulch rate tons/acre	Land slope percent	C Factor	Length limit (feet)
None	0	all	1	-
Straw or hay, tied down by anchoring and tacking equipment	1	1.5	0.20	200
	1	6-10	0.20	100
	1.5	1.5	0.12	300
	1.5	6-10	0.12	150
	2	1.5	0.06	400
	2	6-10	0.06	200
	2	11-15	0.07	150
	2	16-20	0.11	100
	2	21-25	0.14	75
	2	26-33	0.17	50
	2	34-50	0.20	35
Crushed stone, 1/4 to 1 1/2 inch	135	<16	0.05	200
	135	16-20	0.05	150
	135	21-33	0.05	100
	135	34-50	0.05	75
	240	<21	0.02	300
	240	21-33	0.02	200
	240	34-50	0.02	150
Wood chips	7	<16	0.08	75
	7	16-20	0.08	50
	12	<16	0.05	150
	12	16-20	0.05	100
	12	21-33	0.05	75
	25	<16	0.02	200
	25	16-20	0.02	150
	25	21-33	0.02	100
	25	34-50	0.02	75

(Tables C-5, C-6, C-7, C-8 from Wischmeier and Smith, 1978)

P VALUES

Table P-1. P values and topographic limits for contouring

Land Slope (%)	P value	Maximum slope length[1] (m)
1-2	0.60	120
3-5	0.50	90
6-8	0.50	60
9-12	0.60	40
13-16	0.70	25
17-20	0.80	18
21-25	0.90	15
Cross slope farming	0.75	

[1]Limit may be increased by 25% if residue cover after crop seeding will exceed 50%.

Table P-2. P values and topographic limits for contour strip cropping

Land slope	P values[1]			Strip width[2]	Maximum length
(%)	A	B	C	(m)	(m)
1 to 2	0.30	0.45	0.60	40	250
3 to 5	0.25	0.38	0.50	30	185
6 to 8	0.25	0.38	0.50	30	120
9 to 12	0.30	0.45	0.60	25	75
13 to 16	0.35	0.52	0.70	25	50
17 to 20	0.40	0.60	0.80	20	35
21 to 25	0.45	0.68	0.90	15	30

[1]P values:

A For 4-year rotation of row crop, small grain with grass seeding, and 2 years of grass. A second row crop can replace the small grain if grass is established in it.

B For 4-year rotation of 2 years row crop, winter grain with grass seeding, and 1-year grass.

C For alternative strips of row crop and small grain.

[2]Adjust strip-width limit, generally downward, to accommodate widths of farm equipment.

Table P-3. P values for terracing[1]

Horizontal terrace interval (m)	Closed outlets[2]	Terrace P factor values Open outlets, with percent grade of:[3]			
		0.1-0.3	0.4-0.7	0.7-0.8	>0.8
<33	0.5	0.6	0.7	0.8	1
33-42	0.6	0.7	0.8	0.9	1
43-54	0.7	0.8	0.8	0.9	1
55-68	0.8	0.8	0.9	0.9	1
69-90	0.9	0.9	0.9	1	1
>90	1	1	1	1	1

1 Multiply these values by other P values for contouring, stripcropping, or other supporting practices on the interterrace area to obtain composite P factor value.
2 Values for closed outlet terraces also apply to terraces with underground outlets and to level terraces with open outlets.
3 The channel grade is measured on the 90 m of terrace or the one-third of total length closest to the outlet, whichever distance is less.

Table P-4. Support practice (P) for erosion control from erosion plot investigations in Canada

Location	Slope		Soil (surface texture)	Number of Cropping Years	Support Practice	Reduction in Calculated Soil Loss (%)	P factor value	Source
	Steepness	Length						
New Brunswick (Drummond)	11	30	Gravelly Loam	3	Potatoes	95	0.05	Chow et al., 1990
Ontario (Ottawa)	10	-	Clay	12	Corn in Rotation - CONTOURING	26	0.74	Ripley et al., 1961
					Corn, continuous - CONTOURING	82	0.18	
					Oats in Rotaion - CONTOURING	14	0.86	
					Alfalfa in rotation - CONTOURING	83	0.17	
					Corn in rotation - STRIP CROPPING ON CONTOURING	87	0.13	
					Oats in rotation - STRIP CROPPING ON CONTOURING	97	0.03	
British Columbia (Fraser Valley)	9	13 7	Silt Loam	2	Strawberries-Interceptor drains	99	0.01	Wood et al., 1995
					(subsurface), 14m apart, 75 cm deep,			
					backfilled with pea gravel to surface			
British Columbia (Peace River Region)	11	22	Clay Loam and Silty Clay Loam	5	Barley - CROSS SLOPE	79	0.21	van Vliet 1990

