Land Suitability Rating System:

1. Development discussion

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# Acknowledgements

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# 1 Introduction

The identification of soil landscapes suitable for the production of food began with the dawn of arable agriculture (Simonson 1968). Canada was no exception with references in the notes of early explorers such as Champlain in the early 1600s (Fischer 2008) and Palliser in the west in the 1850s (Spry 1963). These early types of assessments were very subjective (good-fair-poor) based on general observations of features such as topography, stoniness, wetness and tree cover.

As agriculture became more mechanized and intensified in the 20th Century, there was a concomitant increase in scientific research into the agronomic requirements of arable crops. The evaluation of production potential became much more specific and quantitative with assessments such as the Storie approach (Storie 1933). This mathematical treatment of individual parameters such as texture, organic matter and pH was well accepted by the technical community of soil specialists and ratings based on his procedure were incorporated into soil reports into the 1960s and 70s.

By the middle of the century agriculture was becoming a mature industry. With greater intensification and further expansion into the less suitable fringe lands, there was a recognition that the push for higher productivity was affecting environmental sustainability (This discussion had started with the wind erosion concerns in the 1920s and 30s). Also there was a growing competition with other land uses such as forestry, wildlife habitat, and recreation all associated with a growing population. It was into this setting that the broader concept of land capability, which included an aspect of sustainability was introduced both in the United States (Klingebiel and Montgomery 1961) and Canada (ARDA 1964).

The Canada Land Inventory (CLI) was introduced in Canada in the mid 1960s (ARDA 1964). It was a general comparative capability approach based on severity of limitations for broadly defined land uses: specifically agriculture, forestry, wildlife and recreation. The stated purpose was to establish regional land use priorities at a scale of about 1: 250,000 recognising significantly different land units down to about Township size. The then relatively new profession of land use planning was becoming important and quickly embraced this new rating system. Capability was an intuitive and easily understandable concept. It was a 7 Class system with #1 being the best with no limitation for the intended use, # 4 being marginal for the use and # 7 being completely unsuitable. Municipal planners and realtors particularly liked the approach. As a result, a cooperative federal-provincial program was undertaken and by 1975 had provided a national CLI coverage for all regions across Canada with multiple land use issues associated with agriculture.

The CLI system worked very well for its intended regional development objectives. These regional assessments , while based on specific soil and land information still required a significant amount of interpretation and extrapolation and amalgamation. In many areas there simply was not a more detailed database. However, many land evaluators and managers required a much more detailed assessment at scales of 1:50,000 or larger (with units as small as several hectares). attempts to extend the CLI approach to address the more detailed requirements provided variable results. In many cases, modifications were made to the original rating system to provide more specific direction and structure to the system (ON, ATL, BC). In other areas, the soils specialists simply used two parallel systems with both the CLI and Storie-type approaches. As well, as long as one person or one closely correlated group was providing the interpretations there was at least consistency within a region. However, as more people and agencies became involved, consistent evaluations became a problem (ASAC 1987).

The overall result was that by 1980 there were many agricultural rating systems being used across Canada. With different parameters and thresholds, even the same crops had different absolute ratings. Even the original CLI was not consistent across Canada as the ratings were based on regionally important crops that differed from one region to another. For example, a Class 1 area in Saskatchewan would be based on wheat and other small grains while a Class 1 in Ontario would have to grow corn. At that time there was not a consistent national approach to soil ratings for agriculture in Canada.

In 1987 the Land Resource Research Centre struck a Agronomic Interpretations Working Group[ (AIWG) to pursue the development of a national rating system for Canada. It was asked to address several specific concerns related to the CLI - Soil Capability for Agriculture, namely:

- the proliferation of modifications

- the influence of climate

- the omission of organic soils in the CLI

- the need for specificity and consistency

The working group met annually over the next five years dealing with issues such as definitions, approaches, specific problems relating to general and specific aspects of the program development. Meetings were held in Edmonton, AB (1988), Quebec City (1989), Summerland, BC (1990) and Truro, NS (1991) to address specific local concerns and to get a good appreciation of the range of conditions that needed to be considered.

