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Land Suitability Rating System for Agricultural Crops

1. Spring-seeded small grains

Canada

Land Suitability Rating System for Agricultural Crops

1. Spring-seeded small grains

A technical report prepared by
Agronomic Interpretations Working Group

Edited by
W.W. Pettapiece

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This report is the result of the combined efforts of many people involved in assessing agricultural potential in Canada. The principal contributors were the members of the working group, but many others contributed by testing and commenting on the system. We particularly thank Dr. J.A. McKeague who helped compile and edit the working document, K. Webb and L. van Vliet for additional testing and the CanSIS staff who provided support for the map component.

Much of the material in this manual comes from other sources, two in particular being the Canada Land Inventory: Soil Capability for Agriculture (ARDA, 1965) and the Land Capability Classification for Arable Agriculture in Alberta (Alberta Soils Advisory Committee, 1987). The working group accepts responsibility for any misrepresentation caused by editing and reorganization or adaptation of the material.

PREFACE

This report outlines a procedure for rating the suitability of land for production of spring-seeded small grains (and hardy oilseeds) in Canada. The system was developed in response to a number of concerns regarding the Canada Land Inventory (CLI): Soil Capability for Agriculture (ARDA, 1965), namely:

- Modifications of the CLI by several agencies had resulted in a variety of non-comparable approaches in land capability ratings across Canada.
- The influence of climate on land suitability for crop production was not adequately taken into account.
- Organic soils were not included.
- Lack of specificity in definitions and application guidelines had led to inconsistent ratings among land rating practitioners.

A working group of pedologists representating all regions of Canada was formed in 1987. It reviewed existing systems and recommended that the basic seven (7) class concept of the CLI should be retained but that the individual components, climate, soil and landscape, should be rated separately using explicitly documented and rated factors. This working document is the response. It uses an expert system approach based on accumulated experience and supporting research with modifications from limited field testing.

While the system described herein gives a rating for spring-seeded small grains, the underlying procedure can be universally applied and is intended to provide a basic framework for rating the land resource base for any crop. The system was designed to accommodate the national scope of conditions but it can be used at any level of detail for regional or local needs. It is based on land and environmental factors as they affect arable, dryland (rainfed, not irrigated) agriculture, and it assumes current management practices.

Economic factors are excluded apart from management considerations implicit in some of the applications. Suitability ratings do not, in themselves, indicate "most profitable" or "best" use of land, nor do they replace the need for land use planning based on economic and social as well as land factors. The ratings, however, do provide one of the essential components in any land use decision involving agriculture.

All users are encouraged to comment on any portion of the technical or descriptive aspects of this publication. Comments should be forwarded to:

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Chapter 1

INTRODUCTION

Attempts to rate the suitability of land for food production probably began with the dawn of arable agriculture (Simonson, 1968). From the early days of soil survey in Canada, ratings were made of the agricultural potentials of mapped areas (McKeague and Stobbe, 1978). The first national land inventory in Canada, the Canada Land Inventory (CLI) (ARDA, 1965), was based largely on soil survey information, and the initial capability rating was for common field crops. Over the years several agencies modified the CLI for a variety of purposes. In some cases, new systems of land capability rating were developed. The use of different systems led to confusion and conflict. Concern about this was expressed at the meeting of the Expert Committee on Soil Survey in 1986, and the Land Resource Research Centre responded in 1987 with the formation of an Agronomic Interpretations Working Group, with representation from all regions of Canada.

The Working Group examined a number of systems used to rate land for the production of agricultural crops. They included the systems used in British Columbia (Kenk and Cotic, 1983), Alberta (Alberta Soils Advisory Committee, 1987) and the Ottawa area (Marshall et al., 1979) as well as Ontario (Brokx and Presant, 1986), Quebec (Mailloux et al., 1964) and the Atlantic Region (Atlantic Advisory Committee, 1988). Several climatic stratifications were also reviewed (Chapman and Brown, 1966; FAO, 1976; Williams, 1983). Conclusions from the initial assessment were:

- The basic concept of the seven (7) class CLI system (ARDA, 1965) should be retained. It was sound and easy to understand, and it was the basis of land legislation in several provinces.
- The major weaknesses of the CLI system included:
  - a) the inadequate consideration of climate,
  - b) the omission of organic soils from the system,
  - c) the inadequate documentation of criteria, and
  - d) the subjectivity of the rating process.

It was agreed that:

- Since climate, soil and landscape factors could independantly control the suitability of a tract of land for crop production, each one should be rated separately.
- An expert system approach (McCracken and Cate, 1986) based on present knowledge should be used in developing an improved national system for rating land suitability for production of crops. Initially, rating factors should be developed for spring-seeded small grains and the system should be tested before proceeding to other crops.

With the above direction, the Working Group proceeded with exploratory work in 1988, development of a climatic framework for the system in 1989, preparation of a draft report in 1990, and testing and modification of the system in 1991. The result was a "working document" published in 1992 which was circulated to Land Resource Units across the country for exposure to local clients and further testing. Feedback from this phase was used for further modification and clarification to produce the present document. At the same time a computer program, written in dBASE, was developed for automated calculations.

This document should be viewed both as a general procedure for assessing land suitability for crop production and as a specific system for rating land suitability for spring-seeded small grains. The spring-seeded small grains, which include wheat, barley and oats, were selected to develop the procedure and format because they can be grown throughout the agriculture area of Canada. The system should work equally well for hardy oilseeds such as canola and flax which have similar land resource requirements. As the CLI ratings were designed for common field crops suited to the area (ARDA, 1965), the two systems should be roughly similar. The system described herein includes most of the attributes of an optimum approach to soil productivity rating as outlined by Huddleston (1984).

The principal objectives of the working group were to clarify and specify the input parameters so that the rating could be documented and automated, to develop a uniform national approach and to provide for expansion of the rating to a variety of crops. As such, this report does not present new information so much as to reorganize, document and specify our present approaches and knowledge. In so doing, it also identifies areas of weakness and directs testing and research for improvements. It is an attempt to improve the quality and particularly the uniformity of land suitability rating in Canada.

Chapter 2

SYSTEM DEVELOPMENT

2.1 Approach and Assumptions

An "expert system" approach was used based on available data and the collective knowledge and experience of people involved with land science and the rating of land suitability for crop production throughout the country. The CLI system (ARDA, 1965) was used as a general framework as it has proven useful and it is familiar to people involved with all aspects of land evaluation. Thus, a seven class system was chosen with Class 1 having the highest suitability (least limitations) and Class 7 having the lowest suitability (greatest limitations). The component breakdown and specific factor ratings follow the early approach of Storie (1933) and more recently that of the Alberta Soils Advisory Committee (1987).

Changes from the CLI are reflected in some of the following guidelines and assumptions:

1. The system is interpretive and based on limitations for crop production. The framework of the system is suitable for all crops but specific rating factors are developed, initially, for only spring-seeded small grains (wheat, barley, oats), crops which can be grown in all the agricultural regions of Canada.
2. The system recognizes three major components that determine the suitability of land for crops: climate, soils and landscape. Each component is rated separately and assigned a value between 0 and 100. The final land suitability rating is based on the most limiting of the three, not on the accumulated total.
3. Distance to market, availability of land transportation, size of farm, cultural patterns, and exceptional skill or resources of the farm operator are not criteria for this classification.
4. Permafrost affected soils are not considered separately because once land is cleared of its vegetative cover the permafrost recedes to a depth greater than 1 m.
5. The interpretations are subject to change as new information on soil response to management becomes available. New technology may also require changes in the classification.
6. Organic soils are rated for the same crops as mineral soils.

As a basis for developing specific ratings for various factors, the following relationship was established:

Table 2.1 Relationship of suitability class to index points.

Suitability class	Index points	Limitations for specified crop*
1	80–100	none to slight
2	60–79	slight
3	45–59	moderate
4	30–44	severe
5	20–29	very severe
6	10–19	extremely severe
7	0–9	unsuitable

*Limitations are for production of the specified crops. This does not imply that the land could not be developed for other crops or for other uses.

2.2 System Description

The system has two categories: "Classes" based on the degree of limitation of land for production of the specified crop or crops (Table 2.1), and "Subclasses" based on the kind of limitation. This information is useful for land use planning and for determining conservation and management requirements. The first three classes are considered suitable for sustained production of the crop in question, Class 4 is considered marginal, and Classes 5 to 7 are not considerd capable of supporting sustained production of the crop using presently recommended practices. Subclasses reflect the kind of climate, soil and landscape limitations.

Provision is made for a third category "Units" which are groupings of soil-landscapes based on management considerations. For example, all areas having similar requirements for conservation practices, or drainage, or fertility amendments might be grouped. This category has not been developed here but attempts have been made where intensive land management is practiced (cf Luttmerding, 1984).

It must be emphasized that land areas assigned to the same suitability class are similar only with respect to the degree, and not the kind, of limitation for production of a crop. Each class can include different soil and landscape characteristics which may require different management practices.

2.2.1 Classes (degree of limitation)

Class 1 Land in this class has no significant limitations for production of the specified crops (80–100 index points).

Class 2 Land in this class has slight limitations that may restrict the growth of the specified crops or require modified management practices (60–79 index points).

Class 3 Land in this class has moderate limitations that restrict the growth of the specified crops or require special management practices (45–59 index points).

Class 4 Land in this class has severe limitations that restrict the growth of the specified crops or require special management practices or both. This class is marginal for sustained production of the specified crops (30–44 index points).

Class 5 Land in this class has very severe limitations for sustained production of the specified crops. Annual cultivation using common cropping practices is not recommended (20–29 index points).

Class 6 Land in this class has extremely severe limitations for sustained production of the specified crops. Annual cultivation is not recommended even on an occasional basis (10–19 index points).

Class 7 Land in this class is not suitable for the production of the specified crops (0–9 index points).

2.2.2 Subclasses (kind of limitation)

CLIMATE (C): a general climatic restriction.

Temperature (H) This subclass indicates inadequate heat units for the optimal growth of the specified crops.

Moisture (A) This subclass indicates inadequate moisture for the optimal growth of the specified crops.

SOIL (S): a general soil restriction.

Water holding capacity/texture (M) This subclass indicates land areas where the specified crops are adversely affected by lack of water due to inherent soil characteristics.

Soil structure (D) This subclass indicates land areas where the specified crops are adversely affected either by soil structure that limits the depth of rooting, or by surface crusting that limits the emergence of shoots. Root restriction by bedrock and by a high water table are considered separately (see Rock and Drainage).

Organic matter (F) This subclass indicates mineral soil with a low organic matter content in the Ap or Ah horizon (often considered a fertility factor).

Depth of topsoil (E) This subclass indicates mineral soil with a thin Ap or Ah horizon (often resulting from erosion).

Soil reaction (V) This subclass indicates soils with a pH value either too high or too low for optimum growth of the specified crops.

Salinity (N) This subclass indicates soils with amounts of soluble salts sufficient to have an adverse effect on the growth of the specified crops.

Sodicity (Y) This subclass indicates soils having amounts of exchangeable sodium sufficient to have an adverse effect on soil structure or on the growth of the specified crops. It's use is restricted to reconstructed soils.

Organic surface (O) This subclass indicates mineral soils having a peaty surface layer up to 40 cm thick.

Drainage (W) This subclass indicates soils in which excess water (not due to inundation) limits the production of specified crops. Excess water may result from a high water table or inadequate soil drainage.

Organic soil temperature (Z) This subclass recognizes the additional temperature limitation associated with organic soils - particularly where the regional climate has less than 1600 Effective Growing Degree Days (EGDD).

Rock (R) This subclass indicates soils having bedrock sufficiently close to the surface to have an adverse effect on the production of the specified crops.

Degree of Decomposition or Fibre Content (B) This subclass identifies organic soils in which the degree of decomposition of the organic material is not optimum for the production of the specified crops.

Depth and Substrate (G) This subclass indicates shallow organic soils with underlying material that is not optimum for the production of the specified crops.

LANDSCAPE (L): a general landscape restriction.

Slope (T) This subclass indicates landscapes with slopes steep enough to incur a risk of water erosion or to limit cultivation.

Landscape Pattern (K) This subclass indicates land areas with strongly contrasting soils and/or nonarable obstacles that limit production of the specified crops or substantially impact on management practices.

Stoniness and Coarse Fragments (P) This subclass indicates land that is sufficiently stony (fragments coarser than 7.5 cm) or gravelly (fragments smaller than 7.5 cm diameter) so as to hinder tillage or limit the production of specified crops.

Wood content (J) This subclass indicates organic soils with a content of wood or of Eriophorum species sufficient to limit the production of the specified crops.

Inundation (I) This subclass indicates land areas subject to inundation or flooding that limits the production of the specified crops.

2.2.3 Units (management groups)

Units should be considered as soil management groups. That is, groupings of soils or map units with similar relevance and response to a particular management objective. It is suggested that criteria and groupings could change with objective of decision and scale of data or application. These types of groupings are more appropriate at levels of detailed land management such as individual farms or site plans and the need for national guidelines has not been established. However, some general statements are included for orientation.

The original concept (Klingebiel and Montgomery, 1961) was that the capability unit should group soils that were nearly alike in their suitability for plant growth and responses to management. Thus, soils in the same unit should be sufficiently uniform to (a) produce similar kinds of cultivated crops and pasture plants with similar management practices, (b) require similar conservation treatment and management under the same kind and condition of plant cover, and (c) have comparable potential productivity. The principal controlling parameters are texture, drainage, slope and climate although others such as fertility requirements, salinity or stoniness can be locally important.

2.3 Information Requirements

Use of the rating system requires information for each factor within the climate, soil and landscape components. The information may be for a specific site or estimated from maps, reports and local information. In some cases, data for factors can be estimated from data for other parameters. For example, the AWC can be estimated from information on texture and structure, or the water table of undrained mineral soils might be estimated from the classification of the soil. The level and purpose of the suitability rating have a bearing on the degree of specificity of the data required. Regional assessments of the suitability of land can generally be made using published data. Assessments of specific tracts of land for the production of specified crops, however, usually require specific data for the sites involved, including on-site inspection, unless the available data are unusually comprehensive.

NOTES

Chapter 3

CLIMATIC FACTORS

Climate is a major factor governing the suitability of land for arable agriculture. The indices selected for this evaluation were based on their relative importance to annual field crops. Emphasis was placed on the summer growing period although spring and autumn periods were also taken into consideration.

The two principal variables are a temperature (or heat) factor and a moisture factor; the most limiting of these determines the basic climatic rating. Factors such as spring moisture, fall moisture, and fall frost can also have an effect on the suitability of land for crop production. These factors, which are mainly of local concern which may differ from one area to another, are included under the section on Modifying Factors. Examples of how they may be applied are given in that section.

Preliminary analysis of the climatic data indicated a strong correlation between complex parameters such as soil moisture budget or corn heat units and simpler indices such as annual precipitation and growing degree days. It was decided, therefore, to choose relatively simple indices which have had general use and for which basic data are readily available. The factors chosen were:

- growing degree days over 5°C (Edey, 1977), and
- moisture deficit (precipitation minus potential evapotranspiration)

both calculated for a defined growing season.

Climatic data, (1951–1980 climate normals, AES) from nearly 2000 stations across Canada were plotted and isolines drawn at an original scale of 1:1M based on elevation and physiography. The climate contours and ratings were then modified in accordance with comments from provincial agronomists and climatologists and then generalized to 1:7.5M (Maps 1 and 2). It must be stressed that climatic "lines" are in reality broad zones that represent long term averages or normals. Yearly variation from the norm can be expected and a greater difference in climate might occur between two points of differing elevation in one zone than between two points located at the same elevation in neighbouring zones.

If detailed local data were available it would be appropriate to recalculate the parameters based on those data. For local computed data to be compatible with the national system, it is important that the same procedures be followed.

3.1 Moisture Factor (A)

The moisture component was determined by calculating precipitation (P) minus potential evapotranspiration (PE) for the May to August period. This was similar to a predictive parameter used by Sly and Coligado (1974) to estimate seasonal water deficits from data on climatic normals. Potential evapotranspiration was estimated using formula 1 of Baier and Robertson (1965) and converting latent to potential evaporation as proposed by Baier (1971). The basic factors are average mean daily maximum and minimum air temperatures and solar radiation at the top of the atmosphere.

The general distribution of the moisture index (Map 1 in pocket) is used with the rating guide (Figure 3.1) for the assessment of the moisture component.

The critical points considered in development of the moisture rating for spring-seeded small grains, assuming no soil limitation, were:

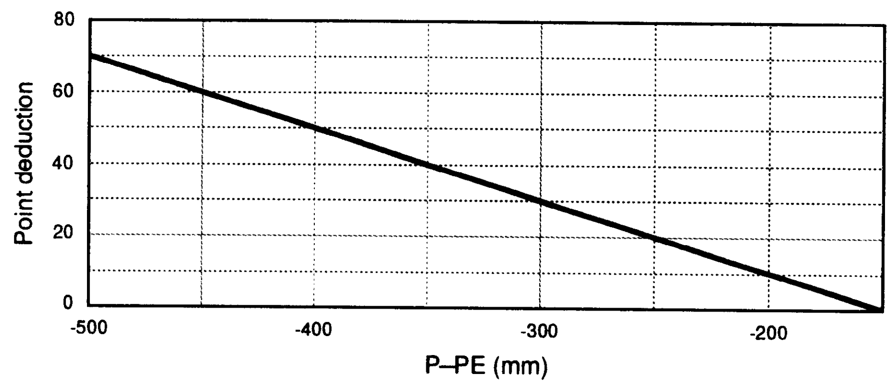
a) P–PE –150 mm: no limitation
- assigned..................0 points deduction

b) P–PE –300 mm: slight moisture limitation most years
- Class 2
- assigned...........30 point deduction (corresponds roughly to the Grassland-Parkland boundary)

c) P–PE –400 mm: near the point where one major crop (barley) becomes a minor part of the cropping system
- considered a moderate moisture limitation
- Class 3
- assigned................. 50 point deduction

d) P–PE –500 mm: dryland farming is severely restricted
- considered a very severe moisture limitation
- Class 4–5
- assigned .... 70 point deduction (this is the driest area in Canada)

Figure 3.1
Point deductions for moisture index values for spring-seeded small grains.

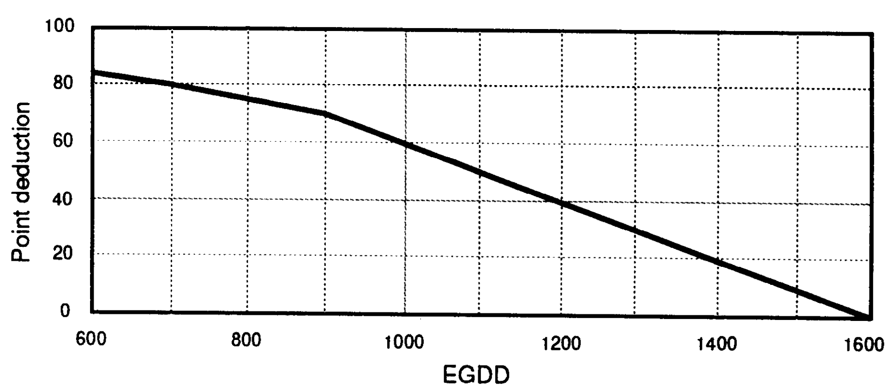


3.2 Temperature Factor (H)

The temperature factor is based on an effective growing degree day (EGDD) calculation which includes length of season, degree days and day length. Growing degrees days were accumulated beginning 10 days after the average date when the mean daily temperature reached 5°C (April 1 was the earliest possible starting date). This approximates date of seeding. The end of the growing season was represented by the average date of the first frost after July 15 (October 31 was taken as the latest possible end date). The GDDs were calculated from the average mean daily air temperatures computed from monthly normal values.

The GDD value was adjusted to recognize the effect of the longer day length in the north (Alberta Soils Advisory Committee, 1987). The

Figure 3.2
Point deductions for effective growing degree day (EGDD) values for spring-seeded small grains.



value of the modification varies from 0% at 49 degrees N to 18% at 64 degrees N latitude. The adjusted value was considered to be the Effective GDD (EGDD).

The general distribution of EGDD (Map 2 in the back pocket) should be used with the rating guide (Figure 3.2) for assessment of the moisture component.

The critical points used for development of the rating, based on requirements for spring-seeded small grains and farming experience, were:

a) 1600 EGDD: no limitation
- assigned.................. 0 point deduction

b) 1200 EGDD: close to the point where wheat becomes a minor component in a dominantly barley system
- this was considered a moderate heat limitation
- Class 3
- assigned................ 40 point deduction

c) 1050 EGDD: the point where spring-seeded small grains occupy less than 50% of the cultivated area
- this was considered a severe heat limitation
- Class 4
- assigned .... 55 point deduction

d) 900 EGDD: approximates the limit of small grain production
- a very severe heat limitation
- Class 5
- assigned................. 70 point deduction

e) 500 EGDD: no potential for small grains
- Class 7
- assigned................. 90 point deduction

3.3 Modifying Factors

It was recognized that a number of factors other than P–PE and EGDD reduce climatic suitability. Some of these are excess spring and fall moisture, fall frost, aspect and coastal effects on accumulated degree days. The effect of these modifiers is mainly a regional concern and specific guidelines have not been developed.

The following are some examples based on Alberta experience for spring-seeded small grains. THESE ARE EXAMPLES ONLY and do not include the entire list of possible modifying factors. If used, it is suggested that individual modifiers should not be allowed more than a 10% deduction.

3.3.1 Excess spring moisture

This modifier was identified to recognize the effect of excess spring moisture in delaying seeding operations and effectively shortening the growing season. It uses the (P–PE) index for May as the rating variable (Figure 3.3). A deficit of 50 mm was considered to be no problem and an excess of 50 mm was considered a significant concern.

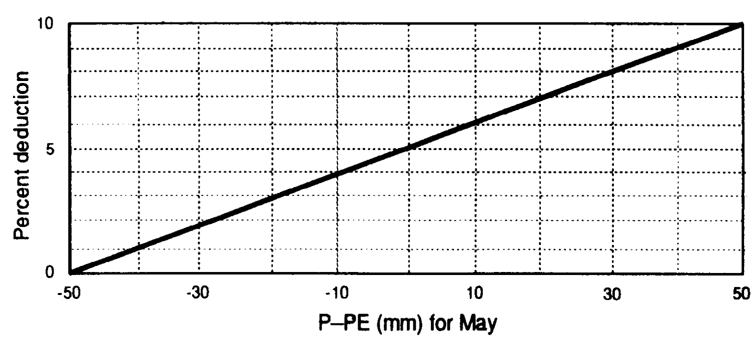


Figure 3.3
Percent deduction for P–PE (May).

3.3.2 Excess fall moisture

This factor reflects the adverse effect of excess moisture during harvesting. It uses the P–PE value for September as the rating variable (Figure 3.4). Soil factors, which may also be important, are not included. Any excess moisture is considered to decrease the suitability of land for crop production.

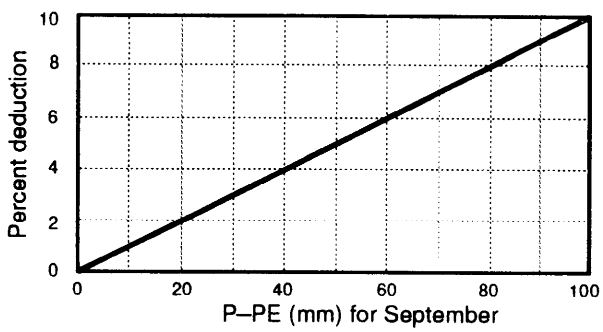


Figure 3.4 Percent deduction for P–PE (September).