PACIFIC REGION — Case Study (Okanagan Valley, British Columbia)

A farm located in the Okanagan Valley, British Columbia has the following attributes (Figure CS-1):

- ! land use - orchard (established)
- ! site - one field, long simple slope

Information on the orchard field is presented in Table CS-1a.

Table CS-1a. Description of a British Columbia orchard landscape

Field attributes	Conditions
soil	- soil - sandy loam texure (particle size distribution unknown) - organic matter > 4 % - well drained soil
topography	- 3 %, 300 m simple slope
crop or land use	- established orchard (apple), 60% canopy cover, grass ground cover except for 3 foot strip with trees in the middle (grass covers approximately 80% of ground) - 15 ft. spacing between rows

Calculating Potential Soil Losses

1. R factor -
   The farm is located to the east of Kelowna
   R = 425

2. K factor -
   No detailed particle size data was available for this site, but surface textures were determined by hand-assessment (Figure K-4)
   Organic matter levels - assumed to be > 2%
   K = 0.016 (Table K-3)

3. LS factor -
   LS = 0.57 (Table LS-1)

4. C factor -
   C = 0.012 (Table C-1)

5. P factor - none
   P = 1.0

6. A values (soil loss)
   Results of USLE calculations are summarized in Table CS-1b.

Table CS-1b. Soil loss rate for a Kelowna, British Columbia orchard

Factor	Value	Source	Comments
R	425	(Figure R-3, Part 2)	
K	0.016	Table K-3, Figure K-4	hand-texture assessment used
LS	0.570	Table LS-1	major process - interrill
C	0.012	Table C-1	
P	1.000	Table P-1	
A (tonnes/hectare/year)	0.050		**Erosion Class 1 (Tolerable rate)**

This land use and landscape combination produces an erosion rate of less than 1 tonne/hectare/year (tons/acre/year) which is well below the suggested tolerance rate of 6 tonnes/hectare/year (3 tons/ acre/year).

Non-agricultural land use

If the same piece of land was used for development purposes and the land was left barren for a long period, the estimated soil loss rate would be higher than with agricultural use:

R and K remain the same,
LS = 1.22 (Table LS-3 for disturbed soil),
C = 1.0 (Table C-8 for construction sites)

A= 8.3 tonnes/hectare/year
= Erosion class 2

Although still a low erosion rate, a significant change in land use can alter the erosion rate classification of even the most erosion-tolerant sites.

PRAIRIE REGION — Case Study (Melfort area, Saskatchewan)

A farm located near Melfort, Saskatchewan has the following attributes:

- land use - cash crops (primarily wheat)
- site - several large fields, with a range of slopes within (one 100-acre field will be considered in this example)
- concerns - extreme changes to present system not possible, due to machinery and market limitations

Information on 1-100 acre field is presented in Table CS-2a. The field has numerous slope length and steepness combinations. Rather than estimate rates for each slope (too time-consuming) or average all slope information to produce one rate (unrepresentative of the topography) the field area has been divided into three categories based on distinct topographical features.

Table CS-2a. Description of a Saskatchewan farm field landscape

Field category	Conditions
1 50% of field area	Rolling topography (representative slope is 5%, 200 m) - rotation on entire field consists of wheat (spring disked and seeded) and summer fallow - soil - loam texure (35% silt and very fine sand, 45% sand, 20% clay, 2% organic matter, granular structure, moderate permeability) - dominant erosion process mainly inter-rill, some rill)
2 30% of field area	Inclined topography (2%, 250 m) - soil - same as above - inter-rill erosion dominant
3 20% of field area	Hummocky topography (8%, 100m) - soil - clay loam (32% silt and very fine sand, 40% sand, 28% clay, 1% organic matter, unknown structure and permeability) - moderate rill:inter-rill ratio - cross slope cultivated

Calculating potential soil losses

USLE calculations are summarized in Table CS-2b.