The purpose of this paper is to report on the resultant national Land suitability Rating System for Agricultural Crops (LSRS), to discuss its development and to compare it to the Canada Land Inventory - Soil Capability for Agriculture (CLI).

This report covers the period from 1987, when the Working Group was established, to 1995, the publication of the LSRS document. A second report will cover the period from 1995 to 2010 as the LSRS was "operationalized" - automated and expanded to cover a greater suite of crops.

# 2 System Development

## 2.1 Preliminary Orientation

The Working Group, composed of members from each province plus the Yukon Territory, examined a number of systems presently being used to rate land for the production of agricultural crops, keeping in mind the need for national consistency and the other concerns raised by the Expert Committee on Soil Survey (ECSS 1986). The systems included those used in British Columbia (Kenk and Cotic, 1983), Alberta (Alberta Soils Advisory Committee, 1987), the Ottawa area (Marshall et al., 1979), Ontario (Brokx and Presant, 1986), Quebec (Mailloux et al., 1964) and the Atlantic Region (Atlantic Advisory Committee, 1988) as well as the CLI and Storie systems.. Several climatic stratifications were also reviewed (Chapman and Brown, 1966; FAO, 1976; Williams, 1983).

Recommendations from the initial assessment were:

1. 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.
2. Since climate, soil and landscape factors could independently control the suitability of a tract of land for crop production, each one should be rated separately.
3. Organic soils must be included and should (at least in the initial development stages) be rated for the same crops as mineral soils.
4. As a limited number of factors were common to all systems reviewed and included most of the parameters of an optimum approach to soil productivity assessment (Heddleston 1984) these should be individually defined and explicitly rated using an expert system approach (Mc Cracken and Cate 1986) based on present knowledge and available data.
5. The individual parameter ratings should follow scientifically proven relationships and managed in a mathematical setting leading to a composite index (climate , soil and landscape) similar to the Storie approach.
6. The system should be developed using the small seeded cereals (wheat, oats and barley) with an emphasis on barley which is the one crop that is grown in every agricultural region of Canada.
7. The system must use data that was presently available across Canada.

The first recommendation provided the overall approach that should be taken while the next four addressed the major weaknesses that had been identified in the CLI approach. The final two recommendations addressed the issue of national consistency and provided further direction for system development.

It may be noted that no mention is made of scale. The reason is that the system is meant to be scaleless- with the ability to be used at any scale appropriate to the objectives of the project and available data.

## 2.2 Terminology

Many terms have overlapping usages: some have been used for more than one meaning, several have often been used for the same meaning. Following are some of the general usages employed in this report.

1. Soil vs Land (soilscape, landscape, landform)

Soil - restricted to those situations specific to soil considerations.

Land - used in a general sense that includes soil, landscape setting (climate and vegetation)  
 - it is a more inclusive than soil and therefore a more appropriate term in a natural systems /   
 ecological approach.

Landscape - used in a general sense that includes features such as stoniness and wetness as well as "landform"

2. Capability vs Suitability (rating, assessment, evaluation)

Capability - a broad concept that addressed potential is terms of crop options, productivity and sustainability.  
 - it is used in a manner, consistent with the CLI, for broad concepts and at generalized scales of detail.

Suitability - has the same general concept as capability but is used for specific objectives (e.g. single crops) or at more detailed (larger) scales.

Assessment and evaluation, when used in an "agricultural rating" context have an economic component but all three terms are used interchangeable in this report in a generic sense with no specific meaning.

3. Agriculture was used in the CLI to signify the industry but in reality it only represented the annual cash crop component which caused some confusion. It is used here only the generic context.

## 2.3 Assumptions

Arising from the preliminary discussion there were a number of assumptions or guidelines that were required to provide boundary conditions for the system.

1. Standard recommended husbandry should be assumed.

2. External economic factors such as distance to market, availability of transportation and size of farm would not be criteria. These are important for Municipal assessment and taxation but would not be part of this natural resource evaluation.

3. One-time costs such as clearing of trees or drainage would not be criteria but continuing annual costs such stone removal and erosion control should be considered in the sustainability considerations.