3.3.3 Fall frost

This deduction accounts for the occurrence of frost prior to the regional average which is recognized in the H factor. Days before the average regional fall frost is used as the rating variable (Figure 3.5).

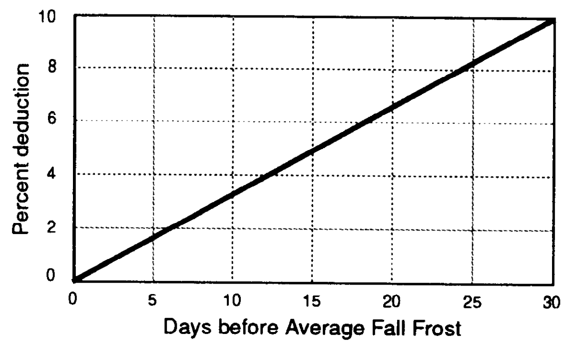


Figure 3.5 Percent deduction for early frost.

3.4 Calculation of the Climate Rating

The attached work sheet (Figure 3.6) should be used to facilitate the calculation. The following steps are suggested:

1. Locate the site on the enclosed moisture map (Map 1).
2. Estimate the moisture index (proportional from isolines) and enter it in the value space on the work sheet.
3. Using Figure 3.1, assign the appropriate deduction.
4. Subtract the deduction from 100 to determine the A rating.
5. Locate the site on the enclosed temperature map (Map 2).
6. Estimate the effective growing degree days and enter the value on the work sheet.
7. Using Figure 3.2, assign the appropriate deduction.
8. Subtract the deduction from 100 to determine the H rating.
9. The basic climate rating is the lowest of A or H.
10. For excess spring moisture, excess fall moisture and fall frost modifiers follow the same procedure as for A and H - enter value and assign appropriate deductions using Figures 3.3 to 3.5.
11. Total the modifier % deductions and multiply by the basic rating to determine the modification point deduction.
12. Subtract the modifier deduction from the basic rating to determine the Final Climatic Rating.
13. You may wish to place the site into a capability class using the classification table (Table 2.1).

To designate a subclass identify any factors which resulted in a 15 or greater point deduction and assign the appropriate symbol. For example, a final rating of 75 with a 23 point deduction for moisture would be 2 A.

CLIMATE (C)

Factor	Value	Point Deduction			
1. Moisture component (A)					
P-PE index =	______	______			
A = 100 -		______	=	______	
2. Temperature factor (H)					
EGDD index =	______	______			
H = 100 -		______	=	______	
Basic Climatic Rating is (lower of A or H)			=	______	a)

		Percent Deduction			
3. Modifiers					
- spring moisture	______	______			
- fall moisture	______	______			
- fall frost	______	______			
modification deduction =		______	% of a) =	______	b)

NOTE: individual modifiers should not exceed 10% deduction.

4. FINAL CLIMATE RATING = a) ______ - b) ______ = [ ]

= Class ______, ______ ______
subclass(es)

Figure 3.6 Work sheet for climate rating.

NOTES

Chapter 4

FACTORS FOR MINERAL SOILS

Mineral soils are those having less than 40 cm of decomposed surface peat or less than 60 cm of undecomposed fluffy peat. Soils with deeper surface organic material are discussed in Chapter 5.

The rating for mineral soils is considered in four sections, the moisture supplying ability, surface factors, subsurface factors and drainage. The emphasis is on the surface layer which is where seeds are planted and plants develop and extract nutrients. Other factors such as subsurface characteristics and drainage modify the surface rating. The factors in the basic rating are assessed point deductions while the modifiers, with the exception of subsurface texture, are assigned percentage reductions of the basic rating.

4.1 Water Supplying Ability (M)

4.1.1 Water holding capacity (texture)

The soil aspect being evaluated is its capacity to retain and supply water to plants. If available water holding capacity (AWHC) measurements are available, they should be used. If AWHC values are not available, soil texture, or data on clay and silt content, can be used to estimate AWHC (Table 4.1).

It should be noted that:

- Depth of rooting zone, bulk density and structure, which all influence AWHC, are not taken into account in this simplified table. They are considered in other sections.
- No allowance is made for material coarser than 2 mm, which has negligible water retention capacity. For soils with more than 5% by volume of coarse material, AWHC estimates should be reduced by the volume percentage of coarse material. For example, a loam soil with 30% coarse fragments would have a water holding capacity of 150 (typical for loam) x (100 – 30) = 105 mm/m.
- High proportions of very fine sand can also result in higher AWHC values than those that would be estimated from Table 2.

Table 4.1 Approximate relationship between available water holding capacity (AWHC) and texture or percent clay plus silt.

Texture	% Clay + Silt	AWHC (mm/m)
S	10	40
LS	20	60
SL	40	100
L	60	150
CL	70	170
SiL	75	180
C	80	190
SiCL	85	200
SiC	95	225
HC	95	225

4.1.2 Link to climate

The amount of water available to plants is a function of climate as well as soil factors. The climatic moisture factor (A) was indexed assuming no soil limitation. Table 4.2 combines the climate and soil factors to give a composite rating for water supplying ability of a soil in a given climatic area.

Table 4.2 was developed using the following assumptions:

- a loam soil with P–PE index of –150 mm or less should have no deduction.
- a loam soil with P–PE index of –400 mm should be marginal (Class 4, 55–70 point deduction).
- a sandy soil with P–PE index of –150 mm should have a moderate limitation (Class 3, 45 point deduction).
- a rooting zone of 100 cm was assumed. Restriction in depth of rooting is handled in the section on structure and consistence.

Table 4.2 Point deductions for combinations of available water holding capacity (surface texture or % clay plus silt) and climate factor A.[1]

Climate(A)	% clay + silt		10	20	40	60	70	75	80	85	95	95
	texture[2]		S	LS	SL	L	CL	SiL	C	SiCL	HC	SiC
P–PE	mm/m[3]	25	40	60	100	150	170	180	190	200	225	225
0		40	15	0	0	0	0	0	0	0	0	0
–50		50	25	0	0	0	0	0	0	0	0	0
–100		60	35	10	0	0	0	0	0	0	0	0
–150		70	45	25	10	0	0	0	0	0	0	0
–200		80	55	40	20	10	10	10	10	10	10	10
–250		90	65	50	35	25	20	20	20	20	20	20
–300		95	75	60	50	40	30	30	30	30	30	30
–350		95	85	70	60	50	45	45	40	40	40	40
–400		95	90	80	70	60	55	55	50	50	50	50
–450		95	95	90	80	70	65	65	60	60	60	60
–500		95	95	95	90	80	75	75	70	70	70	70

[1]Use measured data for AWHC, if available.
[2]S = sand, L = loam, Si = silt, C = clay.
[3]mm available water per 1 m soil depth.

4.1.3 Subsurface texture adjustment

Table 4.2 assumes the common situation of a subsurface with the same or slightly finer texture than the surface (up to one class). Adjustments to the rating are necessary if the subsurface texture differs by more than one texture class from the surface texture (e.g. sandy loam over clay loam). These adjustments apply only to the soil component of the primary rating and are more sensitive to sandier textures (Table 4.3).

Table 4.3 Point adjustment to water supplying ability for subsurface texture.

Average subsurface texture[1] (% clay + silt)	Surface texture (% clay – silt)				
	S (10)	LS (20)	SL (40)	L (60)	CL-C (≥70)
S (10)	0	+5	+15	+25	+30
LS (20)	–5	0	+5	+15	+20
SL (40)	–15	–5	0	+5	+10
L (60)	–25	–10	–5	0	+5
CL-C (≥70)	–30	–20	–15	–5	0

[1]Average for 20 cm to 100 cm: assumed to account for 2/3 of the available moisture.

4.1.4 Water table adjustment

A further adjustment may be made to the moisture supplying ability based on the presence of a water table within the rooting zone. The effect of available subsurface water is to reduce any moisture deficit. The amount of reduction depends on the depth to the water table and the amount of capillary rise of water, which commonly is related to texture (Table 4.4).

As an example of the application of this adjustment, consider a loamy sand in an area with a P–PE index of –250 and a water table at 75 cm (subsurface drain). The basic M factor (Table 4.2) would be a 50 point deduction with no adjustment for subsurface texture. The water table effect would reduce the deduction by 30% or 0.30 x 50 = 15 leaving a final deduction of 50 – 15 = 35 points.

Table 4.4 Percent reduction of moisture deficit as a function of depth to water table during the growing season.[1]

Depth of water table[2] (cm)	Drainage Class	Texture[3]		
		S	L	C
0	very poor	100	100	100
25	poor	90	90	90
50	poor - imperfect	60	70	75
75	imperfect	20	40	50
100	imperfect - mod. well	0	0	20
125	mod. well - well	0	0	0

[1]This is a reduction of deficit which will in effect, reduce both the M and the A factors.

[2]Highest 20 day average.

[3]May be related to texture such that C = clayey, L = loamy and S = sandy.

4.2 Surface Factors

This section deals with the 0 to 20 cm depth. It is recommended that average conditions be determined and used for the surface layer OR to a root restricting layer if it occurs at a depth of less than 20 cm (but extends beyond 20 cm). The averaging should be weighted by depth.

In normal cultivated situations, averaging and rating is relatively straightforward. However, there may be situations where extreme conditions exist and it might be more appropriate to rate by layer or horizon. Two such cases could be forested soils with extremely impoverished, leached, horizons with organic carbon contents of less than 0.5% and extremely calcareous horizons with carbonate contents in excess of 40%. These situations will be accommodated under "depth of topsoil" where they will be treated as root restricting layers.

Note: the Algorithm, as presently constructed, only uses the (recommended) averaging option.

4.2.1 Structure and consistence (D)

Soil structure, the size, shape and arrangement of aggregates and voids, affects infiltration and transmission of water, aeration and workability, root penetration and seedling emergence. It is commonly related to soil texture and organic matter content and to soil management. Associated physical properties are consistence and bulk density. General relationships among structure, consistence, texture, bulk density and limitations of soil as a medium for plant growth are described more fully in Appendix A. Because management can markedly modify surface soil features in cultivated soils, the maximum deduction is set at 10 points (Table 4.5). When combined with organic matter content (4.2.2) and depth of topsoil (4.2.3) the maximum possible is 45 points.

4.2.2 Organic matter content (F)

Organic matter is a very important component of agricultural soils, contributing to the nutrient pool (mainly nitrogen), structure, workability and water holding capacity. Though there is no direct relationship between percentage of organic matter and soil quality, levels of organic matter below approximately 2% are generally associated with low soil quality for crop production. The maximum point deduction for low organic matter is limited to 15 because appropriate management can increase organic matter content.

Organic content can be measured in the laboratory or it can be estimated by soil color. The Value component (the darkness or gray component) of the Munsell Soil Color notation correlates well with percentage organic matter and can be used as a basis for estimating organic matter if other data are not available (Table 4.6).

4.2.3 Depth of topsoil (E)

The relatively dark colored surface horizon (Ah undisturbed, Ap cultivated) usually contains more organic matter and has a more favourable structure than the subsurface. The depth at which the subsoil occurs and the nature of the subsoil are related to both plant growth and ease of management. The main concern is the occurrence of a root restricting layer within the top 20 cm (Table 4.7). Two situations can be recognized:

a) a dense very firm or hard horizon with bulk density >1.55
   - Some Bt, Bnt, Bn, Bx or Cx horizons

b) extreme conditions such as very low OC (<0.5%) or very high carbonate contents (>40%).
   - some Ae or C horizons

The latter should only be used where the conditions extends beyond 20 cm. That is, it would not be destroyed by mixing the top 20 cm.

Table 4.5 Point deductions for surface soil structure and consistence.[1]

Structure	Consistence moist/dry	Point deduction
Granular, subangular or fine blocky	friable/ slightly hard	0
Blocky or platy single grained	firm/hard loose/loose	5
Massive	very firm/ very hard	10

[1]For peaty surfaces see section on organic surface factor.

Table 4.6 Point deductions for surface[1] organic carbon content.

Organic carbon %	Munsell color Value (dry)	Color	Point deduction
>6	2	black	0
4–5	3	black	0
3	4	dark brown or dark gray	2
2	5	brown; gray	5
1	6	gray	10
0.5	7	light gray	15

[1]The surface layer considered is the top 20 cm of mineral soil; in many cases this is the cultivated layer. In uncultivated soils, or when cultivation depth is less than 20 cm, the average organic matter content of the top 20 cm of mineral material should be estimated. If the surface layer is less than 5 cm thick, the organic carbon content (or color) of the underlying layer should be used as a basis for the point deduction.

Table 4.7 Point deductions for depth of topsoil [1]

	Depth (cm) of topsoil[1]				
Type of subsurface	20	15	10	5	0
very firm, hard, massive, or extreme conditions (Bt, Bnt, Bx or Cca horizon)[2]	0	5	10	15	20

[1]Depth to a root restricting layer
[2]Standard soil horizon designations - see glossary.

4.2.4 Reaction (V)

A neutral to slightly acid condition is considered ideal for crop growth. As soils become more acidic than pH 5, yields of many crops are depressed, and at values below 4 some elements may be present in quantities that are toxic to some crops. Crops differ markedly in response to acidity with oats being the most tolerant and wheat the least tolerant of the small grains.

The rating (Table 4.8) was developed from the following assumptions (cf Kiniry et al., 1983):

a) pH 5.5 is a slight limitation ....5 points

b) pH 4.0 is a severe limitation (Class 4).......... .... 55 points

c) pH 3.0 not suitable for small grains........... ....100 points

A high pH or alkaline condition can also affect plant response but this situation is usually associated with saline or sodic conditions (see sections on salinity and sodicity). If a deduction is made for salinity or sodicity no deduction is made for high pH values.

There are several common methods for determining pH: saturated paste (water), 1:2 soil-water suspension and 1:2 soil - 0.01 M $CaCl_2$. Compared to the saturated paste, the $CaCl_2$ pH is usually about 1/2 unit lower in value and the 1:2 water value slightly higher. It should be kept in mind that seasonal variation in soil pH is often in the order of 1/2 unit.

Table 4.8 Point deductions for surface soil pH.[1]

Soil pH[2]	Points deducted
9.0	60
8.5	20
8.0	5
6.0–7.5	0
5.5	5
5.0	15
4.5	30
4.0	55
3.5	80

[1]Measured in saturated paste.

[2]Add 0.5 units to pH values measured in 0.01 M $CaCl_2$.

4.2.5 Salinity (N)

Salinity refers to the presence of excessive amounts of soluble salts such as magnesium sulphate. Salinity affects crop growth in two ways. There are chemical effects, but the presence of salts also makes it more difficult for plants to take up water.

Salinity, expressed in terms of electrical conductivity (EC), can be measured in the field or laboratory, or it can be estimated from soil and vegetation characteristics. Crops vary appreciably in salt tolerance, but in general, the effects become noticeable at an EC of about 4 and moderate to severe by an EC of 8. There is very little crop growth at an EC of 16 (Maas and Hoffman, 1977; Holm, 1982). Table 4.9 was developed from these relationships.

Table 4.9. Point deductions for surface soil salinity for spring-seeded small grains.

Salinity[1] (dS/m)	Common features	Points deducted
2	- no apparent signs - affects sensitive crops	0
4	- presence of foxtail - some white specks on soil surface - crop growth affected to some extent	20
8	- plants restricted to salt tolerant species (e.g. Kochia) - white salt crusts common - crops strongly affected	50
16	- plants restricted to species such as red samphire - salt crust and salts throughout profile - little or no crop growth	90

[1]Measured in extract of water-saturated paste.

4.2.6 Sodicity (Y) (This factor is recommended only for reconstructed soils.)

As the percentage of sodium on the soil exchange complex increases over about 15% (usually associated with a pH over 8.5) the stability of soil aggregates decreases markedly. The finer soil particles, clays and organic matter, become dispersed resulting in adverse physical conditions, i.e. massive and sticky when wet and extremely hard when dry. This factor is not used if the surface texture is coarser than loam (Alberta Soils Advisory Committee, 1987b).

Table 4.10 Point deductions for surface soil sodicity.[1]

Sodicity (SAR)[2]	Saturation percentage[3] (Sat %)	Points deducted
4	60	0
8	80	10
12	120	30
16	160	50
20	>160	80

[1]Used for reclaimed soils only. If points are deducted for SAR, do not deduct for pH and salinity.
[2]SAR = Sodium Adsorption Ratio (see glossary for definition).
[3]Saturation percentage can be used as a proxy for SAR.

4.2.7 Organic (peaty) surface (O)

Organic surfaces, when cultivated, present special management problems which are related to seed bed preparation and cold soil temperatures. The degree of decomposition and the depth of organic material are the rated parameters. The well decomposed, dark colored, humic, sedge peats which are generally well compacted and have a granular structure are the most favourable. The least favourable are the light colored, fibric, moss peats which are quite porous. Mesic materials have characteristics between the other two. Table 4.11 was developed using these guidelines. Organic surfaces greater than 40 cm deep (60 cm if all fibric) are discussed under Organic Soils (Chapter 5).

Table 4.11 Point deductions for organic surfaces.[1]

Depth of Peat[2] (cm)	Degree of decomposition	General structure	General consistence	Point deduction
10	humic	compact	friable	0
10	mesic	↓	↓	0
10	fibric	spongy	fibrous	0
40	humic	compact	friable	12
40	mesic	↓	↓	18
40	fibric	spongy	fibrous	24

[1]If deductions are made for an organic surface, the mineral soil ratings for structure and organic matter are not used.
[2]If the depth of peat is less than 10 cm the soil should be rated as a mineral soil.

4.3 Subsurface Factors

4.3.1 Structure and consistence (D)

Subsurface soil structure, consistence and density affect root penetration and therefore the availability of water and nutrients (Trouse, 1971; Hall et al., 1977; Kiniry et al., 1983). The effects of those three factors are also related to texture (Jones, 1983). For example, a bulk density of 1.5 to 1.6 Mg m^{-3} may be favourable for plant growth in sand but in clay it is likely to be associated with massive material that is waterlogged when wet and very hard when dry and, is thus highly unfavourable as a rooting medium for most crops.

The actual impact of a layer that restricts root penetration depends upon the depth at which the layer occurs and also on the regional climate. Therefore, the primary deduction (Table 4.12) is modified by depth and climate factors (Table 4.13) to give a final point rating for impeding subsurface layers. For example, consider a soil with a clay loam subsoil with a bulk density of 1.6 Mg m^{-3} at a depth of 60 cm occuring in the –150 P–PE zone. The deduction for the impeding subsurface layer would be 40 (from Table 4.12) x 50% (from Table 4.13) = 20%.

Table 4.12 Percent deduction for combination of bulk density and texture (or % clay) of impeding subsurface layer.[1]

Bulk density	% C: 0 Texture: S	10 SL	20 L	35 CL	50 SiC	70 HC
1.20	0	0	0	0	0	0
1.30	0	0	0	0	0	5
1.35	0	0	0	0	5	10
1.40	0	0	0	5	10	20
1.45	0	0	5	10	20	40
1.50	0	5	10	20	40	50
1.60	10	20	30	40	55	70
1.70	30	40	50	60	70	90
1.80	50	60	70	80	90	–
1.90	70	80	90	90	–	–
2.00	80	90	90	–	–	–
Rock - 90						

[1]A paralithic layer (rippable bedrock) is considered to have a bulk density of 2.00.

Table 4.13 Percent depth modifications for impeding subsurface layers in different climatic zones.

Depth (cm)	P–PE –50 (perhumid)	–150 (humid)	–250 (subhumid)
20	90	95	100
40	70	75	80
60	40	50	60
80	10	25	35
100	0	0	10
120	0	0	0

4.3.2 Non-conforming (geologic) layer (M)

A non-conforming layer indicates a distinct change in geologic material. This factor, like structure, consistence and bulk density, is important in terms of water movement and retention, and root penetration. This factor has been restricted to a strongly contrasting situation: gravel and sand underneath loam or finer. The following table indicates the percent deduction for contrasting subsurface texture. **Do not** use this table if Tables 4.12 and 4.13 have already been used.

Table 4.14 Percent deductions for depth to non-conforming subsurface textures in different climatic zones.

Depth to contact (cm)	P–PE –50 (perhumid)	–150 (humid)	–250 (subhumid)
	Percent deduction		
100	0	0	0
50	0	30	50
20	30	60	90

4.3.3 Reaction (V)

Subsurface pH levels have the same kind of effects on nutrient availability and plant growth but the impact will not be as severe as in the surface layer (McKenzie and Nyborg, 1984). It was felt that the 20–60 cm depth was most critical and should serve as the basis for this factor. Also, this section considers only acid soils as alkaline situations are covered under salinity or sodicity. Points are deducted for subsurface acidity (Table 4.15) **only** if they are greater than the deduction for surface acidity.

Table 4.15 Percent deduction for subsurface acidity.[1]

Subsurface pH[2]	Percent deduction
7.0	0
6.5	0
6.0	0
5.5	2
5.0	5
4.5	15
4.0	30
3.5	55

[1]For the 20–60 cm depth.
[2]Measured in saturated paste. Add 0.5 unit to pH values measured in 0.01 M $CaCl_2$.

4.3.4 Salinity (N)

A subsurface salinity deduction (Table 4.16) should be made **only** if it is greater than the deduction for salinity of the surface.

Table 4.16 Percent deduction for subsurface salinity.

EC(dS/m)[1]	Percent deduction
<4	0
4	10
8	20
12	40
16	70

[1]Measured in saturation extract.

4.3.5 Sodicity (Y) (recommended only for reconstructed soils)

A deduction for subsurface sodicity (as measured by SAR) is used **only** if it is more limiting than that for surface sodicity. As with the surface evaluation, this factor should not be used for soils with a texture coarser than loam. The average SAR for the 20–100 cm depth is considered in determining subsurface SAR.

To avoid excess deduction of points for related soil parameters, point deductions are made for SAR **only** if the limitation is more severe than the subsurface salinity limitation (see section on salinity). Table 4.17 indicates the percent point deductions for the various sodicity (SAR) classes.

Table 4.17 Percent deduction for subsurface sodicity.[1]

Sodicity (SAR)[2]	Saturation percent (Sat %)[3]	Percent deduction
4	60	0
8	80	10
12	120	30
16	160	50
20	160	80

[1]If points are deducted for SAR do not also deduct for pH and salinity.
[2]SAR = Sodium Adsorption Ratio (see glossary for definition).
[3]Saturation percentage may be used as a proxy for SAR.

4.4 Drainage (W)

Drainage, as used in this system, refers to site specific evaluations of soil properties which include water table and hydraulic conductivity (permeability). The rating is based principally on management or trafficability considerations (on the ability to work the land on a timely annual basis). The water supplying or plant growth component is dealt with in section 4.1.

Drainage is considered a modifier to the surface rating and is treated as a percent deduction.

There are 3 main considerations:

a) The depth of the water table during the critical (usually) spring period. This is one of the most difficult evaluations in the system (see discussion in Chapter 7).
   - estimate the average depth of water table over a 20-day period. It is recognized that there may be times with higher water table and that it will usually be much lower later in the growing season.
   - perched water tables, particularly common in areas with dense subsoils and high precipitation, should also be considered in this assessment.

b) The saturated hydraulic conductivity of the most limiting layer.
   - this reflects the ability of the soil to drain without a water table constraint.
   - three general categories are recognized: rapid, >15 cm/h; moderate, 0.5–15 cm/h and slow, <0.5 cm/h.

c) The general climate of the region. Drainage is a more critical issue in areas of high rainfall such as Atlantic Canada than it is in the Prairies.
   - Three general regions are recognized with reference to the Ecoclimatic Map of Canada: perhumid - annual surplus and low growing season deficits (P–PE <150 mm) (coastal areas); humid - growing season deficits of 150–250 mm (Central Canada); and subhumid - annual deficit and a growing season deficit of generally >250 mm (Great Plains and interior valleys).