Table CS-2b. Soil loss rate for a wheat field, Melfort area (Saskatchewan)

Area of Field	R	K	LS	C	P	A (tonnes/ha/yr)	Potential Erosion Class
1	663	0.024	1.38	0.47	0.75	7.74	2
2	663	0.024	0.45	0.47	0.75	2.52	1
3	663	0.036	1.83	0.47	0.75	15.4	3
Source: Table			LS-2	C-2	P-1		Section 1.3.3
Figure	R-2a & b	K-1,2,3					
Comments: R - metric units (663) converted to US customary units by dividing by 17.02 K - estimate structure and permeability from Figures K-2 and K-3, respectively C - rotational C = (wheat .44 + fallow .5)/2 P - cross-slope farming (.75)							

Evaluating the Effectiveness of Alternative Practices Using the U.S.L.E.

The tolerable rate of erosion has been suggested as 3 tons/acre/year (6 tonnes/hectare/year). To determine the crop and management practices that could be used to help keep annual erosion to this recommended tolerance level (T), substitute 'T' for 'A' and rearrange the equation to read:

$$C = \frac{T}{RKLSP}$$

Area 1 - erosion potential of 7.74 tonnes/hectare/year (3.5 tons/acre/year),
Area 2 - 2.52 tonnes/hectare/year (1.14 tons/acre/year)
Area 3 - 15.40 tonnes/hectare/year (7 tons/acre/year)

Area 3 has an erosion rate which is greater than the tolerable amount.

When R, K, LS and P values are retained but 'A' value is changed to T = 6 tonnes/hectare/year, the equation would be as follows:

$$C = \frac{6}{RKLSP}$$

$$= \frac{6}{16.47\ (area\ 1)\ or\ 32.76\ (area\ 3)}$$

$$= 0.36\ or\ 0.18$$

This means that any practices with a C value of 0.36 or less (area 1) or 0.18 or less (area 3) would yield soil losses of less than 6 tonnes/hectare/year.

Alternative rotations:
Grain - red clover - fallow = C value of 0.32
Grain - Red clover - canola = C value of 0.16

GREAT LAKES/ST.LAWRENCE REGION — Case Study (Simcoe, Ontario)

A farm located near Simcoe, Ontario has the following attributes (Figure CS-1):

- ! major enterprise - cash crops, livestock
- ! land base - two major fields (Table CS-3a)
- ! concerns - long-term loss of productivity,
  - options to maintain tolerable soil loss without altering farming practices
  - stream water quality

Information on the two fields is presented in Table CS-3a. Note that any distinct sections within each of the fields are described separately.

Table CS-3a. Description of an Ontario farm landscape

Field	Conditions

A	4 distinct slope and soil sections
	- Sections 1, 3 and 4: simple slopes, runoff flows into adjacent streams
	  - permanent grass cover (sections 1,4)
	  - hay mix of grasses and legumes (section 2)
	- Section 2: short, complex slopes - complex topography (slopes, hummocks, small depressions, depositional areas)
	  - sediments are deposited within the section (therefore no attempt made to evaluate or quantify the slope effects between this section and surrounding area
	  - hay mix of grasses and legumes
	- Soils - high level of organic material (greater than 2%).

B	- long slope (ending at stream bank), 250 m, overall gradient of 4%
	- field divided into five segments for purpose of calculating soil loss, because slope has several gradient, soil texture changes
	- 3 year rotation consisting of two years of grain corn followed by one year of mixed grains
	- practices used: spring ploughed, cultivated in a cross-slope direction.
	- segments: boundaries defined on the basis of differing slope gradients, surface soil textures,
	  - assumed to be approximately equal length
	  - numbered from 1 to 5, (starting at top of slope, proceeding downwards)
	  - segment 2: layer of soil slightly higher in clay, lower in organic material than the surrounding slopes has been exposed (i.e. eroded)

The steps used in calculating potential soil losses on each of the fields are outlined as follows:

Calculating Potential Soil Losses

1. R factor -

A climatic station is located at Simcoe, Ont.

R = 1670 (Figure R-1, Part 2)

2. K factor -

No detailed particle size data was available for this site, but surface textures were determined by hand-assessment (Ontario Inst. of Pedology, 1985)

Organic matter levels - assumed to be > 2%, except for segment 2 (an eroded upper slope) in Field B which was assumed to be less than 2%.