4. Exceptional skills or resources of the farm manager or specific cultural practices would not be considered.

5. Permafrost would not be a factor. This was based on the observation that once the vegetative cover is removed, permafrost recedes to depths greater than 1 m in any region of Canada where commercial crop production is considered feasible.

## 2.4 Structure of the Land suitability Rating System

As indicated earlier (Sec 2.1), it was recommended that the basic structure should follow that of the CLI with the addition that it should also specifically identify the factors and components to be assessed.

### 2.4.1 Class and Subclass

1. CLASS - based on the degree of limitation of land for the production of specified crops.

* there are 7 classes ranging from 1 with no or slight limitation to 7 with extremely severe limitations (completely unsuitable).
* Classes 1-3 are considered suitable for the sustained production of the crop under consideration
* Class 4 is considered marginal
* Classes 5-7 are considered to be unsuitable for sustained production under presently recommended practices.

2. SUBCLASS - based on the kind of limitation.

* it identifies the principal parameters that create the limitation.
* the subclass information is critical for determining conservation and management practices and for land use planning.

It must be emphasized that areas assigned the same class are similar only with respect to the degree of limitation. Each class can include different soil landscape and climatic characteristics that may require different management practices.

### 2.4.2 Factors and Parameters

Three main factors were identified: Climate, Soil and Landscape.

The components and measureable parameters identified to characterize and evaluate the major factors were selected from those used in the earlier rating systems (Sec 2.1) and acknowledged to be critical in crop production (Heddleston 1984).

The selection criteria were that the parameters:

* were known to affect the ability to produce crops
* were known to affect the ability to respond to management stress (e.g. could withstand drought)
* must be measureable or able to be estimated from known relationships (pedotransfer funtions)
* data must be commonly available

Based on the above criteria, the following parameters were chosen (Table x)

Table 2.4. Components and parameters chosen to characterize the major rating factors.\*\*

|  |  |  |
| --- | --- | --- |
| Factor | Component | Measureable parameter |
| Climate | Heat (energy) supply | Growing degree days, growing season |
|  | Moisture supply | Precipitation, evapotranspiration, growing season |
| Mineral Soils | Moisture supply | Texture, climate, rooting depth, watertable |
|  | Nutrient supply | Organic matter content, soil reaction |
|  | Physical conditions | Soil structure, soil density |
|  | Chemical conditions | Soil salinity, soil reaction |
|  | Drainage | Depth to water table, climate |
| Organic Soils | Moisture supply | Fibre content, climate, water table |
|  | Nutrient supply | Fibre type, soil reaction |
|  | Physical conditions | Soil structure, soil density |
|  | Chemical conditions | Soil reaction, soil salinity |
|  | Drainage | Depth to water table, climate |
| Landscape | Erodability potential | Slope steepness, slope length, climate |
|  | Management factors | Stoniness, drainage, pattern\* |
|  | Flooding potential\* | Wetness, duration of flooding, landform position |

\*\* See AIWG 1995 for definitions.

\* identified but not incorporated for initial development.

## 2.5 Relationships and Linkages of Factors, Components and Parameters to the Suitability Assessment

The recommendations in sec 2.1 suggested that Climate soils and Landscape factors should be assessed separately with a precisely defined index procedure (#s 2,4,5) and then linked to the 7 Class system (#s 1,5). This required the development of relationships and guidelines.

### 2.5.1 The relationship between Climate, Soils and Landscape Factors.

The general concept was:

Climate - controls what crops can be grown (Flexibility)

Soils - control how well the crops grow (Productivity)

Landscape - controls the annual cost to manage environmental constraints   
such as erosion potential, stoniness or wetness (Sustainability)

It was recognized that there were many instances of overlap and synergy. However, by assessing each separately there were advantages with respect to simplicity, clarity and the ability to highlight specific limitations. Also, it was felt that if the major climatic-soil interactions were built into the soil factor then any remaining disparencies would be small. Given the constraint of available data and the need for national coverage the decision seemed reasonable.

In this approach each of the major factors would be assessed a rating index between 0 (most limiting) and 100 (least limiting) and the final rating being the most limiting of the three factors.. This approach also provides the greatest flexibility to assess various environmental, crop and climatic scenarios.