It is not always practical to make the physical measurements necessary to characterize the water regime, but there are a number of soil and vegetation features which can be used to estimate the the drainage factor (highest 20-day average):

1. Water table at or near the surface.
   - very poorly drained; Gleysolic soils, often Rego or Rego blue-gray) in native state.
2. Water table at 25 to 50 cm.
   - poorly drained; Gleysolic soils, usually Orthic and Luvic subgroups; prominent (reddish) mottles in the 0 to 50 cm zone.
3. Water table at 75 cm.
   - imperfectly drained; usually Gleyed subgroups with prominent mottles in the 50 to 100 cm zone.
4. Water table 100 cm.
   - moderately well and well drained soils; mottling faint or absent.

In addition:

5. Tile drains are assumed to establish a water table at 75 cm.
   - this also applies to a perched water table situation.
6. Hydraulic conductivity or permeability can be estimated from soil structure (McKeague et al., 1986) or from texture with: sands = rapid; loams = moderate, and clays = slow. This is generally true, but there are many well structured clays with moderate permeability and compact, dense loams with very slow permeability so knowledge of soil structure is important.
7. Soil features respond slowly to changes in the drainage regime, particularly in slowly permeable materials moreover, sandy soils often display prominent mottles if imperfectly or even well drained. Therefore, soil features alone can be misleading in artificial or managed systems. In these cases the continuing limitation should be assessed in terms of cultivation experience such as number of years out of 10 when seeding was possible.

Ratings of the drainage factor in Tables 4.18 to 4.21 reflect the above considerations and the experience of pedologists and agronomists across Canada.

Table 4.18 Percent deduction for soil moisture regime in regions with P–PE less negative than –100 mm (perhumid).

Depth to water table (cm)[1]	Usual drainage class	Hydraulic Conductivity (cm/h) low (<0.5)	medium (0.5–15)	high (>15)
Standing water		100	100	100
0	v. poor	100	100	100
25	poor	90	80	75
50	poor - imp.	75	60	50
75	imperfect	60	40	25
100	imp. - mod. well	40	20	0
125+	mod. well - well	20	0	0

[1]Highest 20-day average in growing season.

Table 4.19 Percent deduction for soil moisture regime in regions with P–PE between –100 mm and –200 mm (humid).

Depth to water table (cm)[1]	Usual drainage class	Hydraulic Conductivity (cm/h) low (<0.5)	medium (0.5–15)	high (>15)
Standing water		100	100	100
0	v. poor	95	95	95
25	poor	80	70	65
50	poor - imp.	70	50	40
75	imperfect	45	30	10
100	imp. - mod. well	20	10	0
125+	mod. well - well	10	0	0

[1]Highest 20-day average in growing season.

Table 4.20 Percent deduction for soil moisture regime in regions with P–PE more negative than –200 mm (subhumid).

Depth to water table (cm)[1]	Usual drainage class	Hydraulic Conductivity (cm/h) low (<0.5)	medium (0.5–15)	high (>15)
Standing water		100	100	100
0	v. poor	90	90	90
25	poor	70	65	60
50	poor - imp.	50	40	30
75	imperfect	30	15	10
100	imp. - mod. well	10	0	0
125+	mod. well - well	0	0	0

[1]Highest 20-day average in growing season.

Table 4.21 Percent deduction for soil moisture regime using a management proxy.[1]

Limited seeding (years out of 10)	Percent Deduction
10	100
8	80
5	50
2	20
0	0

[1]This table may be used if information on water table is not available.

4.5 Calculation of the Mineral Soil Rating (S)

The attached work sheet (Figure 4.1) should be used to facilitate the calculation. The following steps are suggested:

1. Examine the soil (or supplied information) and fill in the "value" for each parameter. For example: surface texture, sandy loam; OM content (color), dark gray; etc.
2. Note the value of P–PE from Chapter 3 (Figure 3.6) and from (Table 4.2) read the point deduction for the appropriate value of P–PE and surface texture. If P–PE has not been recorded, it can be determined from Map 2.
3. Determine the subsurface texture and using Table 4.3 assign the appropriate adjustment. Add the deductions from "2" and "3" to obtain the texture deduction.
4. Determine the appropriate percentage adjustment for water table from Table 4.4.
5. Calculate the moisture deduction points.
6. Record the surface structure/consistence; note and record the appropriate point deduction from Table 4.5.
7. Similarly record the values for the other surface properties listed and use the appropriate tables (4.6 to 4.11) to determine the respective point deductions.

Note: deductions are made for only the most limiting of reaction, salinity and sodicity.

8. Add the points deducted for surface factors to the deduction for moisture factor and subtract the total from 100 to give an Interim Soil Rating.
9. Record values for the subsurface properties listed and assign percentage deductions using the appropriate tables (4.12 to 4.17). Follow the rules given in the text. For example, deduct points for only one of surface and subsurface reaction (the one giving the greater reduction).
10. Add the percent deduction for applicable subsurface factors to give the total percentage deduction. Calculate that percentage of the Interim Soil Rating to obtain the deduction for subsurface features. Subtract from the Interim Soil Rating "8" to give the Basic Soil Rating.
11. Estimate depth to water table in the spring (if available) or drainage class and use Tables 4.18 to 4.21, as appropriate, to determine the percentage reduction for drainage. Calculate that percentage of the Basic Soil Rating to get the drainage deduction.
12. Subtract the drainage deduction from the Basic Rating to give a Final Soil Rating.
13. Assign a suitability class using Table 2.1. Identify any factors which resulted in a greater than 15 point or 15% deduction and assign the appropriate subclass symbol. For example, a final soil rating of 65 with a 20% deduction for structure would be 2 D.

Examples of rating soils are given in Appendix C.

Note: If the texture deduction (M) is more than 15 points greater than the climate base (A) then M should be used as the subclass. Do not use both A and M.

MINERAL SOIL (S)

	Factor	Value	deduction	
1.	Moisture Factor (M)			
	- P-PE index (map 1)	_______		
	- AWHC/surface texture	_______	_______	
	- subsurface texture	_______	_______	
	Texture deduction =		_______ a)	
	- water table depth	_______	_______% a) =	_______ b)
	Moisture deduction = a) _______ - b) _______ =			_______ c)
			Point deduction	
2.	Surface Factors			
	- structure/consistence (D)	_______	_______	
	- OM context (color) (F)	_______	_______	
	- depth of top soil (E)	_______	_______	
	- reaction (pH) (V)	_______	_______	
	- salinity (EC) (N)	_______	_______	
	- sodicity (SAR) (Y)	_______	_______	
	- peat depth (O)	_______	_______	
	fibre	_______	_______	
	Interim soil rating= 100 – c)	_______ -	_______	= d)
			Percent deduction	
3.	Subsurface Factors			
	- impeding layer (D, R)			
	texture	_______		
	structure/density	_______		
	depth	_______	_______	
	- contrasting texture	_______	_______	
	- reaction (V)	_______	_______	
	- salinity (N)	_______	_______	
	- sodicity (Y)	_______	_______	
	Subsurface deduction =		_______ % d) =	_______ e)
	Basic Soil Rating = d) _______ - e) _______ =			_______ f)
4.	Drainage Factor (W)			
	- drainage class or depth to water table	_______	_______	
	Drainage deduction =		_______ % f) =	_______ g)

5. FINAL SOIL RATING (S) = f) _______ - g) _______ = [ ]

= Class _______, _____ _____ _____
subclasses

Figure 4.1 Work sheet for mineral soil rating.

Chapter 5

FACTORS FOR ORGANIC SOILS

Organic soils are those which have greater than 40 cm of peat (greater than 60 cm if fluffy fibric peat) (Expert Committee on Soil Survey, 1987). Organic soils having permafrost (Organic Cryosols) are treated as organic soils for the purpose of this rating system.

These soils present many unique features including low bulk density, high water holding capacity, relatively cold soil climate and usually deficient fertility status (Mathur and Lévesque, 1987). Notwithstanding, the system proposed here is based on the same crops and is an extension of the mineral soil rating with appropriate modifications. Classifying land dominated by organic soils in this system involves rating the same three components: climate, soil and landform, that are rated in the case of land areas dominated by mineral soils. There are some differences, however, both in the specific factors considered in the soil components and in the relative importance of the components. For example, because organic soils are colder than the associated mineral soils, soil temperature is introduced as a factor for organic soils. Nutrient supply, which is a special problem in most organic soils, is also included. Organic terrain is usually level to gently sloping so landform is not usually a critical component. However, there are exceptions and pattern, particularly in permafrost areas, and wood content may be a significant factors. As well, reclaimed organic soils continue to subside at about 1 to 3 cm per year, hence, the depth of organic material and nature of the underlying mineral material affect the continued productivity of the organic soils and therefore, are considered in determining suitability.

The organic equivalent to particle size distribution is fibre content and the "texture" of peats is expressed as fibric (a lot of fibre), mesic or humic (very little fibre) (ECSS, 1987). Fibre content relates closely to packing or bulk density (Boelter, 1974) which is a key parameter in water movement and other management factors and will often be used as a proxy for density, recognizing that a good deal of variability can be expected. Also, fibre content is often used as a measure of degree of decomposition. In general, a very fibric material with large air spaces acts very much like a coarse sand and the low fibre peats act somewhat like clays with respect to water movement (Paivanen, 1973). Those peats with no fibre often pose special management problems in terms of both water movement and mechanical issues (Lucas, 1982). The basic correlations between fibre content, bulk density and water aspects as used in this procedure are given in Appendix A (Table A.3).

It is recognized that the source of organic material, whether sphagnum, sedge or woody peat, may influence many of the critical properties. However, the vegetation source is not specifically dealt with in this preliminary procedure beyond the common relationships to such aspects as fibre content and reaction. Another characteristic of peats is the compaction which follows drainage and cultivation. This makes depth comparisons based on undeveloped conditions somewhat difficult. For consistency, it is suggested that a "compacted" depth be used as a standard reference. The following table (Table 5.1) presents some general guidelines for assessing settlement of peat materials.

Table 5.1 Approximate settlement of different peat materials.

Relative density (Mg/m^3)	Degree of decomposition (fibre content)	Approximate settlement
very loose (<0.07)	fibric	40%
loose (0.07–0.10)	fibric - mesic	30%
rather dense (0.10–0.18)	mesic	20%
dense (>0.18)	humic	15%

The soil component considers 5 main aspects: the 4 used for mineral soils, moisture supplying ability, surface factors (0–40 cm), subsurface factors (40–120 cm) and drainage, plus soil temperature. The emphasis is on the surface layer.

Economic factors affecting ease of development are not considered in this rating system, nor are the aspects of a sustainable resource which are present in many organic soil ratings. It must be emphasized that the present approach to the organic rating is a major departure from previous schemes and the relationships expressed are tentative.

5.1 Soil Temperature (Z)

Microclimates of organic soils are commonly colder than those of associated mineral soils because of differences in soil thermal properties and because organic soils usually occupy low positions in the landscape which are subject to cold air pooling. This is particularly important in the colder regions of the country where growing season length is already a limiting factor. To take account of this a separate deduction of up to 25 points is made for organic soils (Table 5.2).

Table 5.2 Point deductions for temperature regime in organic soils.

Heat units (EGDD)*	Point deductions
1600	5
1500	10
1400	15
1300	20
1200	25

*See climate section.

5.2 Water Supplying Ability (M)

All peats hold a large amount of water at saturation but the availability of that water varies markedly with material characteristics. The low density, fibric types, with large pore spaces, drain very quickly under gravity and can become droughty under conditions of climatic moisture deficit. The denser, humic peats, on the other hand, drain very slowly and are subject to waterlogging under humid conditions. Table 5.3 was developed using these general relationships.

Table 5.3 Point deductions for combinations of water holding capacity and regional climate for organic soils.

Climate	Surface	fibric			mesic			humic	
	Fibre content[1]	80	60	40	30	20	10	5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
P–PE	bulk density[2]	0.04	0.07	0.10	0.13	0.16	0.18	0.20	0.22
–250		40	30	20	15	10	5	0	0
–200		35	25	15	10	5	0	0	0
–150		30	20	10	5	0	0	0	0
–100		25	15	5	0	0	0	0	0
– 50		20	10	0	0	0	0	0	0
0		15	5	0	0	0	0	0	0
+50		5	0	0	0	0	0	0	0

[1]% rubbed fibre >0.15 mm.
[2]Bulk density in Mg/m^3.

Drainage or depth to water table is nearly always a factor in managing organic soils. This influence also varies with density (porosity) of material (Table 5.4).

Table 5.4 Water table adjustment (% reduction) to water supplying ability for organic soils.

	Subsurface		fibric	|	mesic		|	humic	
Depth to	Fibre content[1]	80	60	40	30	20	10	5	0
water table	von Post scale	1 2	3	4	5	6	7	8 9	10
(cm)	bulk density[2]	0.04	0.07	0.10	0.13	0.16	0.18	0.20	0.22
0		100	100	100	100	100	100	100	100
25		90	90	95	95	95	100	100	100
50		60	70	80	80	85	90	95	95
75		20	30	40	50	60	70	80	90
100		0	0	10	20	30	45	60	70
125		0	0	0	0	10	20	30	50

[1]% rubbed fibre >0.15 mm.
[2]Bulk density in Mg/m^3.

5.3 Surface Factors

The top 40 cm of compacted peat is considered for the base rating. This is 20 cm more than for mineral soils in recognition of the settlement and mineralization that takes place in organic soils. Even at a rate of 1 cm a year the modification is substantial. Three factors are rated for their contribution to seed establishment, crop growth and management. These are structure and consistence (fibre content), reaction and nutrient status and salinity.

5.3.1 Structure and consistence (B) (Degree of decomposition)

The preparation of a proper seedbed is a major management concern at extremes in density/fibre content. Loose packing results in poor seed to soil contact and soils with no fibre are often amorphous and can seal or crust. Workability is also related to climate. In general, peats derived from sphagnum are more favourable in wetter regions and those from sedges are favoured in the drier areas. This is not explicitly dealt with but is reflected in the fibre/density relationship (Table 5.5).

Table 5.5 Point deductions for surface structure (bulk density) of organic soils.

			fibric	|	mesic		|	humic	
Climate	Fibre content[1]	80	60	40	30	20	10	5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
P–PE	bulk density[2]	0.04	0.07	0.10	0.13	0.16	0.18	0.20	0.22
–250		60	50	40	35	30	25	20	15
–200		50	40	30	25	20	15	15	20
–150		40	30	20	15	10	10	15	25
–100		30	25	15	10	5	10	20	30
–50		25	15	10	5	5	10	25	35
0		20	10	5	0	5	15	30	40
+50		15	5	0	5	15	30	40	50

[1]% rubbed fibre >0.15 mm.
[2]Bulk density in Mg/m^3.

5.3.2 Reaction and nutrient status (V)

Organic soils can have a wide range of nutrient levels which relates largely to the source of water. Those areas receiving water mainly from surrounding mineral soils or from groundwater usually have a near neutral pH and a relatively high nutrient content (eutrophic). Those areas where the water at the surface of the organic deposit is primarily from precipitation are usually more acidic and are generally nutrient poor (oligotrophic). In nearly all cases organic soils have special fertilizer requirements. Potassium need is universal and micronutrient deficiencies are common, particularly in the more acidic environments (Lucas, 1982).

The relationship between fertility and acidity involves several interrelated factors including nutrient content, origin of material and degree of decomposition. Again it is not a simple correlation but one which also involves water source and pH. Very broadly speaking, the raw sphagnum peats have high fibre content, high C:N ratios, low pH, and low nutrient contents while the moderately decomposed sedge peats commonly have low fibre contents, low C:N ratios, a more neutral pH and a better supply of nutrients.

While acknowledging that there are inherent dangers in over simplification it was considered necessary to recognize interaction of the basic factors. Therefore, the following table (Table 5.6) is suggested for a general reaction/nutrient status (fertility) rating.

Table 5.6 Point deductions for reaction/nutrient status.

			fibric	|	mesic		|	humic	
Reaction	Fibre content[1]	80	60	40	30	20	10	5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
pH[3]	bulk density[2]	0.04	0.07	0.10	0.13	0.16	0.18	0.20	0.22
>7.5				see salinity					
7.5		50		35		25		15	
7.0		45		30		20		10	
6.5		40		30		20		10	
6.0		40		30		20		10	
5.5		40		30		20		10	
5.0		45		35		25		15	
4.5		50		40		30		20	
4.0		55		45		35		30	
3.5		60		50		45		40	
3.0		70		60		55		50	

[1]% rubbed fibre >0.15 mm.
[2]Bulk density in Mg/m^3.
[3]Measured in saturated paste. Add 0.5 units to pH values measured in $CaCl_2$.

5.3.3 Salinity (N)

Saline organic soils are rare in the interior but may occur in coastal areas.

Table 5.7 Point deductions for salinity.

Salinity dS/m[1]	Point deduction
2	0
4	20
8	50
16	75

[1]Measured in saturated paste.

5.4 Subsurface Factors

Subsurface factors are considered as modifiers of the surface (base) rating and as such are handled as percentage reductions. The maximum depth considered is 120 cm. This is 20 cm greater than for mineral soils because of the deeper surface horizon defined to recognize subsidence in these soils. Four factors are recognized in this category: structure (degree of decomposition), depth of deposit and kind of substrate, reaction and salinity.

5.4.1 Structure and consistence (B) (degree of decomposition)

This general index reflects the kind of material and its state of decomposition (fibre content). It is based on an average for the 40 to 120 cm depth or to a shallower strongly contrasting material such as mineral soil or a sedimentary peat layer more than 10 cm thick.

Table 5.8 Percent deduction for subsurface structure/bulk density of organic soils.

	Subsurface		fibric	|	mesic		|	humic	
	Fibre content[1]	80	60	40	30	20	10	5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
	bulk density[2]	0.04	0.07	0.10	0.13	0.16	0.18	0.20	0.22
Percent deduction		20	10	0	0	0	5	10	20

[1]% rubbed fibre >0.15 mm.
[2]Bulk density in Mg/m^3.

5.4.2 Depth of deposit and kind of substrate (G)

The depth to and kind of substrate affect a number of aspects in the management of organic soils ranging from water control to nutrition to long term management and sustainability. Many of these are linked to climate which is reflected in the following table.

Table 5.9 Percent deduction for contrasting subsurface layers.

Kind of layer	P–PE	–50 (perhumid)			–150 (humid)			–250 (subhumid)		
	depth	40	80	120	40	80	120	40	80	120
sandy		10	0	0	15	10	0	10	10	0
loamy		30	20	0	10	5	0	0	0	0
clayey		40	30	0	30	15	0	20	10	0
gravel		50	0	0	60	20	10	70	40	10
gyttja[1]		60	30	10	70	40	10	80	50	10
bedrock		80	40	20	90	50	20	90	60	30

[1]Includes sedimentary peat and coprogenous earth.

5.4.3 Reaction and nutrient status (V)

Subsurface acidity, while not as critical as surface considerations can still affect plant growth and nutrient availability.

Table 5.10 Percent deduction for subsurface reaction/nutrient status.

pH[1]	% deduction
7.0	0
6.0	0
5.0	10
4.0	20
3.0	30

[1]Measured in saturated paste.

5.4.4 Salinity (N)

A subsurface salinity deduction (Table 5.11) should be made **only** if it is greater than the deduction for the surface layer.

Table 5.11 Percent deduction for subsurface salinity.

Salinity dS/m[1]	Point deduction
4	0
8	10
16	20

[1]Measured in saturated paste.

5.5 Drainage (W)

Organic soils are characterized by excess water in their natural state. However, uncontrolled drainage can lead to drought, high rates of subsistence, potential physical damage to the soil and increased erosion (and fire) hazard. The ratings (Tables 5.11 to 5.13) focus on the continuing limitation rather than the difficulty of development. As in the case of mineral soils, drainage is considered as a modifier of the main rating and is therefore managed as a percent deduction. There are three main aspects: depth to water table, hydraulic conductivity and regional climate.

Table 5.12 Percent deduction for drainage in regions with P–PE less negative than –100 mm (perhumid).

Depth to water table (cm)[1]	Subsurface		fibric		mesic			humic	
	% fibre[2]	80	60	40	30	20	10	5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
	hydr. cond.[3]	50	15	5.0	1.5	0.5	0.15		0.015
standing water		100		100			100		100
0		90		95			100		100
25		75		80			85		85
50		50		55			60		65
75		25		30			35		40
100		5		10			15		20
125		0		0			0		0

[1]For the most limiting 20 day period.
[2]% rubbed fibre >0.15 mm.
[3]Hydraulic conductivity in cm/hr.

Table 5.13 Percent deduction for drainage in regions with P–PE between –100 mm and –200 mm (humid).

Depth to water table (cm)[1]	Subsurface		fibric		mesic			humic	
	% fibre[2]	80	60	40	30	20	10	5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
	hydr. cond.[3]	50	15	5.0	1.5	0.5	0.15		0.015
standing water		100		100			100		100
0		90		90			95		100
25		65		70			75		80
50		30		40			45		50
75		5		10			15		20
100		0		0			0		0
125		0		0			0		0

[1]For the most limiting 20 day period.
[2]% rubbed fibre >0.15 mm.
[3]Hydraulic conductivity in cm/hr.

Table 5.14 Percent deduction for drainage in regions with P–PE more negative than –200 mm (subhumid).

Depth to water table (cm)[1]	Subsurface		fibric		mesic			humic	
	% fibre[2]	80	60	40	30	20	10	5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
	hydr. cond.[3]	50	15	5.0	1.5	0.5	0.15		0.015
standing water		100		100			100		100
0		80		85			90		100
25		50		60			65		75
50		20		30			35		40
75		0		0			10		15
100		0		0			0		0
125		0		0			0		0

[1]For the most limiting 20 day period.
[2]% rubbed fibre >0.15 mm.
[3]Hydraulic conductivity in cm/hr.

5.6 Calculation of Organic Soil Rating

The attached work sheet (Figure 5.1) should be used to facilitate the calculation. The following steps are suggested.

1. Use the same EGDD value determined for the climate rating. If the climate calculation has not been done then locate the site on the temperature climate map (Map 1) and determine the value. Determine the deduction using Table 5.2.
   The organic base rating is 100 minus the climate deduction.
2. The basic moisture factor is determined from the P-PE index and the bulk density (or fibre content or vonPost index) of the surface layer using Table 5.3. Next, record the depth to water table and the bulk density of the material above the water table and, using Table 5.4, determine the water table adjustment. The moisture deduction is the basic moisture factor minus the adjustment.
3. Determine and record the % fibre, pH and salinity values for the surface 40 cm. Using Tables 5.5, 5.6 and 5.7 assign appropriate point deductions and total them to give the Surface factor deduction.
4. The Interim Soil rating is the Organic base rating from 1 minus the moisture and surface deductions from 2 and 3.

5. Determine and record for the subsurface the % fibre, the depth to and texture of an impeding layer, the pH and salinity values. Using Tables 5.8 to 5.11 assign appropriate percent deductions. Total the deductions and take as a percentage of the Interim rating determined in 4 to determine the subsurface deduction.
6. Subtract the subsurface deduction in 5 from the Interim rating in 4 to give the Basic Organic Rating.
7. Record depth to water table, % fibre and climatic moisture index for the drainage determination. Using either Table 5.12, 5.13 or 5.14 assign the appropriate drainage deduction. This percentage of the Basic rating in 6 gives the Drainage deduction.
8. Subtract the drainage deduction in 7 from the Basic Organic Rating as determined in 6 to give the Final Organic Rating.
7. Assign the soil to a capability class using the classification in Table 2.1. At this stage also identify any factors which resulted in a greater than 15 point or percentage deduction and assign the appropriate subclass symbol. For example, a final rating of 35 with 20 points deducted for climate and 40 points deducted for acidity would be classified 4 ZV.