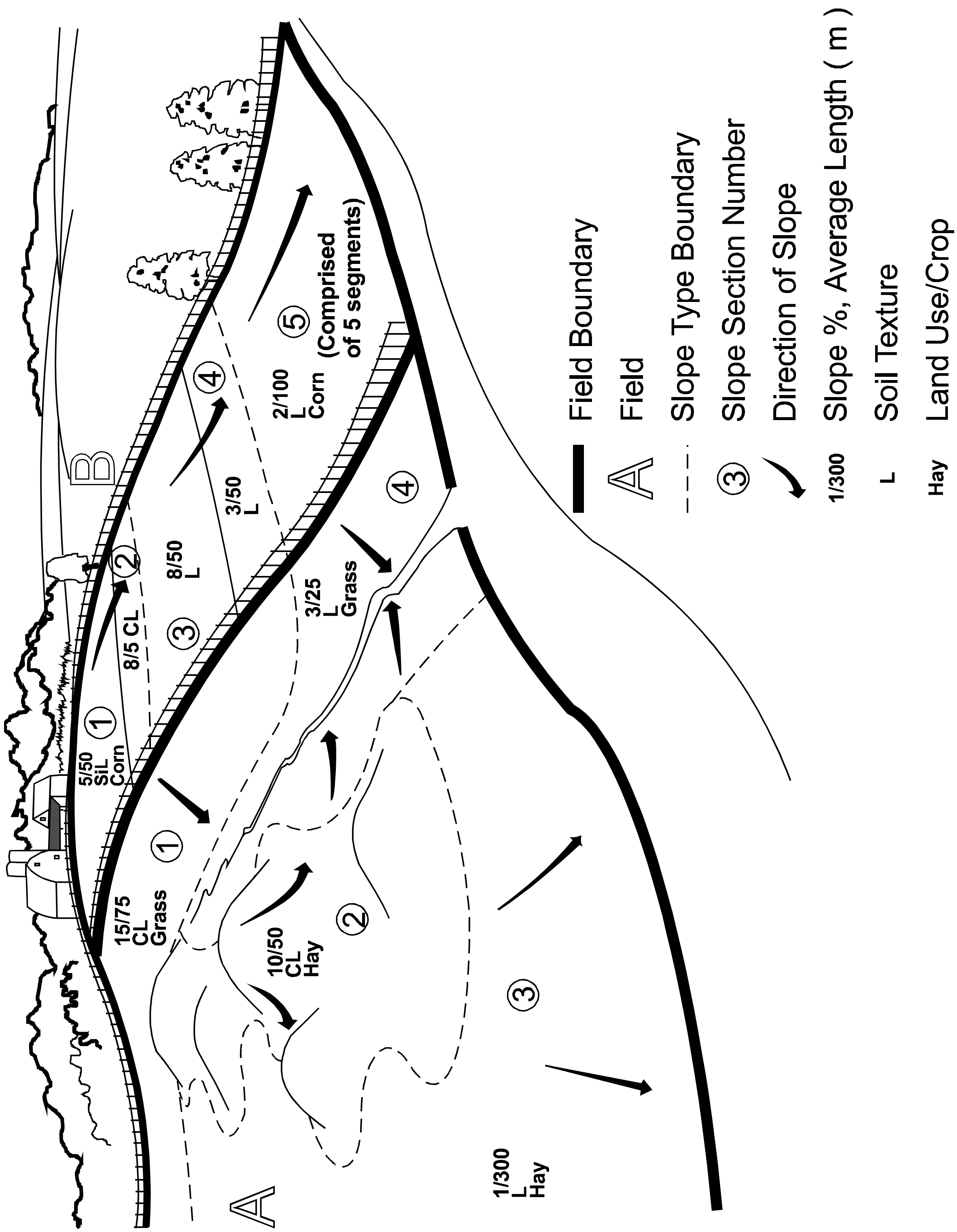

Figure CS-1. Identification of Individual Slope Types on Two Farm Fields

The soil textures varied on Field B enough that a calculation for KLS on irregular slopes was used. This procedure is described below.