### 2.5.2 Linkage of numerical assessment to the descriptive Class structure.

It was necessary to link the prescriptive numerical Factor indices to the descriptive Class definitions based on an assessment of limitations. As productivity is an important consideration in suitability assessments, studies of the relationships of Canada Land Inventory (CLI) Classes to the yields of cereals in Alberta (Peters 1977, Peters and Pettapiece 1981) and apples in Ontario (vanVliet etal 1979) provided the initial guidance. They found a reasonably good correlation for the better classes with Class 1 (none to slight limitation) generally yielding 80% to 100% of the crop maximum. Class 3 areas (moderate limitation) but still considered "Good" generally had yields about 50% of maximum or better. They also noted that with increasing, particularly landscape, limitations the yield relationships disappeared. That is, landscape features may be difficult or costly to manage but are not directly related to yield.

In addition, expert opinion suggested that any index rating of less than about 1/3 of maximum (33 out of 100 points) should be considered a very severe limitation and would not likely be a sustainable situation.

With the above considerations as a guide, the following relationship table was developed.

Table 2.5. Relationship of index points to Suitability Class

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Suitability  Class | Index  points | Limitation level  for specified crops | General  Assessment | Comments |
| 1 | 100 - 80 | None to slight | Excellent | Prime land |
| 2 | 79 - 60 | Slight | Good |
| 3 | 59 - 45 | Moderate | Fair |
| 4 | 44 - 30 | Severe | Poor | Marginal land |
| 5 | 29 - 20 | Very severe | Very poor | Unsustainable or  Unsuitable land |
| 6 | 19 - 10 | Extreme | Unsuitable |
| 7 | 9 - 0 | Unsuitable |

This table became the guide for developing the individual parameter indices and for linking indices to the Classes both conceptually and mathematically.

### 2.6 Information Requirements

Use of the rating system requires specific information for each component within the climate, soil and landscape factors. There are two main considerations.

First is the principal issue of what to measure and how to measure it. For example, climate per se is not measured. However, heat (energy) and moisture parameters have been identified. The measurable components of moisture are precipitation, evapotranspiration and length of growing season (the what to measure). Precipitation is easy to measure and there are good records covering most of Canada. Evapotranspiration is a little more difficult with fewer records. However, there are several accepted approximations in the literature that can be used (transfer function based on other data). Growing season length requires some definition of beginning and end before it can be measured. All weather data is variable at all scales so decisions are required to manage this. The LSRS decision was to follow the National Meteorological approach and use 30 year averages. In the case of climate, many parameters are closely correlated and because the Suitability system is a relative approach comparing neighbouring land areas (not absolute), there are many options that will work equally well when choosing components or that can be substituted with no loss of accuracy.

A second important issue is that of proxies. If there is no information or missing records or a lack of records at the scale of investigation, are there other measurements or features that can be used? This is particularly relevant to the soil factors and fortunately there is a good deal of scientific research and literature that defines relationships that can be used for proxies. (In the case of soils, these are often referred to as pedotransfer functions). For example, soil texture or particle size distribution can be used as a proxy for soil moisture holding potential, soil color can be used as a proxy for organic matter content or soil drainage can be used as a rough estimate of depth to water table. In the landscape analysis, slope steepness (and length) can be used as a measure of the erosion potential. these are defined for the LSRS applications (AIWG 1995) and provided as guidelines for users of the system.

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.

# 3 Factor, Component and Parameter Ratings

This section discusses the essence of the LSRS system. It describes the process of converting concepts to specific defined and measureable components (reification). It is the logic that links scientific research and expert judgements with available data to create a system that can be applied in a consistent, defined mathematical approach.

## 3.1 Actions related to component analysis

(The evaluation of individual parameters and components.)

There are a number of steps involved:

1 Identifying the specific parameters to represent a component and their unit of measurement.

- This is the first stage of documentation and transparency

2 Establishing the values to represent key limitation thresholds such as none, marginal, severe etc. for the specified crop(s).

- This is where the research and judgement was applied.

3 Defining the relationship for the continuous and complete range of expected limitation values.

- This generally involved the creation of a graph, table or curve based on the points indentified in the previous step.