Examples of rating Organic soils are given in Appendix C.

ORGANIC SOIL (O)

	Factor	Value		deduction			
1.	Soil Climate (Z)						
	- EGDD index	______		______			
	Organic base rating =	100	-	______	=	______	a)
2.	Moisture Factor (M)						
	- P-PE index (from map 1)	______					
	surface BD/% fibre	______		______ b)			
	- water table depth	______					
	subsurface BD/% fibre	______		______ % b)	=	______	c)
	Moisture deduction =	b) ______	- c)	______	=	______	d)
				Point deduction			
3.	Surface Factors						
	- structure (% fibre) (B)	______		______			
	- reaction (pH) (V)	______		______			
	- salinity (EC) (N)	______		______			
	Surface factor deduction =			______ e)			

Interim organic rating = a) ______ - d) ______ - e) ______ = ______ f)

	Factor	Value		Percent deduction			
4.	Subsurface Factors						
	- structure (% fibre) (B)	______		______			
	- substrate (G)						
	texture	______					
	depth	______		______			
	- reaction (V)	______		______			
	- salinity (N)	______		______			
	Subsurface deduction =			______ % f)	=	______	g)

Basic Organic Rating = f) ______ - g) ______ = ______ h)

	Factor	Value		deduction			
5.	Drainage Factor (W)						
	- P-PE index	______					
	- water table depth	______					
	subsurface BD/% fibre	______		______			
	Drainage deduction =			______ % h)	=	______	i)

6. FINAL ORGANIC RATING (O) = h) ______ - i) ______ = [ ]

= Class ______ , ______ ______ ______
subclass(es)

Figure 5.1 Work sheet for Organic soil rating.

NOTES

Chapter 6

LANDSCAPE FACTORS

The landscape rating is based on limitations generally related to management such as the ease of use of farm machinery, the uniformity of growth and maturity of crops and to the risk of losing topsoil by either erosion or cultivation. It is calculated by first assessing an initial rating based largely on the steepness of slopes and, to a lesser extent, on slope length. The basic rating is then modified, as appropriate, to recognize such factors as field pattern, stoniness, and flooding risk, to arrive at the final landscape rating.

6.1 Basic Landform Rating (T)

Since the initial landscape rating is based in part on water erosion risk, which is climate dependent, two broad regions based on rainfall erosivity (Wischmeyer and Smith, 1965) have been established (Fig. 6.1). Given the same kind of landscape, the erosion risk will be higher in the more humid parts of the country (Region 1) than in the drier areas (Region 2).

Based on the knowledge that landscapes with short, complex slopes are, given the same slope gradient, considered a more serious management limitation than those having simple but somewhat longer slopes, two landscape types are recognized. These landscape types can be generally related to the surface expression or landform as defined in the Canadian System of Soil Classification (ECSS, 1987) (Table 6.1).

Table 6.1 General relationship between landscape type, surface expression and slope length.[1]

Landscape type	Surface expression	Nominal slope length
simple	undulating level apron fan inclined rolling	>100 m
complex	undulating hummocky ridged	<100 m

[1]See Expert Committee on Soil Survey (1987) for definitions.

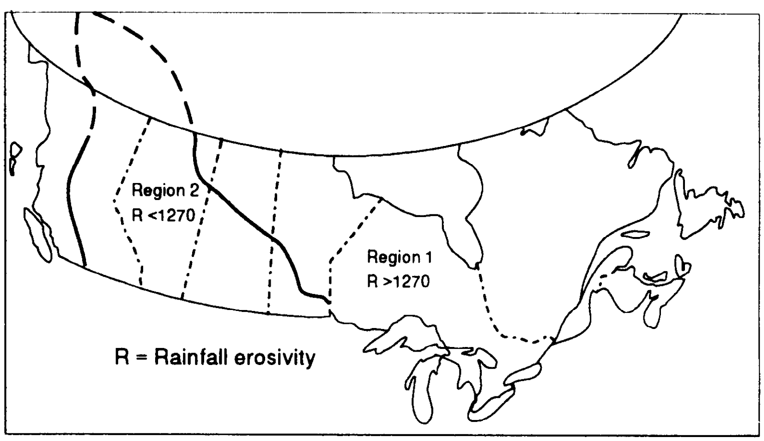


Figure 6.1 Rainfall erosivity regions (after Wischmeyer and Smith, 1965).

The effect of landscape type was recognized by using separate figures for Region 2. In Region 1, it was felt that the longer slopes, while easier to farm, were more prone to erosion and that the two factors would more or less balance. Therefore only one figure was required.

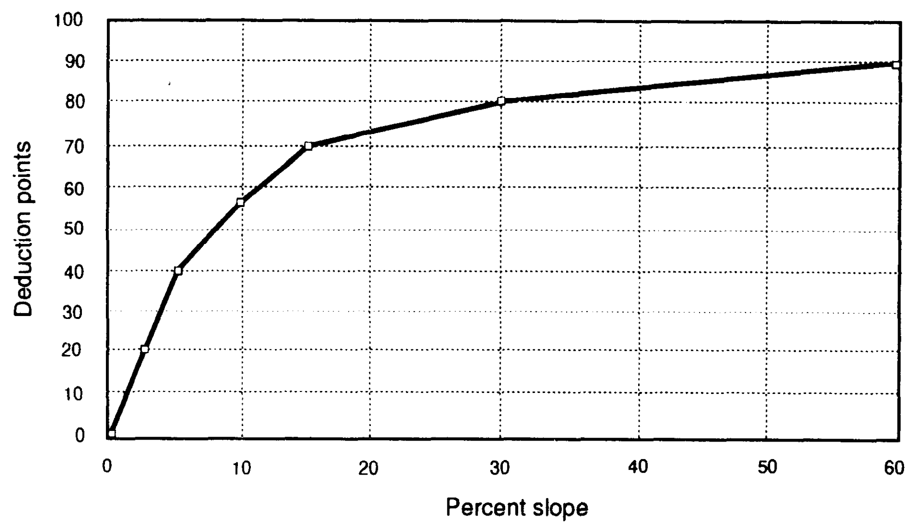


Figure 6.2
Deductions related to slope gradient for all landscape types in Region 1 and for landscapes with complex slopes in Region 2.

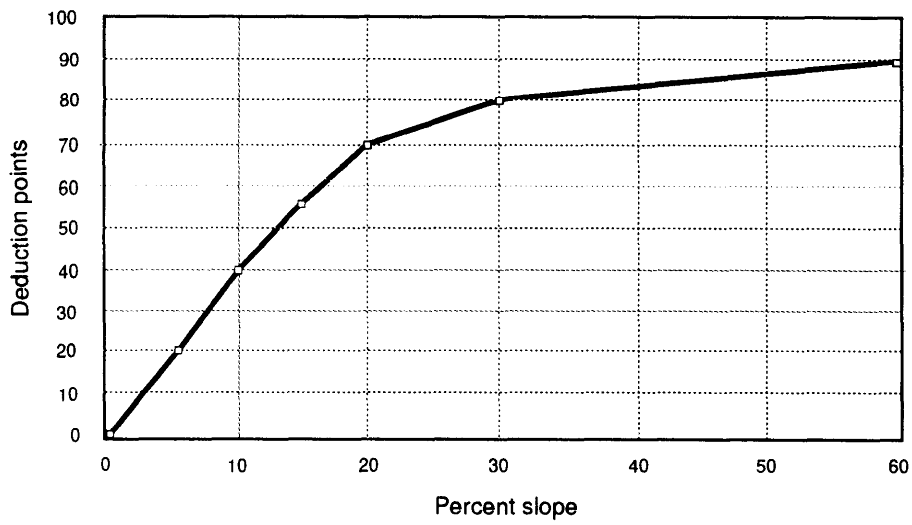


Figure 6.3
Deductions related to slope gradient for landscapes with simple slopes in Region 2.

6.2 Modifying Factors

6.2.1 Stoniness (P)

This factor accounts for limitations due to surface stoniness. Two categories are recognized: stones (>7.5 cm in diameter) and coarse fragments (<7.5 cm in diameter). The deduction for stones is related to the cost of removal and equipment maintenance. The coarse fragments deduction is related to equipment maintenance only, and is applicable to areas where clearing is generally not required. The deductions for stones and for coarse fragments are applied as a percentage of the initial landscape rating (Figures 6.4 and 6.5). Descriptions of conventional stoniness classes in terms of initial and annual removal are proposed for trial (Table 6.2).

6.2.2 Wood content (J)

The problems due to hard, coarse, woody fragments greater than 5 cm in diameter and, in some cases, tough clumps of *Eriophorum* sp. in organic soils are similar to those due to cobbles and stones in mineral soils. Coarse wood fragments in the plow layer or at the surface interfere with seeding, crop emergence, harvesting and tillage. In subsurface layers, wood fragments can improve permeability and reduce the rate of subsidence as they shrink less than peat on drying. Therefore, evaluation of woody fragments is linked to depth within the organic soil profile as well as to amount (Table 6.3).

Figure 6.4
Deductions for surface stoniness.

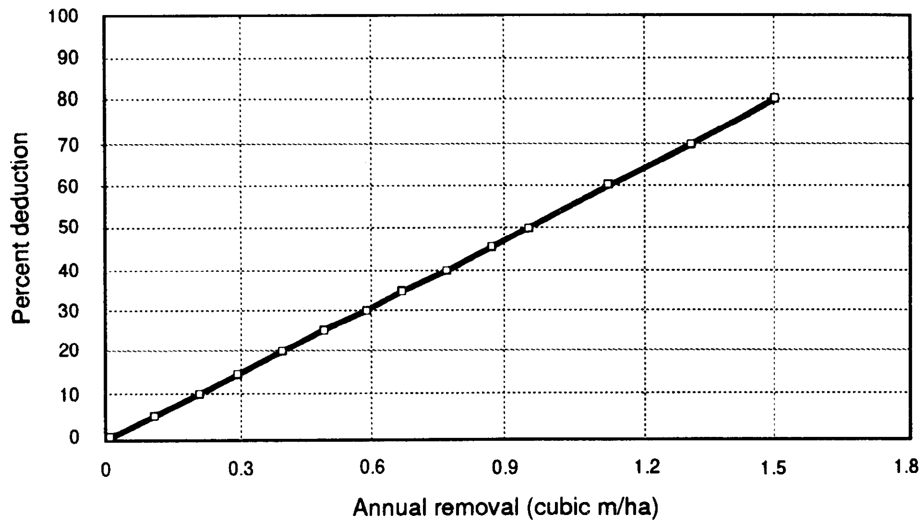


Table 6.2 Stoniness class descriptions[1] in relation to initial and annual removal.

Stoniness Class	Description
1	No hindrance to cultivation; clearing rarely required. initial removal: <0.3 cubic metres/ha; annual removal: <0.01 cubic metres/ha
2	Minor hindrance to cultivation; clearing required every few years. initial removal: 0.3–0.5 cubic metres/ha; annual removal: 0.01–0.3 cubic metres/ha
3	Moderate hindrance to cultivation; clearing required annually or every other year. initial removal: 0.5–1.5 cubic metres/ha; annual removal: 0.3–0.5 cubic metres/ha
4	Severe hindrance to cultivation; substantial clearing required. initial removal: 1.5–3.0 cubic metres/ha; annual removal: 0.5–1.5 cubic metres/ha
5	Nonarable. initial removal: >3.0 cubic metres/ha; annual removal: >1.5 cubic metres/ha

[1]These stoniness class descriptions differ somewhat from those given by the Expert Committee on Soil Survey (1987) although the general intent remains the same.

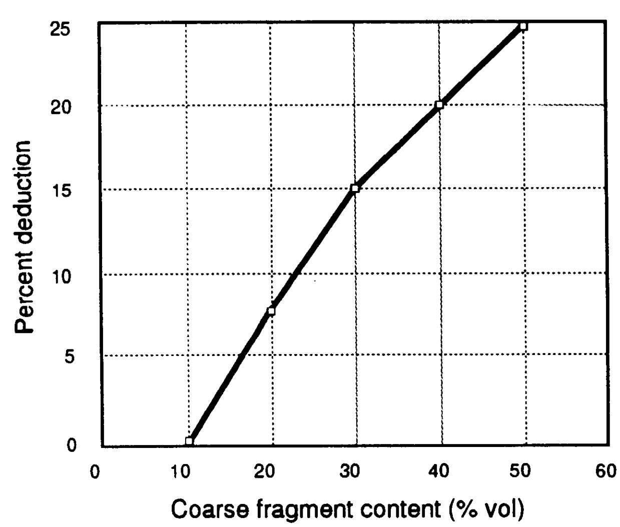


Figure 6.5 Deductions for coarse fragment (gravel) content.

Table 6.3 Percent deduction for wood content in organic soils.

Wood content[1] (% by volume)		Common peatland type	Percent deduction 0–40 cm	40–120 cm
1	very low	treeless fens	0	0
2	low	domed bogs, treed fens	5	0
5	moderate	treed fens, bogs	10	5
10	high	bogs, swamps	20	10
20	very high	hardwood swamps	50	25

[1]Greater than 5 cm diameter.

6.2.3 Landscape pattern (K)

This factor accounts for limitations due to contrasting soil areas within the landscape, including both contrasting arable soils that are limiting in terms of the timing of seeding and harvesting operations, herbicide and fertilizer applications, etc. and non arable obstacles such as sloughs, creeks and streams, rock outcrops, power poles or thermokarst micro- topography which impede normal field operations.

The landscape pattern limitation is applicable where the degree of variability is abnormally high for a particular type of landscape. The normal degree of variability that is inherent in most landscapes, particularly those having relatively steep slopes or characterized by hummocky or ridged surface forms, has already been factored into the initial landscape rating.

The landscape pattern deduction is applied as a percentage of the initial landscape rating. The precise degree of limitation varies substantially from region to region depending upon the type, size and shape of the contrasting soil areas in relation to field-size and the type of machinery used. Specific deductions will need to be developed in each region. For contrasting arable soils, a maximum deduction of about 25% is suggested; for non arable obstacles, a maximum deduction of up to 80% may be warranted.

6.2.4 Flooding (I)

This factor accounts for a temporary covering of the soil surface by flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes, inflow from high tides, or any combination of sources. Standing water (ponding) or water that forms a permanent covering is not considered. The flooding deduction (Table 6.4) is applied as a percentage of the initial landscape rating.

Table 6.4 Percent deduction related to frequency and duration of flooding.

Inundation period		Very brief (<2 days)	Brief (2–7 days)	Long (1–4 weeks)		Very long (>4 weeks)
Usable growing season length			>10 weeks		5–10 weeks	<5 weeks
Frequency						
Scale	Nominal			Percent deduction		
Rare (less than 1 year per 20 years)	1%	0	5	5	10	10
Occasional (1 to 5 years per 20 years)	10%	0	5	10	20	20
Common (5 to 10 years per 20 years)	30%	10	30	65	75	75
Frequent (more than 10 years per 20 years)	50%	30	65	70	85	95

6.3 Calculation of the Landscape Rating

The attached work sheet (Figure 6.7) should be used to facilitate the calculation. The following steps are suggested.

1. Determine and record the appropriate values for steepness and length of slope.
2. Using Figure 6.1, and 6.2 or 6.3 determine the Basic Landscape Rating.
3. Determine and record the stoniness and gravel content or wood content.
4. Assign the percent deductions for each of the factors mentioned in 3 using the appropriate figures or tables.
5. Total the percent deductions in 4 and multiply this by the Basic Landscape Rating to get the deduction for course fragment content.
6. Subtract the deduction (b) from the Basic Landscape Rating to get an Interim Landscape Rating.
7. Determine the pattern and flooding (inundation) characteristics, record them and assign appropriate deductions.
8. Determine the deduction for these factors based on a percentage of the Interim soil rating.
9. The final landscape rating is the basic rating (from 2) minus the coarse fragment deduction (from 5) and the other deduction (from 8).
10. You may wish to place the landscape factor into a capability class by using Table 2.1. At this time identify any factor which resulted in a greater than 15 point or percent deduction with the appropriate subclass symbol. For example, a final rating of 69 with 30% deducted for inundation would be classified as 2 I.

LANDSCAPE (L)

	Factors	Value		Point deduction	
1.	Region (from Fig. 6.1)	_____			
	percent slope	_____			
	landscape type	_____		_____	
	Basic landscape rating (T) = 100	–	_____	=	_____ a)

				Percent deduction	
2.	Coarse fragment modification				
	- stoniness (P)	_____	_____		
	- coarse fragments (P)	_____	_____		
	- wood content (J)	_____	_____		
	- coarse fragment deduction =		_____	% a) =	_____ b)
	Interim landscape rating = a)	_____	– b)	_____ =	_____ c)

3. Other modifications

- pattern (K)	_____	_____	
- flooding (I)	_____	_____	
Other deductions =		_____	% c) = _____ d)

4. FINAL LANDSCAPE RATING (L) = a) _____ – b) _____ – d) _____ = [ ]

= Class _____ , _____ _____ _____
subclass(es)

Figure 6.6 Work sheet for landscape rating.

Chapter 7

HOW TO USE THE SYSTEM

Previous chapters described the basic components developed for assessment of the suitability of land for the production of specified crops, in this case for spring-seeded small grains. This chapter discusses the procedures for application of the system and some common field problems.

Basically, use of the system involves rating each of the three components, climate, soil and landscape and includes the documentation of input data and rating decisions. The suitability class is determined by the most limiting component while the Subclasses indicate significant limiting factors in all three components.

7.1 The General Rating Procedure

a) The initial step is to compile the required data. The Data Input Document (Document 2, in pocket) may be convenient for this purpose but is not essential. It may be used as a check-off to ensure that all the input requirements are met or to identify gaps which must be collected or estimated. It also allows for documentation of the input data.

b) The second step is to document and rate the individual factors. The Tables and Figures are designed on a continuous scale basis rather than by classes or steps. This allows for interpolation beween values if desired. For example, the P–PE climatic index may be estimated off the map as −275 (about half way between −250 and −300). Using Figure 3.1, the point deduction can then be estimated at 25. Or, using this same value in the soil moisture assessment of a loam soil (Table 4.2) it would be necessary to interpolate between the 25 point deduction for −250 and the 40 point deduction for −300. A value of 33 would be appropriate.

c) The third step is to complete the final calculation and rating assessments.

Users of the system should note the following points:

1. There are point deductions for some factors and percentage deductions for others. In general, points are used for the primary or initial ratings and percentages for the modifying factors. This also facilitates the uniform application of a limitation.
2. Only one of the climatic aridity factor A or the soil moisture deficit factor M should be indicated on the final subclass rating. It is suggested that M (the soil factor) take precedence if it results in a deduction of more than 15 points greater than A (the basic climate factor).
3. Only the most limiting of pH, salinity and sodicity are used in the final deductions. These factors are closely correlated and use of all three would not be appropriate.
4. Deductions are made for subsurface salinity and sodicity only if the resulting deduction is greater than that for surface salinity and sodicity.
5. In situations where more than one parameter is available for evaluating a single factor, precedence should be given to measured values followed by the most limiting of proxies.

7.2 The Land Suitability Rating Document

The rating document (Document 1, in pocket) is intended to be used as an integral part of the rating process. It provides basic documentation of both the input data and the calculations.

This document should be completed for each tract of land that is rated. The document allows for the rating of two mineral soils, two landscapes and one organic soil which is adequate for most applications. In complex areas several documents may have to be used. The final rating can be adjusted appropriately to accommodate the ratings for the additional units.

7.3 A Sample Calculation

Following is an example taken from the parkland area of Alberta. It uses Documents 1 and 2 (Figure 7.1 and 7.2).

An additional 6 examples, covering a range of agricultural land conditions in Canada, are given in Appendix C.

DATA INPUT DOCUMENT
(Soil and Landscape factors)

1. LOCATION: *SW 16-46-7 W4* NAME: *WWP* DATE: *10/09/92*
- near Wainwright, Alberta

2. LANDSCAPE: (general) *undulating morainal area (hummocky)*
- trees around depressions

Slope characteristics: (steepness and length) *3% (2-6); 75 m*

Surface stoniness: (size and amount) *S1, mainly small*

Pattern: (kind and number of obstacles) *several (5) permanent sloughs*

Flooding: (duration and frequency) -

3. SOILS: (general) *Black Chernozemic soils, thin on knolls*
- wet soils (Gleysols) in depressions

Profile description: *(Elnora series)*

horizon	depth	texture*	structure	consistence	color	
1. *Ap*	*0-15*	*L*	*strong granular*	*friable*	*black*	*10YR 2/2*
2. *Bm*	*15-40*	*L-CL*	*prismatic sub.blocky*	*friable to firm*	*dk brown*	*10YR 4/4*
3. *Cca*	*40-55*	*L*	*blocky*	*friable to firm*	*grayish brown*	*10YR 5/2*
4. *Ck*	*55+*	*L-CL*	*massive*	*firm*	*brown*	*10YR 5/3*

* for organic soils use % rubbed fibre and % wood.

Depth to limiting horizon =

Laboratory analysis:

horizon	pH	O.C.	$CaCO_3$ /E.C.	bulk density	>2 mm	S	Si	C	*fibre other*
1. *Ap*	*6.5*	*3.8*	-	*1.20*	*<5*	*35*	*43*	*22*	
2. *Bm*	*7.0*	*1.2*	-	*1.45*	*<5*	*30*	*42*	*28*	
3. *Cca*	*7.8*	-	*18/*	*1.45*	*5*	*35*	*40*	*25*	
4. *Ck*	*7.9*	-	*12/1*	*1.50*	*5*	*40*	*34*	*26*	

Drainage: (general) *well drained*

- depth to water table:

4. COMMENTS: (variability, etc.)
- slopes vary from 2-6%
- depth of surface varies from 10 cm on knolls to 25 cm on lower slopes

Figure 7.1 Input data for sample calculation (Document 2).

DOC: 1a

LAND SUITABILITY RATING DOCUMENT

MAP AREA: *Wainwright* NAME: *WWP* DATE: *10/09/92*

SOIL (S)

Map Component 1. *Upland* *80* % 2. ______ %

	Name Value	deduction		value	Name deduction
1. Moisture factor (M)					
texture	*L(65)*	*23*			
subsoil text adj.	*L(70)*	± *0*			±
water table/% adj.		– *–*			–
moisture deduction		*23* c			c
2. Surface factors					
structure (D)	*gr/fr*	*0*			
org. C (F)	*3.8*	*0*			
depth (E)	*20*	*0*			
reaction (V)	*6.6*	*0*			
salinity (N)	*–*				
sodicity (Y)	*–*				
peaty (O)	*–*				
Basic Soil Rating = 100 - c		- *0*	= *77* d	100 - c	- ___ = ___ d
3. Subsoil factors					
impeding layer (D,R)					
struct.(density)	*1.5=10*				
depth/% adj.	*55=0.65*	*7*			
non-conform.	*–*	*–*			
reaction (V)	*7.7*	*0*			
salinity (N)	*1*	*0*			
sodicity (Y)	*–*	*–*			
Subsoil deduction =		*7* % d = *5* e		=	___ %d = ___ e
Interim Soil Rating =	d - e =	*72* f		d - e	= ___ f
4. Drainage factor (W)					
depth water table	*–*				
hydraul. cond.	*M*	*0*			
Drainage deduction	=	*0* % f = *0* g			___ %f = ___ g

FINAL SOIL RATING(S) = f - g = **72** S = f - g = ____

LANDSCAPE (L)

Map Component 1. *Upland* ____ % 2. ______ %

	value	deduction		value	deduction
1. Slope (T)					
steepness	*3* %			%	
landscape type	*complex*			m	
region	*2*	*28*			
Basic Landscape Rating = 100 -		*28*	= *72* a	100 -	___ = ___ a
2. Stoniness/Coarse fragment (%)		deduction			
stoniness (P)	*5*	*0*			
gravel (P)	*<5*	*0*			
wood (J)					
C.F. deduction	=	*0* % a = *0* b			___ %a = ___ b
Interim landscape rating	= a - b =	*72* c		a - b =	___ c
3. Other deductions (%)					
pattern (K)	*5?*	*5?*			
flooding (I)					
other deductions =		*5* % c = *4* d			___ %c = ___ d

FINAL LANDSCAPE RATING (L) = c - d) = **68** L = c - d = ____

Figure 7.2 Documentation of rating procedure (Document 1).