K values for different textures in the fields

clay loam (organic matter > 2 %) = 0.037
(organic matter < 2 %) = 0.044
loam = 0.040
silt loam = 0.050

3. LS factor -

Table CS-3b. KLS values obtained from the irregular slope method (USLE)

KLS FROM IRREGULAR SLOPE METHOD - FIELD B							
Segment Number	**Length (Total)**	**Slope % (Segment)**	**Segment LS**	**Fraction of Soil Loss**	**Soil Texture**	**K**	**Segment KLS**
1	250	5	1.53	0.11	sil	0.05	0.008
2	250	8	2.84	0.17	cl	0.04	0.0212
3	250	8	2.84	0.21	l	0.04	0.0239
4	250	3	0.539	0.24	l	0.04	0.005
5	250	2	0.377	0.27	l	0.04	0.004
						Slope KLS	**0.063**

4. C factor - Cropping practices are:

Field A: Section 1 - permanent grass cover; C =0 .003
Section 2 - forage (alfalfa/brome grass); C = 0 .004
Section 3 - forage (alfalfa/brome grass); C = 0 .004
Section 4 - permanent grass cover; C = 0 .003

Field B: 3 year rotation consisting of -
Corn (grain - 2 years) followed by
Mixed grain (1 year)
C = 0.32

5. P factor -
cross-slope ploughing P = 0.75 (Table P-1, Part 2)

6. A values (soil loss)
Results of A = RKLSCP are presented in Table CS-3c.

Table CS-3c. Summary of RUSLEFAC Factors Determined for Case Study

Section of Field	R	K	LS	KLS	C	P	A (t/ha/y)	Potential Erosion Class
FIELD A								
1	1670	0.04	2.2	135.938	0	1	0.41	1
2	1670	0.04	1.75	108.132	0	1	0.43	1
3	1670	0.04	0.23	15.364	0	1	0.06	1
4	1670	0.04	0.27	18.036	0	1	0.05	1
FIELD B								
	1670			0.063	0.32	0.75	25.3	4

Evaluating the Effectiveness of Alternative Practices Using the U.S.L.E.

The tolerable rate of erosion for most Ontario soils has been identified as 6 tonnes/hectare/year. To determine the crop and management practices that could be used to help keep annual erosion to this recommended tolerance level (T), substitute ‘T’ for ‘A’ and rearrange the equation to read:

$$C = \frac{6}{RKLSP}$$

Field B - erosion potential of almost 24 tonnes/hectare/year, which is greater than the tolerable amount.

When R,K,LS and P values are retained but ‘A’ value is changed to T = 6 tonnes/hectare/year, the equation would be as follows:

$$C = \frac{6}{R(KLSP)}$$

$$= \frac{6}{1670\ x\ 0.063\ x\ 0.75}$$

$$= 0.08$$

This means that any practices with a C value of 0.08 or less would yield soil losses of less than 6 tonnes/hectare/year.

A C value of 0.08 or less could be achieved by incorporating four years of a forage crop into this rotation (Table 5b Part 2). On this particular farm, the loss of cash crop acreage on Field B could be compensated for if corn or grain were grown on Section 3 of Field A.

ATLANTIC REGION — Case Study (Black Brook watershed, St. Andre parish, Madawaska County, New Brunswick)

(Note: for detailed descriptions of this watershed project and methods used to develop RUSLEFAC values see Mellerowicz et al., 1994.)

The Black Brook watershed project is part of an integrated study to identify the effects of surface runoff on stream water quality and soil degradation. Erosion rates for both current and alternative soil management practices were evaluated for fields and slopes in the watershed using existing soil, climate and land use information with the assistance of microcomputers and geographical information systems (CARIS) technologies and software (Mellerowicz et al., 1994.)

The maps illustrated in Figures CS-2a, CS-2b and CS-2c provide examples of the soil conservation planning information produced with the use of RUSLEFAC.

Background information on the Black Brook watershed and RUSLEFAC inputs

- land use - intensive potato production, with small grains, peas, row crops, winter cover crops and hay grown in rotation

- soils - generally sandy or silt loams, 5 distinct soil types
  - K value calculated for each soil type, drainage class, erosion phase (eroded or noneroded), and crop (potato or pasture); then K value corrected for soil-specific coarse fragment content

- slopes - grouped into one of three categories, with representative slope percents of 3.5, 8.5 and 15.
  - LS value calculated for each field or slope, using LS - RUSLEFAC calculations for irregular slopes (i.e. Assumes that a slope is a combination of slope segments, each with different slope steepness and length)

- crop history, management practices and support practice information was obtained from land use surveys and base maps

Output

- K, LS and CP maps were created and overlain using GIS technology

- Soil erosion rates (A) were estimated for:

  1. Current situation, reflecting existing crop and management conditions (Figure CS-2a).
  2. Different scenarios after introduction of chisel plowing, winter cover crop cover, and contouring into farming practices wherever warranted (Figure CS-2b).