4 Identifying proxies as appropriate.

- This was necessary to recognize the variability in data availability across the country and to accommodate the introduction of new data.

The following example describes part of the assessment of chemical soil limitations for small grains.

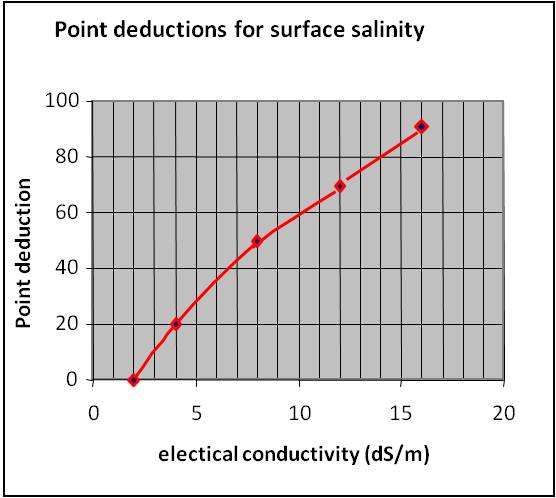
1 One of the parameters chosen to address this component was salinity.  
It was defined by the electrical conductivity of a saturated paste extract measured in dS/m.

2 Table 3.1. Point deductions for surface soil salinity limitations for small grains.

|  |  |  |
| --- | --- | --- |
| Salinity  (dS/m) | Assessment of limitations\*  (some common vegetation responses) | Assigned point deductions\*\* |
| 2 | No visible effect on plant growth  No limitation | 0 |
| 4 | Slight effect on crop growth  drop 1 Class (Class 1-2 boundary) | 20 |
| 8 | Noticeable effect on crop growth, presence of foxtail  Moderate to severe limitation (lower part of Class 3) | 50 |
| 16 | Little or no small grain growth, presence of salicornia  Very severe limitation (Class 7) | 90 |

\* Assessment based on research literature and expert opinion.   
\*\* Points assigned using the relationships described in Table 2.5x.

3 To define the complete range of expected values, one could extrapolate from the above table, create a more detailed table based on the data above or graph the results (Fig 3.1). From the graph one can derive the mathematical relationship.



y = -0.2067x2  + 10x - 18

(R2 = 0.998)

Fig 3.1. Deductions for surface soil salinity

Once the relationship has been established, it becomes the logic statement for the salinity assessment and any value for salinity can be related to the limitation deduction from the curve or using the formula for the curve.

Some component deductions involving several parameters are more complicated but the point is that all the analyses are rated on a continuous scale (1-100) and can be described mathematically.

4. A proxy for electrical conductivity could be vegetation observations. These would not be as precise but could be adequate for broad assessments. Also, other procedures for E.C. could be substituted by developing a correlation function.

## 3.2 Actions related to the determination of the 3 major factors

(How the components and parameters should be merged)

### 3.2.1 Clarifying roles or contributions

Several of the identified components are really concepts that may involve more than one contribution.

- the whole soil pedon (the top 1-1.5m or rooting zone) contributes to plant productivity but the near-surface portion that contains the majority of the root mass is clearly more important than the lower portion (ref). Therefore a decision was taken to define the top 20 cm as the 'surface layer' in mineral soils (in organic soils it is defined the top 40 cm to recognize compaction and mineralization). the next 80 cm is considered to be the 'subsoil layer'. Values for the soil components are averaged for these layers.

- the depth to water table (soil drainage is the standard proxy) involves two consideration. First is its contribution to available water for plant use which is incorporated into the 'water supplying ability' calculation. Second is the influence on workability (trafficability) and land management which will referred to as 'drainage' in this report.

### 3.2.2 Recognition of significant interactions.

This is mainly the recognition of synergistic climate-soil (and also landscape) relationships.

- water supplying ability - was defined as a relationship between climate (P-PE), soil water holding capacity and near-surface water tables.

- the drainage (workability) deduction was defined by a relationship between depth to water table, soil hydraulic conductivity and regional climate (P-PE).

- the root impedence deduction was defined by a relationship between bulk density, texture, depth and climate (P-PE).

- the climate (Heat) assessment recognized a daylength influence.