MAP AREA *Wainwright* NAME: *WWP* DATE: *10/09/92*

AGROCLIMATIC (C)

factor	value	deduction		
1. Moisture Component (A)				
P-PE Index	*-250*	*20*		
A = 100	-	*20*	=	*80*
2. Energy Component (H)				
EGDD Index	*1250*	*35*		
H = 100	-	*35*	=	*65*

Basic Climate rating is lowest of A or H= *65* a

factor	value	deduction
3. Modifying factors		
spring moisture	*-45*	*1*
fall moisture	____	____
local frost	____	____

modification deduction = *1* %a = *1* b

FINAL CLIMATE RATING (C) = a - b = [*64*]

ORGANIC SOILS (O)

1. Soil Climate (Z)
   - EGDD Index ____ ____
   - Organic base rating = 100 - ____ = ____ a
2. Moisture factor (M)
   - P-PE index ____
   - surface % fibre ____ ____ b
   - water table ____
   - subsurf. % fibre ____ ____ %b= ____ c
   - Moisture deduction = b - c = ____ d
3. Surface factors
   - struct. (% fibre) (B) ____ ____
   - reaction (V) ____ ____
   - salinity (N) ____ ____
   - Surface deduction = ____ e

Basic Organic Rating = a - d - e = ____ f

4. Subsurface factors
   - struct. (%fibre) (B) ____ ____
   - substrate (G)
     - texture ____
     - depth ____ ____
   - reaction (V) ____ ____
   - salinity (N) ____ ____
   - Subsurface deduction = ____ %f= ____ g

Interim Organic Rating = f - g = ____ h

5. Drainage factor (W)
   - depth water table ____
   - subsurf. % fibre ____ ____
   - Drainage deduction = ____ %h= ____ i

FINAL ORGANIC RATING (O) = h - i = [ ]

FINAL RATING CALCULATION

	index		class	factors		%
C=	*64*	or class	*2* ,	*H*	*A*	( )
S=	*72*	or class	*2* ,	*M*		( )
S=		or class	,			( )
O=		or class	*2* ,	*7*		( )
L=	*68*	or class	,			( )
L=		or class	,			( )

Index	Class
80-100	1
60-79	2
45-59	3
30-44	4
20-29	5
10-19	6
0-9	7

Final rating using: average [ ] ; complex [ ] ; most limiting [ ]

Symbol

C S(O) L = *2* Class *H* *M* *7* factors % *(80)*

2 *2* *2* classes

C S(O) L = ____ Class ____ ____ ____ factors ( )

____ ____ ____ classes

Comments

This is a landscape well suited for the production of small grains - slight limitations in all categories 2HM7

Figure 7.2 Documentation of rating procedure (Document 1) (cont.).

7.4 Common Field Problems

The majority of field problems associated with the application of the rating system relate to variability. Some factors, mainly those related or controlled by climate, vary in time (temporal variability). Others, usually related to topography, vary across the landscape (spatial variability). Both kinds must be dealt with. The problems outlined are not unique to this system but apply equally to any evaluation of the natural environment.

7.4.1 Climate

Climatic conditions can vary widely from year to year. This concern was addressed by using long-term (30 year) means. The approach is valid as long as the aim is to assess overall suitability or potential and not to model crop growth in any one year. Landscapes with substantial differences in relief commonly have associated micro-climates; air drainage may result in late spring and early fall frosts in the valleys, average growing seasons on the slopes may be substantially longer than those in the valleys, soils on north-facing slopes may warm up more slowly in the spring and thus the real growing season may be shorter than on the south-facing slopes or south-facing slopes may be more droughty. As long as these features are known and documented and can be mapped, they can be rated.

7.4.2 Soils

Soils commonly vary across a landscape and in some cases respond to seasonal differences as well. Following are some general considerations:

Texture will often vary with depth. The usual procedure is to use an average. In the subsurface, the whole depth (20 to 100 cm) should be considered unless there is a discontinuity in materials, in which case refer to the section on nonconforming layers in Chapter 4.

Structure and particularly consistence can change with moisture content. Moisture extremes should be avoided if possible with "moist" being the ideal. If there is a discrepancy between ratings of structure and consistence, use the most limiting.

Acidity can vary by up to one pH unit over the growing season so estimates to the nearest one-half unit are adequate. Also, more than one landscape position should be checked and an average or the least limiting value used.

Salinity is even more variable than pH with surface values commonly higher in the spring or after a prolonged dry spell. Vegetation growth, which tends to average annual variation, is often a better indicator than individual EC values.

Organic (peaty) surface horizons can decompose at a rate of 1 to 3 cm per year. Therefore, depths of less than 10 cm are dealt with in the sections on surface organic matter and depth (4.2.2, 4.2.3). The same is true for LFH or duff layers.

Drainage is a particularly difficult assessmemt depending, as it frequently does, on seasonal moisture distribution. A typical water table pattern for a poorly drained soil in central Canada (Figure 7.3) shows as much as 100 cm fluctuation. The average depth for the May 1 to 20 period would be 30 cm but it is easy to see

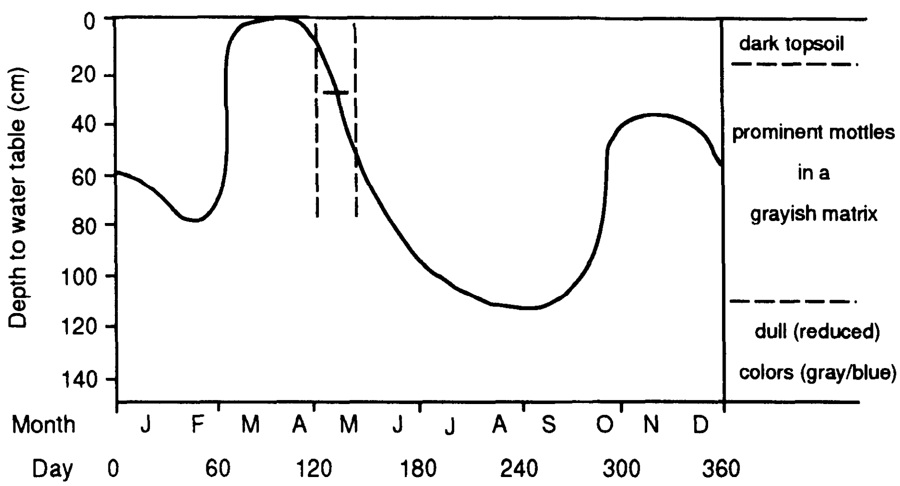


Figure 7.3 An annual water table curve for a poorly drained soil in the Ottawa area. Note the spring maximum, summer drawdown, fall recharge and some winter drainage. (G.C. Topp, personal communication).

how one-time observations of water table levels could be misleading. Soil or vegetation features often give a more realistic picture but in much of Canada natural conditions have been modified so they too must be used with caution.

7.4.3 Landform

Landscapes are seldom uniform at most scales of mapping. The two main concerns are how to assess slope and pattern.

Slope is usually expressed in terms of the **generally limiting slope.** This will be higher than the average but lower than the most extreme slope. For example, an area of hummocky terrain may have slopes ranging from 0 to 10%. The steeper slopes establish the management limitation and, even though 50% of the area will have slopes of less than 3%, it might be reasonably characterized as having a 7% slope. The slope length is the average length associated with the limiting slope.

7.4.4 Final Rating

How the area should be rated depends largely on how it can or will be managed. The management options are often related to pattern, a landform related issue describing a situation where two or more different soil areas occur within the landscape or field being rated. There are three main options:

(a) The sub-areas are **similar** enough that they will likely be **managed the same** way.
- the use of averages is appropriate in this situation
- for example, if soil texture ranged from sandy loam to silt loam, and average of loam could be assigned.

(b) The sub-areas are **contrasting** and must or should be **managed separately**.
- the areas should be rated separately and listed as a complex [e.g. 2T(60)–6W(40)] (see Figure 7.4 a).

(c) The sub-areas are **contrasting** but are so intimately mixed that they **cannot be managed separately**.
- the most limiting sub-area rating should be used (see Figure 7.4 b).

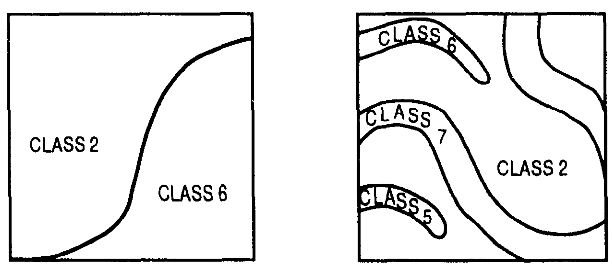
Two questions are pertinent to deciding which approach to use:
- are properties of the sub-areas contrasting?
- can the sub-areas be managed separately?

Sub-areas can be considered to be contrasting if:

(a) they differ by more than one suitability class (Class 2 vs Class 4 or Class 6), or

(b) if they have different kinds of limitations such that different management practices would be required in their use (4T vs 4W).

If the contrasting soils are so intimately associated that they can not be managed separately in producing the crops of interest, the area should be assigned a single suitability rating. A decision must then be made whether to assign an average rating or to rate on the basis of the most limiting factors. Figure 7.4 b) illustrates the kind of situation which can arise. In this example, a floodplain is so dissected that it is practically inaccessible. To average it to Class 4 is perhaps better than saying 60% Class 2, but still does not recognize the limitation properly. In this case Class 6 would be the most appropriate rating.



a) b)

Figure 7.4 Land areas with contrasting soils.
a) An area with two contrasting soils that can be managed separately.
b) A badly dissected area that should be rated as a single unit.

A practical approach to rating a parcel of land is to first determine if there is a contrasting component. If so, then rate it first. If there is another contrasting component rate it. Average the remainder into a third component. It is often necesssary to recognize two components in a unit, but it is suggested that 3 components should be used rarely and should be the maximum.

7.5 Obtaining Adequate Data

Data requirements need to be matched to the objectives of the assessment. A regional analysis, for example, would require less detailed information than a site rating and it is likely that existing resource inventories would suffice. Rating of individual parcels of land, on the other hand, would probably require on-site inspection. Climate assessments are a special case because the availability of local data is limited and it is usually necessary to rely on regional compilations.

The system has attempted to identify the controlling or critical factors responsible for the ratings and to separate these from the proxies that are often used in their place. For example, in the case of drainage it is really the water regime that is being rated and not soil taxonomy even though terms like Orthic Gleysol are used when actual measurements are not available. We have tried to clearly indicate the reasoning behind each rating so that users of the system, in the absence of the required data, can make reasoned decisions about alternate data or data sources. Where proxies are commonly used or can be used, these have been identified along with suggested correlations.

7.5.1 Climate

Climatic data may be estimated from Maps 1 and 2. If more detailed climatic information is available, it may be used. Care should be taken to ensure that the same procedures are followed so that the final estimates are broadly comparable to the estimates from the maps. As knowledge of relationships between climatic factors and the performance of specific crops improves, revision of the rating of climatic parameters, or of the parameters themselves may be necessary. Such modifications would not likely result in major changes of relative climatic ratings.

7.5.2 Soil and landscape

Soil and landscape data should be collected in the field as they are more site specific than climatic data. This is particularly important for the rating of specific tracts of land. In some cases, all of the required information may be available from detailed soil survey reports and maps. In others, where soil maps are not available or are of small scale and the pattern of soils and landscape is complex, on-site inspection, and perhaps sampling, may be necessary. It is important that users of this system avoid the uncritical application of generalized information for large regions to the rating of suitabilities of specific small tracts of land within the region. Aerial photographs are a particularly valuable aid in assessing local attributes and variability but should not substitute completely for on-site inspections. Care should be taken in choosing appropriate inspection sites and in evaluating the relevance of the site to the rest of the parcel under investigation.

For general suitability ratings at a regional scale, existing data may be used to develop reliable ratings with very little field work. Soil survey maps and reports usually provide the most comprehensive set of soil and landscape data, but other sources of information such as Municipal Assessment data, topographic and geological maps, and data from agronomic research should be considered where applicable.

The definitions and descriptions of soil and landscape parameters follow national standards (Expert Committee on Soil Survey, 1983; 1987) except that the description of stoniness classes is changed. Soil classification is not required but it may be used for estimating some of the soil parameters if other data are not available. For example, an Orthic Humic Gleysol will have a surface horizon enriched in organic matter, and a high water table in the spring unless it is drained.

Chapter 8

APPLICATIONS OF THE SYSTEM

The intent of this chapter is to indicate how the Land Suitability Rating System compares to other systems, some benefits and limitations of the system, how it can be used in land use planning and other land management decision making and how it can be modified for specific uses.

8.1 Comparison with the Canada Land Inventory: Soil Capability for Agriculture (CLI)

The Land Suitability Rating System differs from the CLI by being more specific and providing a means of documenting and quantifying the rating process. It also includes organic soils. While the format is different, the basic parameters are essentially the same (Table 8.1) and the "class" ratings are very similar. Therefore, changes resulting from the substitution of the present system for the CLI will be minor and there should be no substantial change in land use implications.

Table 8.1 A comparison of the Land Suitability Rating System with the CLI.

Component	CLI	Land Suitability
general	-capability	-suitability
	-11 factors	-17 factors
	-factors not indexed	-factors indexed
	-7 classes	-7 classes
	-limitation (specified)	-limitation (specified)
climate	-frost-free period	-growing season
	-annual precipitation	-moisture index (P–PE)
		-energy index (EGDD)
		-modifiers
soils	-structure	-structure
	-salinity	-salinity, sodicity
	-texture	-texture
	-drainage	-drainage
	-depth	-depth
	-erosion	-organic matter
	-fertility	-soil reaction
	-no organic rating	-organic rating
	-subjective	-specific
landscape	-topography	-slope steepness and length
	-stoniness	-stoniness
	-inundation	-inundation
		-pattern

8.2 Benefits and Limitations of the Land Suitability Rating System

8.2.1 Benefits

1. The system explicitly deals with climate, soils and landscape components.
2. The system accommodates all of the land base including organic soils.
3. Individual factors are identified and explicitly rated.
4. The system provides for documentation of the process.
5. The system is independant of scale.
6. The input requirements are commonly available in most natural resource inventories or soil surveys.
7. The system is flexible. The separation of climate, soils and landscape components facilitates adaptations to a variety of crop, soil quality or land use analyses.
8. The assessments can be converted to algorithms and the final ratings automatically generated.

8.2.2 Limitations

1. The system is designed to assess arable agriculture and cannot be used (without modification) for any other purpose such as carrying capacity for livestock.
2. The system is designed to assess capability for sustained agricultural production. It is not an assessment of crop productivity, which also relies on species selection, management inputs and annual climatic variation.
3. The system does not address unusual nutrient deficiencies (or excesses) in mineral soils.
4. The system does not indicate "best" use or "most profitable" use; these include social and economic considerations.
5. The system does not correspond exactly to previous systems therefore ratings may differ somewhat at both site specific and regional levels. This may affect planning decisions based on past ratings.
6. The system is not process based and cannot be used as a crop growth model.
7. The system is an assessment under a given set of conditions and does not reflect either potential or direction for soil quality change. However recalculation under different conditions could be useful in such an assessment.

8.3 Relationship of Land Suitability Rating to Land Use Planning

The function of land use planning is to guide the decisions on land use in such a way that the resources of the environment are put to the most beneficial use for man, whilst at the same time conserving those resources for the future (FAO, 1976). Land use planning, thus, requires land evaluation: a comparison of the benefit obtained (or potentially obtainable) and the inputs required for different potential uses of land. Ideally land evaluation includes assessment of both the natural resource (physical land evaluation) and socioeconomic aspects (integral land evaluation) of the use of land (Smit et al., 1984).

An agricultural rating is part of a physical land evaluation. In areas where agriculture is the main endeavor it may be the only physical component involved. In areas of competing use of the natural resource base it would be only one of several evaluations which might include forestry, wildlife or industrial assessments. The point is that agricultural rating is only part of the planning process. In some instances it has been used exclusively in land use plans to a) allow for alienation of public lands if over a specified rating or b) allow subdivision if below a particular value. This might or might not be an appropriate use but it must be stressed that it is not the rating system **per se** which governs the land use but rather the decision of the planning body to use the rating system and to define specific critical values.

This system includes not only the identification of specific kinds of limitations for the specified crops but also rates the seriousness of those limitations. This makes it possible for planners to consider not only the present suitability of the land but also to estimate the kinds and costs of management options to overcome those limitations. For example, a climatic limitation such as inadequate heat units for the specified crops would preclude further consideration of that use of the land. However, a soil limitation such as poor drainage might have a practical solution which could be subjected to a cost-benefit analysis. This could include an analysis of the environmental effects.

8.4 Application to Disturbed/Reclaimed Lands

The system can be used to assess the agricultural suitability or capability of land before and after disturbance. The component factors are all measurable climate, soil or landscape features that affect plant growth. As they are not dependent on undisturbed sites or taxonomic classifications, the fact that the pre- and post-conditions may be quite different in terms of the soil and landscape characteristics should in no way reduce the reliability of the suitability assessment. The kinds and degrees of limitation may be different but the comparative assessment should be valid. Also, if the disturbed or reclaimed condition had a lower capability than prior to disturbance, the specific limitations would be clearly identified and remedial measures could be designed.

8.5 Application to Land Assessment

Information from capability and productivity ratings have aided land assesssors for many years. This system will provide improved information for that purpose as the basis of the ratings is more clearly spelled out and the ratings will be uniform throughout the country. It must be pointed out, however, that the physical suitability of land for production of specified crops is only one of the factors that influence land assessment.

8.6 Application of the System for Other Crops

The majority of factors in the system relate to plant growth. It follows that using the same factors but altering the rating scales could modify the system to provide suitability ratings for other crops. Or, modifications to the landscape component could rate different managements requirements. A suitability rating for sugar beets, for exmaple, would need to recognize different class limits for the climatic parameters and, if irrigated, the slope ratings would also need to reflect different limitations.

Forestry is another area to which the system might be applied. While the individual ratings might change, the factors would still be applicable.

8.7 Application to Soil Quality Assessments

This report describes a procedure for determining the suitability of a tract of land for the production of a particular crop(s). While not explicitly stated, it is understood that sustainability is a key consideration. As quality is defined as "fitness for use", it is clear that any assessment of suitability must also be a statement of quality. In this instance, the use is specified as the suitability for spring-seeded small grains and the system provides a measure of quality for a specified set of conditions. In so doing, it assesses climate, soil and landscape quality as well as the combined "land" quality.

Soil quality change can be evaluated by applying the system before and after a period of time, after a particular incident such as a wind erosion event or by assignment of specific values. The issue then becomes whether or not the system is sensitive enough to respond to the changes in question.

8.8 Continuing Development of the System

There are a number of initiatives being planned to continue the development of this procedure including:

a) to evaluate the system and modify as required,

b) to develop specific rating scales for other important crops or groups of crops such as corn, alfalfa or grasses and,

c) to develop, for this and future developments, a series of computerized algorithms for the automatic calculation of ratings.

In addition, users are encouraged to contact the Chair, Agronomic Interpretations Working Group with any comments on the present system or suggestions for continuing development.

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APPENDICES

APPENDIX A. SUPPLEMENTARY DATA IN SUPPORT OF THE RATING SYSTEM

A.1 Water Holding Capacity

Soil material larger than 2 mm in diameter holds little water and its volume reduces the available water capacity of the soil by an equivalent amount. Thus, a soil with 25% coarse fragments would have only 75% as much available water as the same soil without gravel or stones. For soils having less than 5% coarse material this factor is generally ignored. However, if it is important, the texture rating should be modified as follows. Reduce the appropriate water holding capacity by an amount equal to the % coarse material.

For example, consider a loam soil with 30% gravel or cobbles (by volume)

- without the gravel the AWHC would be about 150 mm/m
- with the 30% reduction the AWHC would be 70% of 150 or about 105 mm/m — about equivalent to that of sandy loam.

In Chapter 4, Table 4.2 showed the combined climate–soil deductions. The following table separates the climate (base rate) and soil contributions.

Table A.1 Soil texture contribution to moisture stress limitation.

Climate index	Base rate	% C + Si texture	S	20 LS	40 SL	60 L	70 CL	75 SiL	80 C	85 SiCL	95 SiC	95 HC
0	0		15	0	0	0	0	0	0	0	0	0
–50	0		25	5	0	0	0	0	0	0	0	0
–100	0		35	10	0	0	0	0	0	0	0	0
–150	0		45	25	5	0	0	0	0	0	0	0
–200	10		45	30	10	0	0	0	0	0	0	0
–250	20		45	30	15	5	0	0	0	0	0	0
–300	30		45	30	20	10	0	0	0	0	0	0
–350	40		45	30	20	10	5	0	0	0	0	0
–400	50		40	30	20	10	5	5	0	0	0	0
–450	60		35	30	20	10	5	5	0	0	0	0
–500	70		25	25	20	10	5	5	5	0	0	0

A.2 Relationship of Structure, Consistence and Texture to Bulk Density of Mineral Soils

Bulk density is not easily measured in the field but there are some general relationships with structure, consistence and texture which can be used for estimating resistance to root growth (Table A.2). The reader should be aware that these are common or usual relationships but are not absolute.

Table A.2 Common relationships between kind of horizon, structure, consistence, texture and bulk density.[1]

Kind of horizon	Common structure	Common consistence dry/moist	S LS	Texture class SL	L	SiL CL	SiCL SiC	C
Ah	granular	sl. hard friable	1.30	1.20	1.15	1.10	1.00	0.95
Ae	platy, massive	soft, sl. hard friable	1.45	1.40	1.35	1.30	1.30	–
Ap (>1% OC)	granular	friable	1.40	1.35	1.25	1.20	1.10	1.05
Ap (<1% OC)	massive	soft-hard friable-firm	1.40	1.40	1.40	1.35	1.30	1.25
Bm	subangular prismatic	sl. hard friable-firm	1.50	1.45	1.40	1.40	1.35	1.30
Btj	blocky prismatic	hard firm	1.50	1.50	1.45	1.45	1.45	1.40
Bt	blocky	hard-v. hard firm-v. firm	–	1.55	1.55	1.55	1.50	1.45
Btnj	blocky-columnar	v. hard v. firm	–	1.55	1.55	1.55	1.50	1.45
Bnt	columnar-blocky	ex. hard ex. firm	–	1.60	1.60	1.65	1.60	1.50
Bn	columnar-massive	ex. hard ex. firm	–	–	1.65	1.65	1.60	1.50
Bf	wk. granular massive	sl. firm friable	1.40	1.30	1.10	0.90	–	–
BCc	massive	ex. firm	–	1.80	1.80	1.80	–	–
BCx	massive	ex. firm	–	1.80	1.80	1.80	–	–

[1]Core method.