- A map illustrating the location where soil conservation practices are required to sustain production was also produced (Figure CS-2c).

One of the conclusions derived from RUSLEFAC-produced soil loss estimates was that over 50% of the cropland in the Black Brook watershed required implementation of soil conservation management practices to reduce soil loss to less than 12 T/ha/year or 2T (Figure CS-2d). Tolerance (T — no significant loss of soil productivity) for this area is estimated to be 6 T/ha/year:however; from an economical perspective, acceptable soil loss under optimal farm management conditions was set at 12 T/ha/year. Based on the RUSLEFAC results, however, potatoes can't be produced and still maintain tolerable soil loss rate levels.

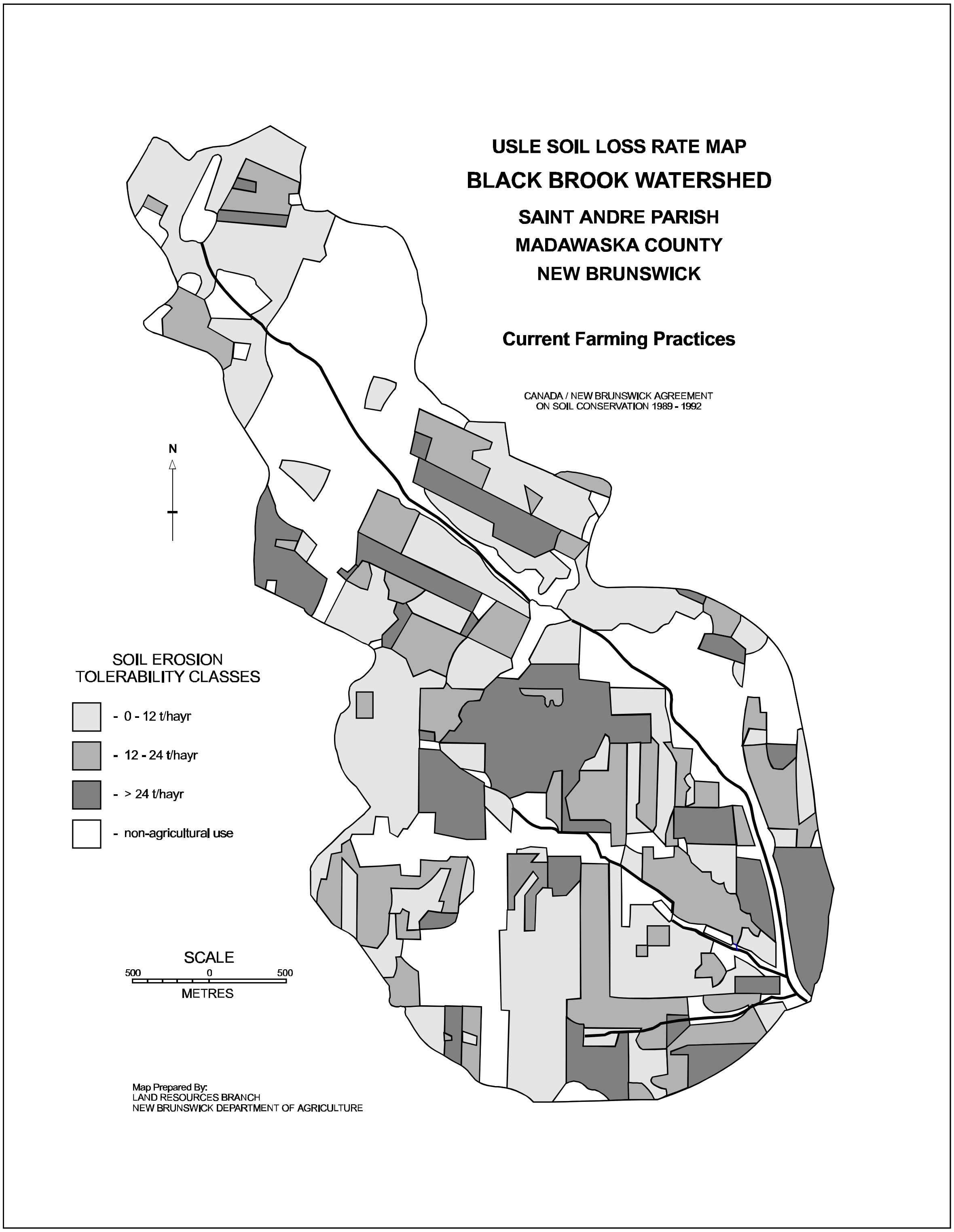

Figure CS-2a. Simplified copy of soil loss map showing general distribution of effects of current farming practices on soil erosion (based on the USLE model) (Mellerowicz et al., 1994)