A.3 Comparison of Fibre Content, Degree of Decomposition, Bulk Density, Water Holding Capacity and Hydraulic Conductivity in Organic Soils

As with mineral soils, key factors such as bulk density and various water relationships are often difficult and time consuming to obtain. Relationships between these factors and degree of decomposition or fibre content have been studied by Boelter (1974) and Paivanen (1973) among others and the following summary, taken from their work (Table A.3), is used as a basis for the rating in this report. It must be emphasized that these represent only general relationships and are to be used when more specific data are not available.

Table A.3 General relationships between fibre content, bulk density and various water characteristics for organic soils.

Category		|	fibric	|	mesic			|		humic	
% rubbed fibre[1]	80		60	40	30		20	10	5		0
% unrubbed fibre	90			60				30			
von Post scale	1	2	3	4	5		6	7	8	9	10
Bulk density	0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20		0.22
(Mg/m^3)											
average/class			0.07				0.15		0.20		
Water holding capacity			(% by volume)								
0 kPa/m (sat.)[2]	95			90				85			82
10 KpA/m (F.C.)	30		40	50			66	72	71		70
1500 kPa/m (W.P.)	6		10	12			16	20	21		22
"available water"	24		30	38			50	52	50		48
"free drain water"	65			40				13			12
Hydraulic conductivity (cm/hr)[3]	50		15	5.0	1.5		0.5	0.15	0.05		
	high		|	moderate			|		low		

[1]Fibre >0.15 mm.
[2]Sat. = saturation; F.C. = field capacity; W.P. = wilting point.
[3]Categories recommended by Expert Committee on Soil Survey.

APPENDIX B. GLOSSARY

The following definitions were taken mainly from Canadian Society of Soil Science (1976) supplemented by Soil Conservation Society of America (1976).

A horizon A mineral horizon formed at or near the surface in the zone of removal of materials in solution and suspension, or maximum accumulation of organic carbon, or both.

Ae A horizon that has been eluviated of clay, iron, aluminum, or organic matter, or all of these.

Ah A horizon in which organic matter has accumulated as a result of biological activity.

Ap A horizon markedly disturbed by cultivation or pasture.

acid soil A soil having a pH of less than 7.0.

aggregate A group of soil particles cohering so as to behave mechanically as a unit.

alkaline soils Any soil that has pH greater than 7.0.

arable Tillage; agricultural production based on cultivation practices; land that is cultivated or capable of being cultivated. Arable is used as a comparison to agriculture based on grazing (non-cultivated) systems.

B horizon A subsoil horizon characterized by one of:

a) an enrichment in clay, iron, aluminum, or humus (Bt or Bf).

b) a prismatic or columnar structure that exhibits pronounced coatings or stainings associated with significant amounts of exchangeable sodium (Bn or Bnt).

c) an alteration by hydrolysis, reduction, or oxidation to give a change in color or structure from the horizons above or below, or both (Bm).

bedrock The solid rock underlying soils and the regolith or exposed at the surface.

bog A peat-covered or peat-filled wetland, generally with a high water table. The water of a bog is generally acid and low in nutrients. Bogs usually support a black spruce forest but may also be treeless. They are usually covered with sphagnum and feather mosses and ericaceous shrubs.

Brunisolic An order of soils whose horizons are developed sufficiently to exclude them from the Regosolic Order but lack the degrees or kinds of horizon development specified for soils in other orders. They always have Bm or Btj horizons.

bulk density, soil The mass of dry soil per unit bulk volume.

C horizon A mineral horizon comparatively unaffected by the pedogenic processes operative in the A and B horizons except for the process of gleying (Cg) or the accumulation of calcium carbonate (Cca) or other salts (Csa). A naturally calcareous C horizon is designated Ck.

calcareous soil Soil containing sufficient calcium carbonate (often with magnesium carbonate) to effervesce visibly when treated with cold 0.1 N hydrochloric acid.

capability An assessment which focuses on the nature and degree of limitations imposed by the physical characteristics of a land unit for a certain use (Smit et al., 1984).

capability class (soil) The class indicates the general suitability of the soils for agricultural use. It is a grouping of subclasses that have the same relative degree of limitation or hazard. The limitation or hazard becomes progressively greater from Class 1 to Class 7.

capability subclass (soils) This is a grouping of soils with similar kinds of limitations and hazards. It provides information on the kind of conservation problem or limitation. The class and subclass together provide the map user with information about the degree and kind of limitation for broad land use planning and for the assessment of conservation needs.

cation An ion carrying a positive charge of electricity; the common soil cations are calcium, magnesium, sodium, potassium, and hydrogen.

cation exchange capacity (C.E.C.) A measure of the total amount of exchangeable cations that can be held by the soil; it is expressed in terms of cmols per kg of soil (formerly meq/100 g).

Chernozemic An order of soils that have developed under xerophytic or mesophytic grasses and forbs, or under grassland-forest transition vegetation, in cool to cold, subarid to subhumid climates. The soils have a dark-colored surface (Ah, Ahe or Ap) horizon and a B or C horizon, or both, of high base saturation. The order consists of the Brown, Dark Brown, Black and Dark Gray great groups.

chroma The relative purity, strength, or saturation of a color; directly related to the dominance of the determining wavelength of the light and inversely related to grayness; one of the three variables of color.

classification, soil The systematic arrangement of soils into categories and classes on the basis of their characteristics. Broad groupings are made on the basis of general characteristics and subdivisions on the basis of more detailed differences in specific properties.

clay As a particle-size term: a size fraction mm equivalent diameter.

clod A compact, coherent mass of soil produced by digging or plowing.

coarse fragments Rock or mineral particles 2.0 mm in diameter.

coarse texture The texture exhibited by sands, loamy sands, and sandy loams except very fine sandy loam. A soil containing large quantities of these textural classes.

consistency (i) The resistance of a material to deformation or rupture. (ii) The degree of cohesion or adhesion of the soil mass. Terms used to describe a moist soil are - loose, very friable, friable, firm, very firm, compact, very compact, and extremely compact. Terms used to describe dry soils are - loose, soft, slightly hard, hard, very hard and extremely hard.

control section The vertical section upon which soil classification is based.

drainage Soil drainage refers to the frequency and duration of periods when the soil is not saturated. Terms used are - excessively, well, moderately, imperfectly and poorly drained.

droughty soil Sandy or very rapidly drained soil.

dryland farming The practice of crop production in low-rainfall areas without irrigation.

eolian Material that has been deposited by wind action.

erosion The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep.

evapotranspiration The combined loss of water from a given area and during a specific period of time, by evaporation from the soil surface and by transpiration from plants.

fen A peat-covered or peat-filled wetland with a water table which is usually at or above the surface. The waters are mainly nutrient-rich, minerotrophic waters from mineral soils. The vegetation consists mainly of sedges, grasses, reeds and brown mosses with some shrub cover and at times, a scanty tree layer.

fertility, soil The status of a soil with respect to the amount and availability of elements necessary for plant growth.

fibric An organic layer containing large amounts of weakly decomposed material whose origins are readily identifiable.

fine texture Consisting of or containing large quantities of the fine fractions, particularly of silt and clay.

floodplain The land bordering a stream, built up of sediments from overflow of the stream and subject to inundation when the stream is at flood stage.

fluvial Material that has been transported and deposited by streams and rivers. Also alluvial.

friable A consistency term pertaining to the ease of crumbling of soils.

frost-free period Season of the year between the last frost of spring and first frost of fall.

Gleysolic An order of soils developed under wet conditions and permanent or periodic reduction. These soils have low chromas, or prominent mottling, or both, in some horizons. The great groups Gleysol, Humic Gleysol and Luvic Gleysol are included in the order.

gravelly Containing appreciable or significant amounts of gravel (particles 2 to 75 mm in diameter).

groundwater That portion of the hydrosphere which at any particular time is either passing through or standing in the soil and the underlying strata and is free to move under the influence of gravity.

growing degree days (GDD) The accumulated heat units above a threshold temperature of 5°C. They are calculated as (mean daily temperature - 5) x days.

horizon A layer in the soil profile approximately parallel to the land surface with more or less well-defined characteristics that have been produced through the operation of soil forming processes. Soil horizons may be organic or mineral.

hue One of the three variables of color. It is caused by light of certain wavelengths and changes with the wavelength.

humic An organic layer of highly decomposed material containing little fibre.

hummocky Abounding in rounded or conical knolls or mounds, generally of equidimensional shape and not ridge-like.

immature soil A soil with indistinct or only slightly developed horizons.

impeded drainage A condition which hinders the movement of water through soils under the influence of gravity.

impervious Resistant to penetration by fluids or by roots.

indicator plants Plants characteristic of specific soil or site conditions.

infiltration The downward entry of water into the soil.

irrigation The artificial application of water to the soil for the benefit of growing crops.

lacustrine Material deposited in lake water and later exposed.

land evaluation An assessment which involves economic and social analyses as well as physical capability. It generally involves a comparison of more than one use and is often associated with changes in land use.

landscape All the natural features such as fields, hills, forests, water, etc., which distinguish one part of the earth's surface from another part. Usually that portion of land or territory which the eye can comprehend in a single view, including all its natural characteristics.

lithic A feature of a soil subgroup which indicates a bedrock contact within 50 cm of the soil surface.

loam See soil texture. A mixture of sand, silt and clay. It is not related to color.

loose A soil consistency term.

Luvisolic An order of soils that have eluvial (Ae) horizons, and illuvial (Bt) horizons in which silicate clay is the main accumulation product. The soils developed under forest of forest-grassland transition in a moderate to cool climate. The Gray Luvisol great group is the most common in western Canada.

medium texture Intermediate between fine-textured and coarse-textured (soils). (It includes the following textural classes: very fine sandy loam, loam, silt loam, and silt).

mesic An organic layer of intermediately decomposed material (between that of fibric and humic).

moderately-coarse texture Consisting predominantly of coarse particles. (In soil textural classification, it includes all the sandy loams except the very fine sandy loam).

moderately-fine texture Consisting predominantly of intermediate and fine sized particles. (In soil textural classification, it includes clay loam, sandy clay loam, and silty clay loam).

morphology, soil The physical constitution, particularly the structural properties, of a soil profile as exhibited by the kinds, thickness and arrangement of the horizons and by the structure, consistence and porosity of each horizon.

Munsell color system A color designation system that specifies the relative degree of the three simple variables of color: hue, value, and chroma. For example: 10YR 6/4 is a color with a hue 10-YR, value -6, and chroma -4. These notations can be translated into several different systems of color names as desired. See chroma, hue, and value.

neutral soil A soil in which the surface layer, at least to normal plow depth, is neither acid nor alkaline in reaction.

Organic An order of soils that have developed dominantly from organic deposits. The majority of organic soils are saturated for most of the year, unless artificially drained. The great groups include Fibrisol, Mesisol, Humisol and Folisol.

organic matter The decomposition residues of biological materials derived from: (a) plant and animal materials deposited on the surface of the soils; and (b) roots and micro-organisms that decay beneath the surface of the soil.

paralithic Poorly consolidated bedrock which can be dug with a spade when moist. It is severely constraining but not inpenetrable to roots.

parent material The unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of a soil is developed by pedogenic processes.

particle size The effective diameter of a particle measured by sedimentation, sieving, or micrometric methods.

peat Unconsolidated soil material consisting largely of organic remains (mainly derived from mosses or sedges).

pedology Those aspects of soil science involving especially the constitution, distribution, genesis and classification of soils.

percolation, soil water The downward movement of water through soil; especially, the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of 1.0 or less.

pH, soil The negative logarithm of the hydrogen-ion activity of a soil. The degree of acidity (or alkalinity) of a soil as determined by means of glass, quinhydrone, or other suitable electrode or indicator at a specified moisture content of soil-water ratio, and expressed in terms of the pH scale.

platy Consisting of soil aggregates that are developed predominately along the horizontal axes, laminated; flaky.

productivity A measure of the physical yield of a particular crop. It must be related to a specified management. Productivity may be used to describe or define suitability but it would be inappropriate as a definition of capability which puts more emphasis on vulnerability or flexibility - on available options - rather than simply yields.

profile, soil A vertical section of the soil through all its horizons and extending into the parent material.

reaction, soils The degree of acidity or alkalinity of soil, usually expressed as a pH value.

reconstructed soil A soil profile formed by selected placement of suitable overburden materials on reshaped spoils.

Regosolic An order of soils having no horizon development or development of the A and B horizons insufficient to meet the requirements of the other orders. Included are Regosol and Humic Regosol great groups.

residual material Unconsolidated and partly weathered mineral materials accumulated by disintegration of consolidated rock in place.

saline soil A nonalkali soil containing soluble salts in such quantities that they interfere with the growth of most crop plants. The conductivity of the saturation extract is greater than 4 dS/m (formerly mmhos/cm), the exchangeable-sodium percentage is less than 15, and the pH is usually less than 8.5.

salinization The process of accumulation of salts in soils.

sand A soil particle between 0.05 and 2.0 mm in diameter.

saturation percentage The amount of water required to saturate a unit of soil (often correlated with sodicity).

silt A soil separate consisting of particles between 0.05 to 0.002 mm in equivalent diameter.

soil The unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

sodicity A measure of the amount of sodium on the exchange complex (often expressed as sodium adsorption ratio - SAR).

soil map A map showing the distribution of soil types or other soil mapping units in relation to the prominent physical and cultural features of the earth's surface.

soil moisture Water contained in the soil.

soil potential Land evaluation at a local scale. It is determined using a process of comparing locally occurring soil landscapes on the basis of productivity and cost of managing limitations. Suitability assessments can be a useful support to the analyses in the identification and ranking of limitations.

soil structure The combination or arrangement of primary soil particles into secondary particles, units or peds. These secondary units may be, but usually are not, arranged in the profile in such a manner as to give a distinctive characteristic pattern. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively. Common terms for kind of structure are - single grain, amorphous, blocky, subangular blocky, granular, platy, prismatic and columnar.

soil survey The systematic examination, description, classification, and mapping of soils in an area. Soil surveys are ranked according to the kind and intensity of field examination.

Solonetzic An order of soils developed mainly under grass or grass-forest vegetative cover in semiarid to subhumid climates. The soils have a stained brownish or blackish solonetzic B (Bn, Bnt) horizon and a saline C horizon. The order includes the Solonetz, Solodized Solonetz and Solod great groups.

solum (plural sola) The upper horizons of a soil in which the parent material has been modified and within which most plant roots are confined. It consists usually of A and B horizons.

subsoil Although a common term it cannot be defined specifically. It may be the B horizon of a soil with a distinct profile. It can also be defined as the zone below the plowed soil in which roots normally grow. In this publication it refers to the soil material between 20 cm and 100 cm depth.

suitability (crop) An estimate of the fitness of a given type of land for a specified use (FAO, 1976). It is usually local or regional in scope and management may be implicated or may have to be specified.

texture The relative proportions of sand, silt and clay (the soil separates). It is described in terms such as sand (S), loamy sand (LS), sandy loam (SL), loam (L), silt loam (SiL), clay loam (CL), silty clay loam (SiCL) and clay (C). See chart below.

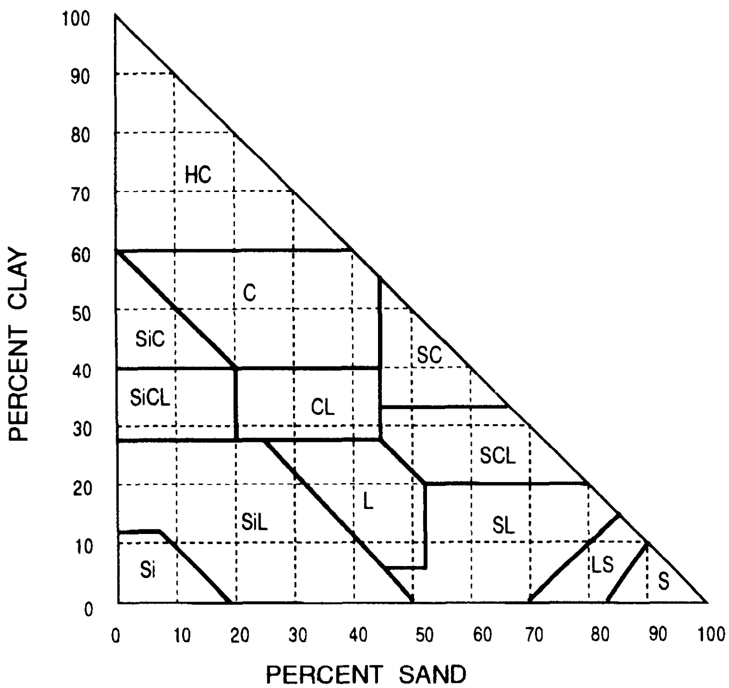
till Unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel, and boulders intermingled in any proportion.

value, color The relative lightness of intensity of color and approximately a function of the square root of the total amount of light. One of the three variables of color.

von Post humification scale A manual method for estimating degree of decomposition of peat materials. It is a 10 point scale with assessment based on color of drained water and structure of hand squeezed material.

water table The upper surface of groundwater or that level below which the soil is saturated with water.

weathering The physical and chemical disintegration, alteration and decomposition of rocks and minerals at or near the earth's surface by atmospheric agents.



Soil texture classes. Percentages of clay and sand in the main textural classes of soils; the remainder of each class is silt.

APPENDIX C. CALCULATION OF THE DAYLENGTH FACTOR

It must be recognized that this is simply an index and is not meant to represent absolute relationships. Because of the controversy over the specifics of both the effect of longer days and the effectiveness of twilight hours for photosynthesis, some arbitrary decisions were taken. The following assumptions were made:

1. June 21 was taken as the reference date.
2. Civil Daylength (CD), which includes civil twilight, was used.
   - calculated from Smithsonian Meteorological tables
3. Because June 21 is the extreme in daylength and as the period of plant growth extends over several months, a value of 1/2 the difference calculated on June 21 was used.

The daylength factor then becomes:

$$\text{Daylength Factor} = 1 + \frac{(\text{CD @ } n^\circ \text{ N} - \text{CD @ } 49^\circ \text{ N}) \times 1/2}{\text{CD @ } 49^\circ \text{ N}}$$

The values so calculated range from 0 at 49° N to 1.136 at 60° N. Above 60° N twilight quickly becomes continuous on June 21 and the point of 24 hour light saturation is attained, resulting in a maximum factor of 1.18.

Table A.4 Daylength factor for latitudes north of 49° N

Degrees	49	50	52	54	56	58	60	61	62+
Factor	1.000	1.008	1.020	1.036	1.058	1.088	1.136	1.180	1.180

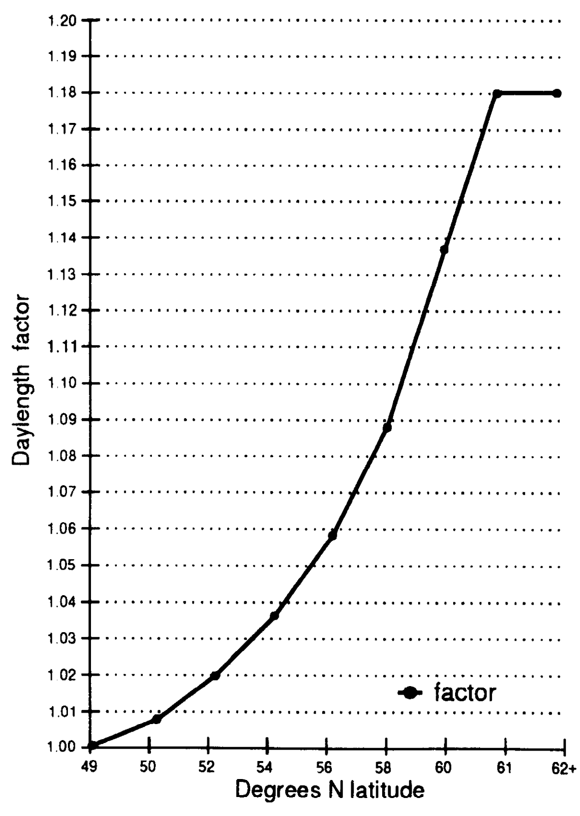


Figure A.1
Daylength factor for latitudes north of 49° N

APPENDIX D. SAMPLE CALCULATIONS

Six examples of typical situations covering a range of conditions are included to illustrate application of the system.

Example	Location	Issue	Rating	Page
1	Nova Scotia	perched water table	4WDT	70
2	Quebec	tile drained	2W	73
3	Saskatchewan	hummocky topography moisture limitation	4TM	76
4	Yukon	temperature limitation	5HM	79
5	Manitoba	organic soil	5BVH	82
6	Ontario	complex landscape	4WD(70) 6WV(30)	85

Example #1

DATA INPUT DOCUMENT
(Soil and Landscape factors)

1. LOCATION: *20T MQ 7086 9615* NAME: *DAH* DATE: *18/09/92*
   - near Shubenacadie, Nova Scotia

2. LANDSCAPE: (general) *undulating to rolling*

   Slope characteristics: (steepness and length) *3% to north, 150 m*

   Surface stoniness: (size and amount) *S2, some S3*

   Pattern: (kind and number of obstacles) -

   Flooding: (duration and frequency) -

3. SOILS: (general) *Reddish soils with dense hardpan at 30–50 cm*
   - many mottles

Profile description: *(Queens soil)*

horizon	depth	texture*	structure	consistence	color	
1. *Ap*	*0–20*	*L*	*moderate granular*	*friable*	*gray brown*	*10YR 5/2*
2. *Bf*	*20–35*	*L*	*granular*	*friable*	*brown*	*7.5YR 5/4*
3. *Btg*	*35–60*	*L*	*blocky*	*very firm*	*reddish brown*	*5YR 4/4*
4. *C*	*60+*	*L*	*massive*	*extremely firm*	*reddish brown*	*5YR 3/4*

* for organic soils use % rubbed fibre and % wood.