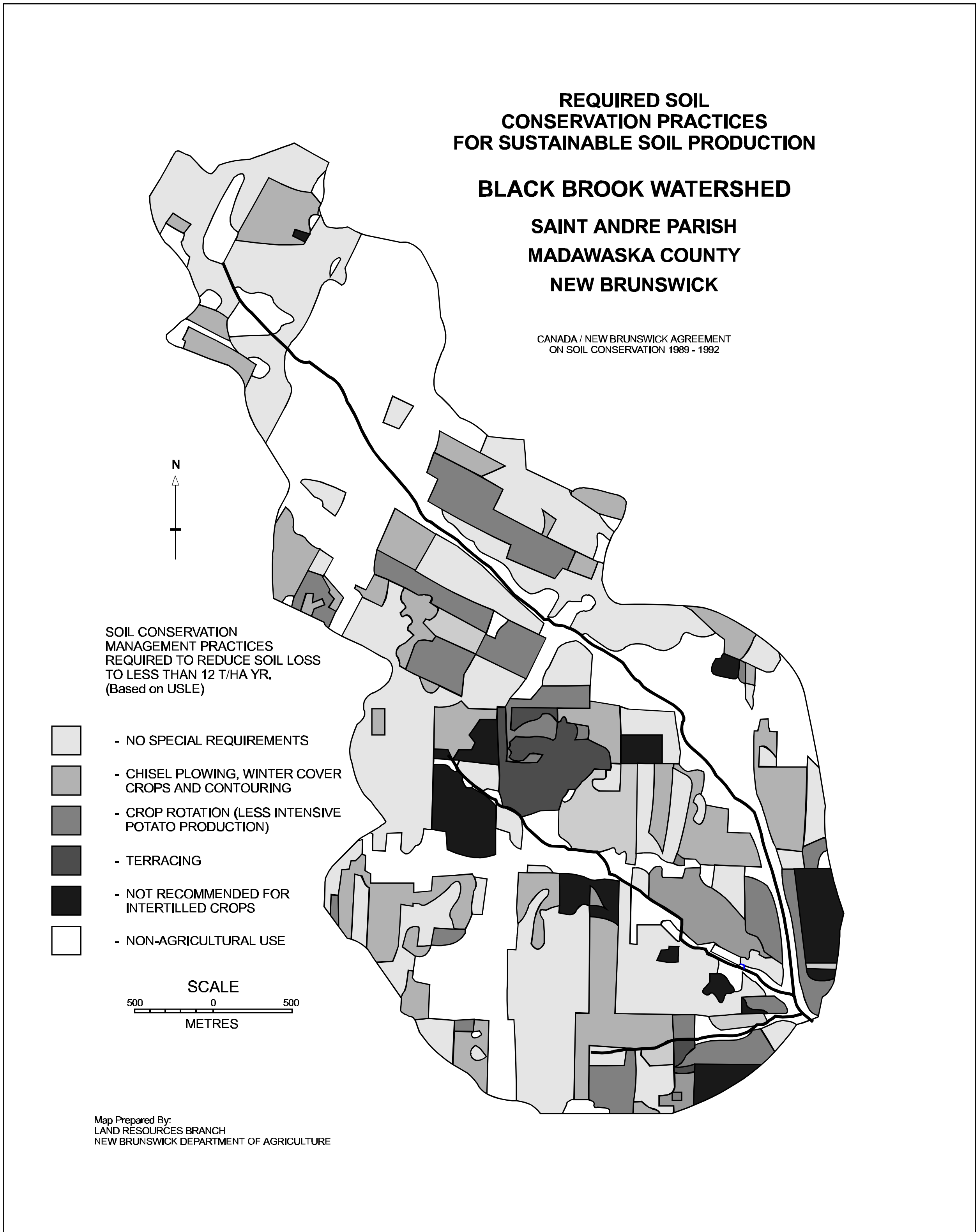

Figure CS-2b. Simplified copy of required soil conservation practices to reduce soil loss to less than 12 T/ha/yr (based on the USLE model) (Mellerowicz et al., 1994)

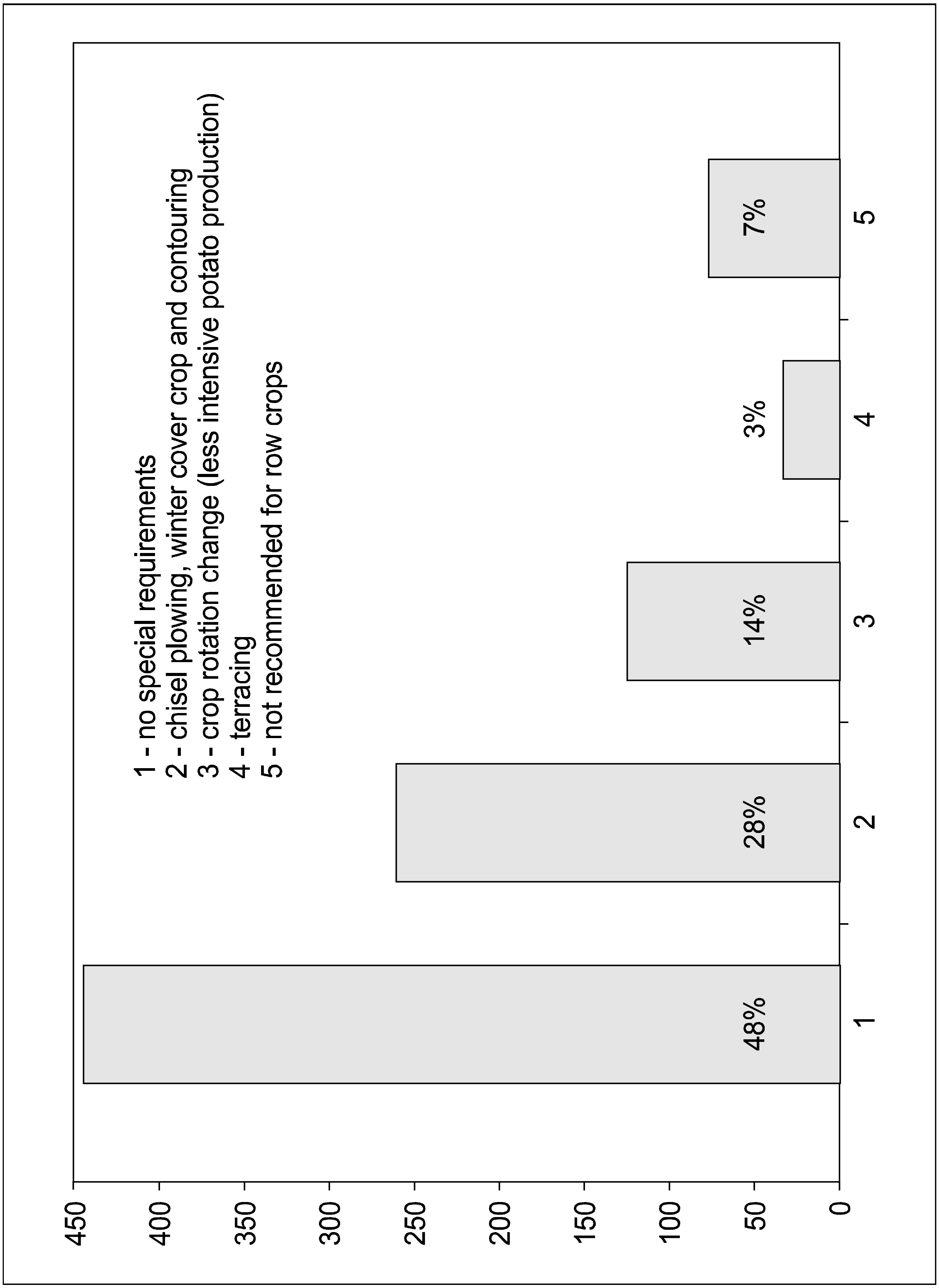

Figure CS-2c. Soil Conservation management practices required to reduce soil loss to less than 12 T/ha/yr (based on USLE model) (Mellerowicz et al., 1994)