Depth to limiting horizon = *35 cm*

Laboratory analysis:

horizon	pH	O.C.	$CaCO_3$ /E.C.	bulk density	>2 mm	S	Si	C	H.C./ cm/hr
1. *Ap*	*5.9*	*2.9*		*1.4*	*5*	*42*	*38*	*20*	*5.6*
2. *Bf*	*5.3*	*1.6*		*1.5*	*5*	*41*	*36*	*23*	
3. *Btg*	*5.5*	–		*1.7*	*10*	*41*	*33*	*26*	*0.4*
4. *C*	*6.9*	–		*1.8*	*10*	*42*	*35*	*23*	*0.06*

Drainage: (general) *Imperfect, wet in spring and after heavy rains.*

- depth to water table: *perched (assume 75 cm)*

4. COMMENTS: (variability, etc.)
   - depth to impeding layer varies from 30–60 cm
   - stoniness varies from S1 to S3
   - nearby areas have slopes of 5 to 6%

LAND SUITABILITY RATING DOCUMENT

MAP AREA: *Nova Scotia* NAME: *DAH* DATE: *18/09/92*

SOIL(S)

Map Component 1. *Upland* *100* % 2. ____ %

	Name Value	deduction		Name value	deduction	
1. Moisture factor (M)						
texture	*L*	*0*				
subsoil text adj.	*L*	± *0*			±	
water table/% adj.	*75*	- *-*			-	
moisture deduction		*0* c			c	
2. Surface factors						
structure (D)	*mod.gr.*	*0*				
org. C (F)	*2.9*	*2*				
depth (E)	*20*	*-*				
reaction (V)	*5.9*	*1*				
salinity (N)						
sodicity (Y)						
peaty (O)						
Basic Soil Rating = 100 - c		- *3*	= *97* d	100 - c	-	= ____ d
3. Subsoil factors						
impeding layer (D,R)						
struct.(density)	*1.7=50*					
depth/% adj.	*35=0.80*	*40*				
non-conform.	*-*					
reaction (V)	*5.5*	*2*				
salinity (N)	*-*					
sodicity (Y)	*-*					
Subsoil deduction =		*42* % d	= *41* e	=	%d	= ____ e
Interim Soil Rating =	d - e =	*56* f		d - e	=	____ f
4. Drainage factor (W)						
depth water table	*75*					
hydraul. cond.	*0.4*	*45*				
Drainage deduction	=	*45* % f	= *25* g		%f	= ____ g

FINAL SOIL RATING(S) = f - g = *31* S = f - g = [ ]

LANDSCAPE (L)

Map Component 1. ____ % 2. ____ %

	value	deduction		value	deduction	
1. Slope (T)						
steepness	*3* %			%		
landscape type	*100*			m		
region	*1*	*28*				
Basic Landscape Rating = 100 -		*28*	= *72* a	100 -		= ____ a
2. Stoniness/Coarse fragment (%)		deduction				
stoniness (P)	*S2(0.2)*	*10*				
gravel (P)	*5*	*0*				
wood (J)						
C.F. deduction	=	*10* % a	= *7* b		%a	= ____ b
Interim landscape rating = a - b =		*65* c		a - b =	____ c	
3. Other deductions (%)						
pattern (K)	*-*	*-*				
flooding (I)						
other deductions =		*-* % c	= ____ d		%c	= ____ d

FINAL LANDSCAPE RATING (L) = c - d) = *65* L = c - d = [ ]

MAP AREA *Nova Scotia* NAME: *DAH* DATE: *18/09/92*

AGROCLIMATIC (C)

factor	value	deduction	
1. Moisture Component (A)			
P-PE Index	-125	0	
A = 100	-	0	= 100
2. Energy Component (H)			
EGDD Index	1500	10	
H = 100	-	10	= 90

Basic Climate rating is lowest of A or H= 90 a

factor	value	deduction
3. Modifying factors		
spring moisture	-5	4
fall moisture	+40	4
local frost		

modification deduction = 8 %a = 7 b

FINAL CLIMATE RATING (C) = a - b = [83]

ORGANIC SOILS (O)

1. Soil Climate (Z)
   - EGDD Index ______ ______
   - Organic base rating = 100 - ______ = ______ a
2. Moisture factor (M)
   - P-PE index ______
   - surface % fibre ______ ______ b
   - water table ______
   - subsurf. % fibre ______ ______ %b= ______ c
   - Moisture deduction = b - c = ______ d
3. Surface factors
   - struct. (% fibre) (B) ______ ______
   - reaction (V) ______ ______
   - salinity (N) ______ ______
   - Surface deduction = ______ e

Basic Organic Rating = a - d - e = ______ f

4. Subsurface factors
   - struct. (%fibre) (B) ______ ______
   - substrate (G)
     - texture ______
     - depth ______ ______
   - reaction (V) ______ ______
   - salinity (N) ______ ______
   - Subsurface deduction = ______ %f= ______ g

Interim Organic Rating = f - g = ______ h

5. Drainage factor (W)
   - depth water table ______
   - subsurf. % fibre ______
   - Drainage deduction = ______ %h= ______ i

FINAL ORGANIC RATING (O) = h - i = [ ]

FINAL RATING CALCULATION

	index		factors			%
C=	83	or class 1,				( )
S=	31	or class 4,	W	D		( )
S=		or class ,				( )
O=		or class ,				( )
L=	65	or class 2,	7			( )
L=		or class ,				( )

Index	Class
80-100	1
60-79	2
45-59	3
30-44	4
20-29	5
10-19	6
0-9	7

Final rating using: average [ ] ; complex [ ] ; most limiting [ ]

Symbol

C S(O) L = 4 Class W D 7 factors % ( )

1 4 2 classes

C S(O) L = ___ Class ___ ___ ___ factors ( )

___ ___ ___ classes

Comments

A marginal situation due to impeded drainage caused by an impermeable subsoil 4WD7

Example #2

DATA INPUT DOCUMENT
(Soil and Landscape factors)

1. LOCATION: *45°36'N 73°14'W - near St-Thomas, Quebec* NAME: *MCN* DATE: *18/09/92*

2. LANDSCAPE: (general) *flat lacustrine plain*

   Slope characteristics: (steepness and length) *nearly level, <1%*

   Surface stoniness: (size and amount) *none*

   Pattern: (kind and number of obstacles) -

   Flooding: (duration and frequency) *could on occasion*

3. SOILS: (general) *dark colored, poorly drained clays*

Profile description: *(St. Urbain series)*

horizon	depth	texture*	structure	consistence	color	
1. *Ap*	*0-30*	*SiCL*	*moderate granular*	*friable*	*dark gray brown*	*2.5YR 3.5/2*
2. *Bg*	*30-80*	*C*	*subangular blocky*	*friable - firm*	*olive gray*	*5YR 4.5/2*
3. *Cg*	*80+*	*C*	*massive*	*very firm*	*olive gray*	*5YR 5/2*
4.						

* for organic soils use % rubbed fibre and % wood.

Depth to limiting horizon =

Laboratory analysis:

horizon	pH	O.C.	$CaCO_3$ /E.C.	bulk density	>2 mm	S	Si	C	
1. *Ap*	*6.4*	*2.8*		*1.3*	–	*12*	*49*	*40*	
2. *Bg*	*7.5*	–		*1.3*	–	*2*	*25*	*73*	
3. *Cg*	*7.8*	–		*1.4*	–	*1*	*23*	*76*	
4.									

Drainage: (general) *There are now both surface and tile drains (was originally poorly drained)*

- depth to water table: *assume 75 cm (depth of tile)*

4. COMMENTS: (variability, etc.)
   - *some variation in surface texture*
   - *well structured B horizon is quite permeable*

LAND SUITABILITY RATING DOCUMENT

MAP AREA: *Quebec* NAME: *MCN* DATE: *18/09/92*

SOIL(S)

Map Component 1. *Upland* *100* % 2. ______ ______ %

	Name Value (1)	deduction (1)		Name value (2)	deduction (2)	
1. Moisture factor (M)						
texture	*SiCL*	*0*				
subsoil text adj.	*C*	± *-*			±	
water table/% adj.	*75*	- *-*			-	
moisture deduction		*0*	c			c
2. Surface factors						
structure (D)	*mod.gr.*	*0*				
org. C (F)	*2.8*	*2*				
depth (E)	*20*	*0*				
reaction (V)	*6.4*	*0*				
salinity (N)	*-*					
sodicity (Y)	*-*					
peaty (O)	*-*					
Basic Soil Rating = 100 - c		- *2*	= *98* d	100 - c	-	= ______ d
3. Subsoil factors						
impeding layer (D,R)						
struct.(density)	*mass 1.4=20*					
depth/% adj.	*80=0.25*	*5*				
non-conform.	*-*					
reaction (V)	*7.5*	*0*				
salinity (N)	*-*					
sodicity (Y)	*-*					
Subsoil deduction =		*5* % d = *5*	e	=	%d =	______ e
Interim Soil Rating =	d - e =	*93*	f	d - e	=	______ f
4. Drainage factor (W)						
depth water table	*75*					
hydraul. cond.	*mod.*	*30*				
Drainage deduction	=	*30* % f = *28*	g		%f =	______ g
FINAL SOIL RATING(S) = f - g =		*65*		S = f - g =		

LANDSCAPE (L)

Map Component 1. ______ ______ % 2. ______ ______ %

	value (1)	deduction (1)		value (2)	deduction (2)	
1. Slope (T)						
steepness	*<1* %			______ %		
landscape type	*simple*		______ m			
region	*1*	*3*				
Basic Landscape Rating = 100 -		*3*	= *97* a	100 -		= ______ a
2. Stoniness/Coarse fragment (%)		deduction				
stoniness (P)	*-*					
gravel (P)	*-*					
wood (J)						
C.F. deduction	=	*-* % a = *0*	b		%a =	______ b
Interim landscape rating	= a - b =	*97*	c	a - b =	______	c
3. Other deductions (%)						
pattern (K)	*-*					
flooding (I)	*occ./brief*	*5*				
other deductions =		*5* % c = *5*	d		%c =	______ d
FINAL LANDSCAPE RATING (L) = c - d) =		*92*		L = c - d =		

MAP AREA *Quebec* NAME: *MCN* DATE: *18/09/92*

AGROCLIMATIC (C)

factor	value	deduction	
1. Moisture Component (A)			
P-PE Index	*-150*	*0*	
A = 100	-	*0*	= *100*
2. Energy Component (H)			
EGDD Index	*1800*	*0*	
H = 100	-	*0*	= *100*

Basic Climate rating is lowest of A or H= *100* a

factor	value	deduction
3. Modifying factors		
spring moisture	*-15*	*3*
fall moisture	*+35*	*4*
local frost		

modification deduction = *7* %a = *7* b

FINAL CLIMATE RATING(C) = a - b = *93*

ORGANIC SOILS (O)

1. Soil Climate (Z)
   - EGDD Index ______ ______
   - Organic base rating = 100 - ______ = ______ a
2. Moisture factor (M)
   - P-PE index ______
   - surface % fibre ______ ______ b
   - water table ______
   - subsurf. % fibre ______ ______ %b= ______ c
   - Moisture deduction = b - c = ______ d
3. Surface factors
   - struct. (% fibre) (B) ______ ______
   - reaction (V) ______ ______
   - salinity (N) ______ ______
   - Surface deduction = ______ e

Basic Organic Rating = a - d - e = ______ f

4. Subsurface factors
   - struct. (%fibre) (B) ______ ______
   - substrate (G)
     - texture ______
     - depth ______ ______
   - reaction (V) ______ ______
   - salinity (N) ______ ______
   - Subsurface deduction = ______ %f= ______ g

Interim Organic Rating = f - g = ______ h

5. Drainage factor (W)
   - depth water table ______
   - subsurf. % fibre ______ ______
   - Drainage deduction = ______ %h= ______ i

FINAL ORGANIC RATING (O) = h - i = [ ]

FINAL RATING CALCULATION

	index			factors		%
C=	*93*	or class	*1*,			( )
S=	*65*	or class	*2*,	*W*		( )
S=		or class	,			( )
O=		or class	,			( )
L=	*92*	or class	*1*,			( )
L=		or class	,			( )

Index	Class
80-100	1
60-79	2
45-59	3
30-44	4
20-29	5
10-19	6
0-9	7

Final rating using: average [ ] ; complex [ ] ; most limiting [ ]

C S(O) L = Symbol *2* Class *W* ____ ____ factors % ( )

1 *2* *1* classes

C S(O) L = ____ Class ____ ____ ____ factors ( )

____ ____ ____ classes

Comments

Good climate with minor spring and fall moisture problems which are aggravated by the clay textures (slow to dry) 2W

Example #3

DATA INPUT DOCUMENT
(Soil and Landscape factors)

1. LOCATION: *SE 1-24-15 W 3 - Southwestern Saskatchewan* NAME: *GAP* DATE: *18/09/92*

2. LANDSCAPE: (general) *hummocky (knoll and kettle) moraine*

   Slope characteristics: (steepness and length) *10-15% limiting slopes (12); 75 m*

   Surface stoniness: (size and amount) *S1-2, some large on knolls*

   Pattern: (kind and number of obstacles) - *a number of enclosed depressions*
   - *dry up in summer*

   Flooding: (duration and frequency) -

3. SOILS: (general) *Brown, loam to clay loams, Chernozemic*
   - *light colored knolls*

Profile description: *(Haverhill soils)*

horizon	depth	texture*	structure	consistence	color	
1. *Ap*	*0-12*	*L*	*moderate granular*	*friable*	*gray brown*	*10YR 5/2*
2. *Bm*	*12-25*	*L*	*prismatic sub. blocky*	*friable*	*dark brown*	*10YR 4/3*
3. *Cca*	*25-40*	*L*	*sub. blocky massive*	*friable*	*gray brown*	*10YR 6/3*
4. *Ck*	*40+*	*L*	*massive*	*firm*	*light brown*	*10YR 5/2*

* for organic soils use % rubbed fibre and % wood.

Depth to limiting horizon = -

Laboratory analysis:

horizon	pH	O.C.	$CaCO_3$ /E.C.	bulk density	>2 mm	S	Si	C	
1. *Ap*	*7.2*	*2.1*	-		*5*	*48*	*29*	*23*	
2. *Bm*	*7.2*	*1.2*	-		*5*	*42*	*32*	*26*	
3. *Cca*	*7.8*	-	*20/-*		*10*	*45*	*29*	*26*	
4. *Ck*	*8.0*	-	*14/-*		*5*	*44*	*31*	*25*	

Drainage: (general) *good*
- depth to water table: -

4. COMMENTS: (variability, etc.)
   - *depth of soils quite variable (10-60 cm) with up to 30% shallow (<20 cm) knolls.*

LAND SUITABILITY RATING DOCUMENT

MAP AREA: *Saskatchewan* NAME: *GAP* DATE: *18/09/92*

SOIL(S)

Map Component 1. *Upland* (Name) *70* % — 2. *knolls* (Name) *30* %

	Component 1 Value	Component 1 deduction		Component 2 value	Component 2 deduction	
1. Moisture factor (M)						
texture	L(58)	51		L-CL(60)	50	
subsoil text adj.	L(55)	± 0			±	
water table/% adj.	-	- -			-	
moisture deduction		51	c		47	c
2. Surface factors						
structure (D)	mod.gr.	0		wk gr	2	
org. C (F)	1.8	6		1	10	
depth (E)	20	-		20	-	
reaction (V)	7.2	0		7.9	4	
salinity (N)	-					
sodicity (Y)	-					
peaty (O)	-					
Basic Soil Rating = 100 - c		- 6 = 43	d	100 - c	- 16 = 37	d
3. Subsoil factors						
impeding layer (D,R)						
struct.(density)	prism					
depth/% adj.		0				
non-conform.	-					
reaction (V)	7.8	0				
salinity (N)	-					
sodicity (Y)	-					
Subsoil deduction =		0 % d = 0	e	=	%d = 0	e
Interim Soil Rating =	d - e =	43	f	d - e	=	f
4. Drainage factor (W)						
depth water table	-					
hydraul. cond.		-				
Drainage deduction =		- % f = -	g		%f = 0	g
FINAL SOIL RATING(S) = f - g =		43		S = f - g =	37	

LANDSCAPE (L)

Map Component 1. ______ % — 2. ______ %

	Component 1 value	Component 1 deduction		Component 2 value	Component 2 deduction	
1. Slope (T)						
steepness	12 %			%		
landscape type	complex			m		
region	2	60				
Basic Landscape Rating = 100 -		60 = 40	a	100 -	=	a
2. Stoniness/Coarse fragment (%)		deduction				
stoniness (P)	S2(0.15)	8				
gravel (P)	6	0				
wood (J)						
C.F. deduction =		- % a = 3	b		%a =	b
Interim landscape rating = a - b =		37	c	a - b =		c
3. Other deductions (%)						
pattern (K)	5?	5				
flooding (I)	-					
other deductions =		5 % c = 2	d		%c =	d
FINAL LANDSCAPE RATING (L) = c - d) =		35		L = c - d =		

MAP AREA *Saskatchewan* NAME: *GAP* DATE: *18/09/92*

AGROCLIMATIC (C)

factor	value	deduction	
1. Moisture Component (A)			
P-PE Index	*-350*	*40*	
A = 100	-	*40*	= *60*
2. Energy Component (H)			
EGDD Index	*1500*	*10*	
H = 100	-	*10*	= *90*

Basic Climate rating is lowest of A or H= *60* a

factor	value	deduction
3. Modifying factors		
spring moisture	*-75*	*0*
fall moisture	*-50*	*0*
local frost	____	____

modification deduction = *0* %a = ____ b

FINAL CLIMATE RATING (C) = a - b = *60*

ORGANIC SOILS (O)

1. Soil Climate (Z)
   EGDD Index ____ ____
   Organic base rating = 100 - ____ = ____ a
2. Moisture factor (M)
   P-PE index ____
   surface % fibre ____ ____ b
   water table ____
   subsurf. % fibre ____ ____ %b= ____ c
   Moisture deduction = b - c = ____ d
3. Surface factors
   struct. (% fibre) (B) ____ ____
   reaction (V) ____ ____
   salinity (N) ____ ____
   Surface deduction = ____ e
Basic Organic Rating = a - d - e = ____ f

4. Subsurface factors
   struct. (%fibre) (B) ____ ____
   substrate (G)
   texture ____
   depth ____ ____
   reaction (V) ____ ____
   salinity (N) ____ ____
   Subsurface deduction = ____ %f= ____ g

Interim Organic Rating = f - g = ____ h

5. Drainage factor (W)
   depth water table ____
   subsurf. % fibre ____
   Drainage deduction = ____ %h= ____ i

FINAL ORGANIC RATING (O) = h - i = [ ]

FINAL RATING CALCULATION

	index		factors			%
C=	*60*	or class	*2-3*,	*A*	____	( )
S=	*43*	or class	*4*,	*M*	____	*(70)*
S=	*37*	or class	*4*,	*M*	____	*(30)*
O=	____	or class	____,	____	____	( )
L=	*35*	or class	*4*,	*T*	____	( )
L=	____	or class	____,	____	____	( )

Index	Class
80-100	1
60-79	2
45-59	3
30-44	4
20-29	5
10-19	6
0-9	7

Final rating using: average [X] ; complex [ ] ; most limiting [ ]

C S(O) L = Symbol *4* Class — *T* *M* ____ factors (%)

2-3 *4* *4* classes

C S(O) L = ____ Class ____ ____ ____ factors ( )

____ ____ ____ classes

Comments

An area of pronounced moisture deficit as well as a severe topographic limitation. Marginal 4TM

Example #4

DATA INPUT DOCUMENT
(Soil and Landscape factors)

1. LOCATION: *1 km north of mile 925 - near Whitehorse, Yukon* NAME: *MW* DATE: *18/09/92*

2. LANDSCAPE: (general) *level lacustrine or fluvial terrace*

   Slope characteristics: (steepness and length) *1-2%; >100 m*
   Surface stoniness: (size and amount) -
   Pattern: (kind and number of obstacles) -
   Flooding: (duration and frequency) -

3. SOILS: (general) *brownish FSL - L over fine lacustrine material*

Profile description: *(Lewes soils)*

horizon	depth	texture*	structure	consistence	color	
1. *Bm*	*0-20*	*L*	*weak granular to platy*	*soft*	*pale brown*	*10YR 6/3*
2. II*Bm*	*20-40*	*SiC*	*sub. blocky*	*firm*	*olive brown*	*2.5Y 5/4*
3. II*Ck*	*40+*	*SiC*	*massive*	*very firm*	*gray*	*5Y 6/2*
4.						

* for organic soils use % rubbed fibre and % wood.

Depth to limiting horizon = -

Laboratory analysis:

horizon	pH	O.C.	$CaCO_3$ /E.C.	bulk density	>2 mm	S	Si	C	
1. *Bm*	*6.1*	*1.0*		*1.0*	-	*45*	*40*	*15*	
2. II*Bm*	*7.3*	*0.4*		*1.3*	-	*13*	*46*	*41*	
3. II*Ck*	*8.0*		*18/-*	*1.3*	-	*14*	*40*	*46*	
4.									

Drainage: (general) *good*
- depth to water table: -

4. COMMENTS: (variability, etc.)

LAND SUITABILITY RATING DOCUMENT

MAP AREA: *Yukon* NAME: *MW* DATE: *18/09/92*

SOIL (S)

Map Component 1. *Upland* *100* % 2. ______ %

	Name Value	deduction		Name value	deduction	
1. Moisture factor (M)						
texture	*L(55)*	*43*		L		
subsoil text adj.	*SiC(86)*	± *-5*			±	
water table/% adj.		-			-	
moisture deduction		*38*	c			c
2. Surface factors						
structure (D)	*wk. gr.*	*2*				
org. C (F)	*1.0*	*10*				
depth (E)	*20*	*-*				
reaction (V)	*6.1*	*-*				
salinity (N)	*-*					
sodicity (Y)	*-*					
peaty (O)	*-*					
Basic Soil Rating = 100 - c		- *12*	= *50* d	100 - c	-	= ___ d
3. Subsoil factors						
impeding layer (D,R)						
struct.(density)	*1.3*					
depth/% adj.	*-*	*0*				
non-conform.	*-*					
reaction (V)	*7.3*	*0*				
salinity (N)	*-*					
sodicity (Y)	*-*					
Subsoil deduction =		*0* % d = *0*	e	=	%d =	___ e
Interim Soil Rating =	d - e =	*50*	f	d - e	=	___ f
4. Drainage factor (W)						
depth water table	*-*					
hydraul. cond.						
Drainage deduction =		% f = *0*	g		%f =	___ g

FINAL SOIL RATING(S) = f - g = **[*50*]** S = f - g = [ ]

LANDSCAPE (L)

Map Component 1. ______ % 2. ______ %

	value	deduction		value	deduction	
1. Slope (T)						
steepness	*2* %			%		
landscape type	*simple*			m		
region	*2*	*15*				
Basic Landscape Rating = 100 -		*15*	= *85* a	100 -		= ___ a
2. Stoniness/Coarse fragment (%)		deduction				
stoniness (P)	*-*					
gravel (P)	*-*					
wood (J)						
C.F. deduction =		*-* % a = *0*	b		%a =	___ b
Interim landscape rating = a - b =		*85*	c	a - b =	___	c
3. Other deductions (%)						
pattern (K)	*-*					
flooding (I)						
other deductions =		*-* % c = *0*	d		%c =	___ d

FINAL LANDSCAPE RATING (L) = c - d) = **[*85*]** L = c - d = [ ]

MAP AREA *Yukon* NAME: *MW* DATE: *18/09/92*

AGROCLIMATIC (C)

factor	value	deduction	
1. Moisture Component (A)			
P-PE Index	-300	30	
A = 100	-	30	= 70
2. Energy Component (H)			
EGDD Index	800	75	
H = 100	-	75	= 25

Basic Climate rating is lowest of A or H= 25 a

factor	value	deduction
3. Modifying factors		
spring moisture	-	____
fall moisture	-	____
local frost	-	____

modification deduction = ____ %a = - b

FINAL CLIMATE RATING (C) = a - b = [25]

ORGANIC SOILS (O)

1. Soil Climate (Z)
   - EGDD Index ____ ____
   - Organic base rating = 100 - ____ = ____ a
2. Moisture factor (M)
   - P-PE index ____
   - surface % fibre ____ ____ b
   - water table ____
   - subsurf. % fibre ____ ____ %b= ____ c
   - Moisture deduction = b - c = ____ d
3. Surface factors
   - struct. (% fibre) (B) ____ ____
   - reaction (V) ____ ____
   - salinity (N) ____ ____
   - Surface deduction = ____ e

Basic Organic Rating = a - d - e = ____ f

4. Subsurface factors
   - struct. (%fibre) (B) ____ ____
   - substrate (G)
     - texture ____
     - depth ____ ____
   - reaction (V) ____ ____
   - salinity (N) ____ ____
   - Subsurface deduction = ____ %f= ____ g

Interim Organic Rating = f - g = ____ h

5. Drainage factor (W)
   - depth water table ____
   - subsurf. % fibre ____ ____
   - Drainage deduction = ____ %h= ____ i

FINAL ORGANIC RATING (O) = h - i = [ ]

FINAL RATING CALCULATION

	index		class	factors			%
C=	25	or class	5	H		A	( )
S=	50	or class	3	M			( )
S=		or class					( )
O=		or class					( )
L=	85	or class	1				( )
L=		or class					( )

Index	Class
80-100	1
60-79	2
45-59	3
30-44	4
20-29	5
10-19	6
0-9	7

Final rating using: average [ ] ; complex [ ] ; most limiting [ ]

Symbol

C S(O) L = 5 Class; H M ____ factors; % ( )

5 3 1 classes

C S(O) L = ____ Class; ____ ____ ____ factors; ( )

____ ____ ____ classes

Comments

A cold, short-season climate is a severe limitation for cereals. There is also a moderate droughtiness problem.
5HM

Example #5

DATA INPUT DOCUMENT
(Soil and Landscape factors)

1. LOCATION: *Centre 29-1-15 E1 - near Sprague, Manitoba* NAME: *RES* DATE: *21/09/92*

2. LANDSCAPE: (general) *flat bog with black spruce forest*

Slope characteristics: (steepness and length) *level*
Surface stoniness: (size and amount) -
Pattern: (kind and number of obstacles) *several slight depressions with water.*
Flooding: (duration and frequency) -

3. SOILS: (general) *fibric mossy surface over dark brown mesic woody peat.*

Profile description: *(Okno soil)*

horizon	depth	texture*	structure	consistence	color	
1. *Of*	*0-15*	*fibric*	*fluffy*		*pale brown*	*10YR 6/4*
2. *Om1*	*15-70*	*mesic*	*mod. woody*		*dark brown*	*10YR 4/4*
3. *Om2*	*70-110*	*mesic-humic*	*layered*		*dark brown*	*5YR 4/4*
4. II*Cg*	*110+*	*SiC*	*massive*		*dark gray*	*5Y 4/1*

* for organic soils use % rubbed fibre and % wood.

Depth to limiting horizon = *110*

Laboratory analysis:

horizon	pH	O.C.	$CaCO_3$ /E.C.	bulk density	>2 mm	S	Si	C	% fibre
1. *Of*	*4.2*			*<0.10*					*60*
2. *Om1*	*5.7*								*15*
3. *Om2*	*6.4*			*0.17*					*10*
4. II*Cg*	*7.2*	-	*tr*		-	*8*	*40*	*52*	

Drainage: (general) *poorly under natural conditions*
- 1.2 m surface drains

- depth to water table: *Original = 20 cm; drained = 75 cm*

4. COMMENTS: (variability, etc.)
- variable amounts of surface sphagnum (0-50 cm) which mixes with next layer with development and cultivation.

LAND SUITABILITY RATING DOCUMENT

MAP AREA: *Manitoba* NAME: *RES* DATE: *18/09/92*

SOIL(S)

Map Component 1. ______ ___% 2. ______ ___%

	Component 1 Value	Component 1 Name deduction		Component 2 value	Component 2 Name deduction	
1. Moisture factor (M)						
texture						
subsoil text adj.		±			±	
water table/% adj.		-			-	
moisture deduction			c			c
2. Surface factors						
structure (D)						
org. C (F)						
depth (E)						
reaction (V)						
salinity (N)	-					
sodicity (Y)	-					
peaty (O)	-					
Basic Soil Rating =	100 - c	-	= ___ d	100 - c	-	= ___ d
3. Subsoil factors						
impeding layer (D,R)						
struct.(density)						
depth/% adj.						
non-conform.	-					
reaction (V)						
salinity (N)	-					
sodicity (Y)	-					
Subsoil deduction =		___% d =	___ e	=	___%d =	___ e
Interim Soil Rating =	d - e =		___ f	d - e	=	___ f
4. Drainage factor (W)						
depth water table	-					
hydraul. cond.						
Drainage deduction	=	___% f =	___ g		___%f =	___ g

FINAL SOIL RATING(S) = f - g = [ ] S = f - g = [ ]

LANDSCAPE (L)

Map Component 1. ______ ___% 2. ______ ___%

	Component 1 value	Component 1 deduction		Component 2 value	Component 2 deduction	
1. Slope (T)						
steepness	*0* %			%		
landscape type	-			m		
region	*2*	*0*				
Basic Landscape Rating = 100 -		*0* =	*100* a	100 -		= ___ a
2. Stoniness/Coarse fragment (%)		deduction				
stoniness (P)	-					
gravel (P)	-					
wood (J)	*5%*	*10*				
C.F. deduction	=	*10* % a	= *10* b		___%a =	___ b
Interim landscape rating = a - b =			*90* c	a - b =		___ c
3. Other deductions (%)						
pattern (K)	*5?*	*5*				
flooding (I)						
other deductions =		*5* % c =	*5* d		___%c =	___ d

FINAL LANDSCAPE RATING (L) = c - d) = [*85*] L = c - d = [ ]

MAP AREA Manitoba NAME: RCS DATE: 18/09/92

AGROCLIMATIC (C)

factor	value	deduction	
1. Moisture Component (A)			
P-PE Index	-200	10	
A = 100	-	10	= 90
2. Energy Component (H)			
EGDD Index	1400	20	
H = 100	-	20	= 80

Basic Climate rating is lowest of A or H= 80 a

factor	value	deduction
3. Modifying factors		
spring moisture	-20	3
fall moisture	+20	2
local frost	-7	2

modification deduction = 7 %a = 6 b

FINAL CLIMATE RATING (C) = a - b = [74]

ORGANIC SOILS (O)

1. Soil Climate (Z)
   - EGDD Index 1400 15
   - Organic base rating = 100 - 15 = 85 a
2. Moisture factor (M)
   - P-PE index -200
   - surface % fibre 32 11 b
   - water table 75
   - subsurf. % fibre 12 68 %b= 7 c
   - Moisture deduction = b - c = 4 d
3. Surface factors
   - struct. (% fibre) (B) 32 26
   - reaction (V) 5.1 28
   - salinity (N) - -
   - Surface deduction = 54 e

Basic Organic Rating = a - d - e = 27 f

4. Subsurface factors
   - struct. (%fibre) (B) 12 4
   - substrate (G)
     - texture SiC
     - depth 90 4
     - reaction (V) 6.2 0
     - salinity (N) -
   - Subsurface deduction = 8 %f= 2 g

Interim Organic Rating = f - g = 25 h

5. Drainage factor (W)
   - depth water table 75
   - subsurf. % fibre 12 11
   - Drainage deduction = 11 %h= 3 i

FINAL ORGANIC RATING (O) = h - i = [22]

FINAL RATING CALCULATION

	index		factors			%
C=	74	or class	2 ,	H		( )
S=		or class	,			( )
S=		or class	,			( )
O=	22	or class	5 ,	B	V	( )
L=	85	or class	1 ,			( )
L=		or class	,			( )

Index	Class
80-100	1
60-79	2
45-59	3
30-44	4
20-29	5
10-19	6
0-9	7

Final rating using: average [ ] ; complex [ ] ; most limiting [ ]

Symbol

C (O) L = 5 Class B V H factors ( ) %

2 5 1 classes

C S(O) L = ___ Class ___ ___ ___ factors ( )

___ ___ ___ classes

Comments

This area has a very severe limitation - a combination of surface structure nutrient status, and coolness

5 BVH

Example #6

DATA INPUT DOCUMENT *(a)*
(Soil and Landscape factors)

1. LOCATION: *48° N 80° W* NAME: *EWP* DATE: *22/09/92*
- near New Liskeard, Ontario

2. LANDSCAPE: (general) *gently undulating lacustrine plain*

Slope characteristics: (steepness and length) *1-2% slopes*
Surface stoniness: (size and amount) -
Pattern: (kind and number of obstacles) *several organic depressions*
Flooding: (duration and frequency) *rarely*

3. SOILS: (general) *imperfectly drained, leached clayey soils (70%)*
poorly drained shallow organic soils (30%)

(a) Profile description: *Upland (mineral) component: Gleyed Gray Luvisol*

horizon	depth	texture*	structure	consistence	color	
1. *Ap*	*0-15*	*SiL*	*weak granular*	*very friable*	*gray*	*10YR 5/2*
2. *Ae*	*15-25*	*SiL*	*weak platy*	*friable*	*lt. gray (mottles)*	*10YR 7/1*
3. *Bt*	*25-60*	*C*	*sub. blocky*	*very firm*	*dark gray brown*	*2.5Y 4/2*
4. *BCg*	*60+*	*C*	*massive*	*very firm*	*dark gray (mottles)*	*2.5Y 4/0*

* for organic soils use % rubbed fibre and % wood.

Depth to limiting horizon = *25 cm*

Laboratory analysis:

horizon	pH	O.C.	$CaCO_3$ /E.C.	bulk density	>2 mm	S	Si	C	
1. *Ap*	*5.9*	*1.2*		*1.30*		*20*	*55*	*25*	
2. *Ae*	*5.3*	*0.2*		*1.35*		*24*	*50*	*26*	
3. *Bt*	*5.3*	*0.4*		*1.45*		*20*	*30*	*50*	
4. *BCg*	*5.6*	*-*		*1.45*		*10*	*35*	*55*	

Drainage: (general) *Imperfect*

- depth to water table: *70 cm in mineral*

4. COMMENTS: (variability, etc.)
- requires both external and internal drainage
- definite pattern problem with organic depressions
- fall wetness is a concern and 4 years out of 10 get early frosts (extension worker comments)

Example #6

DATA INPUT DOCUMENT (Soil and Landscape factors) *(b)*

1. LOCATION: *Ontario* NAME: *EWP* DATE: *22/09/92*

2. LANDSCAPE: (general)

   Slope characteristics: (steepness and length)
   Surface stoniness: (size and amount)
   Pattern: (kind and number of obstacles) *see (a)*
   Flooding: (duration and frequency)

3. SOILS: (general)

(b) Profile description: *Organic component - Terric Mesisol*

horizon	depth	texture*	structure	consistence	color	
1. *Om1*	*0-20*	*mesic - fibric*	*fine fibred*		*dark brown*	*10YR 3/2*
2. *Om2*	*20-70*	*mesic*	*fine fibred*		*dark brown*	*10YR 2/2*
3. *Oh*	*70-80*	*humic*	*amorphous*	*slippery*	*black*	*5YR 2/1*
4. *Cg*	*80+*	*SiC*	*massive*	*sticky*	*dark gray*	*2.5Y 4/1*

* for organic soils use % rubbed fibre and % wood.

Depth to limiting horizon = *80 cm*

Laboratory analysis:

horizon	pH	O.C.	$CaCO_3$ /E.C.	bulk density	>2 mm	S	Si	C	% fibre
1. *Om1*	*5.9*			*0.10*					*30*
2. *Om2*	*5.7*			*0.16*					*12*
3. *Oh*	*6.2*			*0.20*					*2*
4. *Cg*	*7.2*			*1.30*	*-*	*10*	*45*	*45*	

Drainage: (general) *poor*

- depth to water table: *40 cm*

4. COMMENTS: (variability, etc.)

Depth to clay varies from 0-100 cm with most in the 60-80 cm range.

LAND SUITABILITY RATING DOCUMENT

MAP AREA: *Ontario* NAME: *EWP* DATE: *18/09/92*

SOIL(S)

Map Component 1. *Upland* (Name) *70* % 2. ______ (Name) ____ %

	Value	deduction	value	deduction
1. Moisture factor (M)				
texture	*SiL(79)*	*0*		
subsoil text adj.	*C(85)*	± *-*		±
water table/% adj.	*70-*	- *-*		-
moisture deduction		*0* c		c
2. Surface factors				
structure (D)	*v.wk.gran.*	*5*		
org. C (F)	*1.0*	*10*		
depth (E)	*20*	*-*		
reaction (V)	*5.7*	*3*		
salinity (N)	*-*			
sodicity (Y)	*-*			
peaty (O)	*-*			
Basic Soil Rating = 100 - c		- *18* = *82* d	100 - c	- ____ = ____ d
3. Subsoil factors				
impeding layer (D,R)				
struct.(density)	*1.45=20*			
depth/% adj.	*25=0.9*	*18*		
non-conform.	*-*			
reaction (V)	*5.5*	*2*		
salinity (N)	*-*			
sodicity (Y)	*-*			
Subsoil deduction =		*20* % d = *16* e	=	____ %d = ____ e
Interim Soil Rating = d - e =		*66* f	d - e	= ____ f
4. Drainage factor (W)				
depth water table	*70*			
hydraul. cond.	*mod.*	*35*		
Drainage deduction =		*35* % f = *23* g		____ %f = ____ g
FINAL SOIL RATING(S) = f - g =		*43*	S = f - g =	

LANDSCAPE (L)

Map Component 1. ______ *100* % 2. ______ ____ %

	value	deduction	value	deduction
1. Slope (T)				
steepness	*2* %		%	
landscape type	*complex*		m	
region	*1*	*20*		
Basic Landscape Rating = 100 -		*20* = *80* a	100 -	____ = ____ a
2. Stoniness/Coarse fragment (%)		deduction		
stoniness (P)	*-*			
gravel (P)	*-*			
wood (J)				
C.F. deduction =		*-* % a = *0* b		____ %a = ____ b
Interim landscape rating = a - b =		*80* c	a - b =	____ c
3. Other deductions (%)				
pattern (K)	*-?*	*10*		
flooding (I)				
other deductions =		*10* % c = *8* d		____ %c = ____ d
FINAL LANDSCAPE RATING (L) = c - d) =		*72*	L = c - d =	

MAP AREA *Ontario* NAME: *EWP* DATE: *18/09/92*

AGROCLIMATIC (C)

factor	value	deduction		factor	value	deduction
1. Moisture Component (A)				3. Modifying factors		
P-PE Index	*-150*	*0*		spring moisture	*0*	*5*
A = 100	-	*0*	= *100*	fall moisture	*+40*	*4*
2. Energy Component (H)				local frost	*7 days*	*2*
EGDD Index	*1300*	*30*		modification deduction = *11* %a = *8* b		
H = 100	-	*30*	= *70*			

Basic Climate rating is lowest of A or H= *70* a

FINAL CLIMATE RATING (C) = a - b = *62*

ORGANIC SOILS (O)

1. Soil Climate (Z)
   - EGDD Index *1300* *20*
   - Organic base rating = 100 - *20* = *80* a
2. Moisture factor (M)
   - P-PE index *-150*
   - surface % fibre *21* *0* b
   - water table *40*
   - subsurf. % fibre *8* *97* %b= *0* c
   - Moisture deduction = b - c = *0* d
3. Surface factors
   - struct. (% fibre) (B) *21* *10*
   - reaction (V) *5.8* *20*
   - salinity (N) -
   - Surface deduction = *30* e

Basic Organic Rating = a - d - e = *50* f

4. Subsurface factors
   - struct. (%fibre) (B) *8* *7*
   - substrate (G)
     - texture *SiC*
     - depth *80* *15*
     - reaction (V) *6.5* *0*
     - salinity (N) -
   - Subsurface deduction = *15* %f= *8* g

Interim Organic Rating = f - g = *42* h

5. Drainage factor (W)
   - depth water table *40*
   - subsurf. % fibre *8* *72*
   - Drainage deduction = *72* %h= *30* i

FINAL ORGANIC RATING (O) = h - i = *12*

FINAL RATING CALCULATION

	index		factors			%
C=	*62*	or class	*2*	*H*		( )
S=	*43*	or class	*4*	*W*	*D*	(*70*)
S=		or class				( )
O=	*12*	or class	*6*	*W*	*V*	(*30*)
L=	*72*	or class	*2*	*T*		( )
L=		or class				( )

Index	Class
80-100	1
60-79	2
45-59	3
30-44	4
20-29	5
10-19	6
0-9	7

Final rating using: average [ ] ; complex [X] ; most limiting [ ]

Symbol

C S L = *4* Class *W* *D* factors (*70*)

2 *4* *2* classes

C (O) L = *6* Class *W* *V* factors (*30*)

2 *6* *2* classes

Comments

This is a marginal area for crop production. It has a mixture of contrasting soil/drainage combinations. 4WD(70)-6WV(30)

D.1 Help Guide

Document 1a

CATEGORY	FACTOR	Table/Fig	Page
Soils	texture	4.2	14
	subsoil text.	4.3	15
	water table	4.4	15
	surface structure	4.5	16
	organic content	4.6	16
	depth of topsoil	4.7	16
	surface reaction	4.8	17
	surface salinity	4.9	17
	surface sodicity	4.10	18
	organic surface	4.11	18
	impeding layer	4.12	19
	depth to restriction	4.13	19
	depth to non-conf.	4.14	19
	subsurface reaction	4.15	20
	subsurface salinity	4.16	20
	subsurface sodicity	4.17	20
	drainage (perhumid)	4.18	22
	(humid)	4.19	22
	(subhumid)	4.20	22
	drainage proxy	4.21	23
Landscape	landscape type	6.1	35
	region	6.1	35
	steepness	6.2, 6.3	36
	stoniness	Table 6.2	36
		Fig. 6.4	37
	gravel	Fig. 6.5	37
	wood	Table 6.3	37
	flooding	6.4	38

Document 1b

CATEGORY	FACTOR	Table/Fig	Page
Climate	P-PE	Map 1	
		Fig. 3.1	8
	EGDD	Map 2	
		Fig. 3.2	8
	spring moisture	3.3	9
	fall moisture	3.4	10
	local frost	3.5	10
Organic	EGDD	5.2	26
	surface fibre	5.3	26
	water table	5.4	27
	surface structure	5.5	27
	surface reaction	5.6	28
	surface salinity	5.7	28
	subsurface structure	5.8	29
	substrate	5.9	29
	subsurface reaction	5.10	30
	subsurface salinity	5.11	30
	drainage (perhumid)	5.12	30
	(humid)	5.13	31
	(subhumid)	5.14	31

Other	common field probl.	46
	final rating consid.	47
	proxy relationships (mineral)	58
	proxy relationships (organic)	59
	glossary	61

LAND SUITABILITY RATING DOCUMENT

MAP AREA: ____________ NAME: ____________ DATE: ____________

SOIL(S)

Map Component 1. ____________ Name ____ % 2. ____________ Name ____ %

	Value	deduction		value	deduction	
1. Moisture factor (M)						
texture	____	____		____	____	
subsoil text adj.	____	± ____		____	± ____	
water table/% adj.	____	– ____		____	– ____	
moisture deduction		____ c			____ c	
2. Surface factors						
structure (D)	____	____		____	____	
org. C (F)	____	____		____	____	
depth (E)	____	____		____	____	
reaction (V)	____	____		____	____	
salinity (N)	____	____		____	____	
sodicity (Y)	____	____		____	____	
peaty (O)	____	____		____	____	
Basic Soil Rating = 100 – c		– ____	= ____ d	100 – c	– ____	= ____ d
3. Subsoil factors						
impeding layer (D,R)						
struct.(density)	____			____		
depth/% adj.	____	____		____	____	
non-conform.	____	____		____	____	
reaction (V)	____	____		____	____	
salinity (N)	____	____		____	____	
sodicity (Y)	____	____		____	____	
Subsoil deduction =		____ % d =	____ e	=	____ %d =	____ e
Interim Soil Rating =	d – e =	____ f		d – e	= ____ f	
4. Drainage factor (W)						
depth water table	____			____		
hydraul. cond.	____			____		
Drainage deduction	=	____ % f =	____ g		____ %f =	____ g

FINAL SOIL RATING(S) = f – g = [ ] S = f – g = [ ]

LANDSCAPE (L)

Map Component 1. ____________ ____ % 2. ____________ ____ %

	value	deduction		value	deduction	
1. Slope (T)						
steepness	____ %			____ %		
landscape type	____			____ m		
region	____	____		____	____	
Basic Landscape Rating = 100 –		____	= ____ a	100 –	____	= ____ a
2. Stoniness/Coarse fragment (%)		deduction				
stoniness (P)	____	____		____	____	
gravel (P)	____	____		____	____	
wood (J)	____	____		____	____	
C.F. deduction	=	____ % a =	____ b		____ %a =	____ b
Interim landscape rating	= a – b =	____ c		a – b =	____ c	
3. Other deductions (%)						
pattern (K)	____	____		____	____	
flooding (I)	____	____		____	____	
other deductions =		____ % c =	____ d		____ %c =	____ d

FINAL LANDSCAPE RATING (L) = c – d) = [ ] L = c – d = [ ]

MAP AREA ______________________ NAME: ______________ DATE: ________

AGROCLIMATIC (C)

factor	value	deduction	
1. Moisture Component (A)			
P-PE Index	____	____	
A = 100	-	____	= ____
2. Energy Component (H)			
EGDD Index	____	____	
H = 100	-	____	= ____

Basic Climate rating is lowest of A or H= _____a

factor	value	deduction	
3. Modifying factors			
spring moisture	____	____	
fall moisture	____	____	
local frost	____	____	
modification deduction		=_____%a	=_____b

FINAL CLIMATE RATING(C)= a - b = [ ]

ORGANIC SOILS (O)

1. Soil Climate (Z)
   - EGDD Index ______ ______
   - Organic base rating = 100 -______ = _____a
2. Moisture factor (M)
   - P-PE index ______
   - surface % fibre ______ ______b
   - water table ______
   - subsurf. % fibre ______ ______%b=_____c
   - Moisture deduction = b - c = ______d
3. Surface factors
   - struct.(% fibre)(B) ______ ______
   - reaction (V) ______ ______
   - salinity (N) ______ ______
   - Surface deduction = ______e

Basic Organic Rating = a - d - e = ______f

4. Subsurface factors
   - struct.(%fibre)(B)_____ _____
   - substrate (G)
     - texture _____
     - depth _____ _____
   - reaction (V) _____ _____
   - salinity (N) _____ _____
   - Subsurface deduction = _____%f=____g

Interim Organic Rating = f - g =_____h

5. Drainage factor (W)
   - depth water table _____
   - subsurf. % fibre _____ _____
   - Drainage deduction = _____%h=____i

FINAL ORGANIC RATING (O) = h - i = [ ]

FINAL RATING CALCULATION

	index		factors			%
C=	_____	or class	____,	______	______	( )
S=	_____	or class	____,	______	______	( )
S=	_____	or class	____,	______	______	( )
O=	_____	or class	____,	______	______	( )
L=	_____	or class	____,	______	______	( )
L=	_____	or class	____,	______	______	( )

Index	Class
80-100	1
60-79	2
45-59	3
30-44	4
20-29	5
10-19	6
0-9	7

Final rating using: average [ ] ; complex [ ] ; most limiting [ ]

Symbol

C S(O) L / ___ ___ ___ classes = _____ Class ____ ____ factors ____ % ( )

Comments

C S(O) L / ___ ___ ___ classes = _____ Class ____ ____ factors ____ ( )

DATA INPUT DOCUMENT
(Soil and Landscape factors)

1. LOCATION: NAME: DATE:

2. LANDSCAPE: (general)

Slope characteristics: (steepness and length)

Surface stoniness: (size and amount)

Pattern: (kind and number of obstacles)

Flooding: (duration and frequency)

3. SOILS: (general)

Profile description:

horizon	depth	texture*	structure	consistence	color	
1.						
2.						
3.						
4.						

* for organic soils use % rubbed fibre and % wood.

Depth to limiting horizon =

Laboratory analysis:

horizon	pH	O.C.	$CaCO_3$ /E.C.	bulk density	>2 mm	S	Si	C	
1.									
2.									
3.									
4.									

Drainage: (general)

- depth to water table:

4. COMMENTS: (variability, etc.)