- the landscape deduction recognized a simple (rainfall) influence.

- the reaction, salinity, sodicity relationship was recognized as one of considerable overlap that could lead to 'double counting'. Therefore, only the most limiting was used within the surface and subsurface calculations and also between the surface and subsurface contributions.

### 3.2.3 Assessment of major vs minor contributors to the factor ratings.

The major (controlling or principal) components were recognized by direct point deductions while the minor (modifying) contributors were handled as percentage deductions (Table 3.2.3).

Table 3.2.3 Controlling and modifying components for determining the major factors.

|  |  |  |
| --- | --- | --- |
| Factor | Controlling Components  (point deductions) | Modifying components  (percent deductions) |
| Climate | Heat  Moisture  (Use the most limiting) | - excessive spring moisture  - excessive fall moisture  - frost pockets  - daylength |
| Mineral soils | - water supplying ability  - surface soil layer | - subsoil layer  - drainage |
| Organic soils | - water supplying ability  - surface soil layer | - subsoil layer  - drainage  - soil temperature |
| Landscape | Landform  (slope steepness and length) | - stoniness  - flooding potential  - pattern\* |

\* recognized but not incorporated in the initial system.

### 3.2.4 Assessment of the final rating and symbolization

Once the individual factors have been assessed, one can then assign Class and Subclass designations.

1. A single soil-site situation.

- the Factor with the greatest limitation is identified

- the limitation value determines the Class (see Table2.5)

- the components with values greater than 20 points or percent deduction (1 Class) are listed to a maximum of three and the Subclass symbols (see Appendix 1) are added to the Class.

2. A multiple soil-site situation.

This is the usual case for small scale map units with more than one soil-landscape component.

2.1 If the Factor values are non-contrasting (differ by less than 30 points) the factors are combined into a single unit with all values prorated.

- Class and subclasses determined as per the single situation.

2.2 If the Factors have contrasting values a two or three (maximum) Class symbol is warranted.

- all units with major wetness (>60 points) = Category 1.

- the largest remainder plus similar soil-sites = Category 2

- the remainder = Category 3.

- the Category components are combined into single units.

- Class and Subclass determined as above.

Note: One could assign Class and Subclass symbols to the individual factors if wished. for example, one might wish to compare soil quality before and after site reclamation when climate and/or landscape were not at issue (were constant).

# 4 Comparison of the LSRS and CLI Features

The LSRS differs from the CLI in several respects (Table 4.1).

Table 4.1 A comparison of the LSRS with the CLI-Soil Capability for Agriculture.

|  |  |  |
| --- | --- | --- |
| Component | CLI | LSRS |
| General | -capability | -suitability |
| -11 factors | - 17 factors |
| -factors not indexed | -factors indexed |
| -7 classes | -7 classes |
| -no organic soil rating | -organic soil rating |
| -limitation identified | -limitation identified |
| -subjective analyses | -specific defined analyses |
| Climate | -frost-free period | -growing season |
| -annual precipitation | -moisture index (P-PE) |
|  | -energy index (EGDD) |
|  | -modifiers |
| Soils | -structure | -bulk density (structure) |
| -salinity | -salinity, sodicity |
| -texture | -texture |
| -drainage | -drainage |
| -depth | -depth |
| -erosion | -organic matter |
| -fertility | -soil reaction |
|  | -fibre content |
| Landscape | -topography | -slope steepness and length |
| -stoniness | -stoniness |
| -inundation | -inundation |
|  | -pattern |

The LSRS includes a more comprehensive treatment of climate, it includes organic soils and there are several additional rating parameters. In addition, it provides a means of documenting and quantifying the rating process. While the calculation procedures are different, the two methods follow the same concepts, use essentially the same rating factors and have the same rating symbol format.

# 5 Preliminary Testing of the LSRS

In 1992 a draft of the new LSRS system was circulated to the working group requesting field testing to:

1. evaluate the functionality of the system (does it work),

2. provide an assessment of the consistency of application, and

3. to compare the results to the local CLI ratings (the LSRS was developed using the CLI as the rating standard as one of the directing recommendations was that the new system should mimic the CLI but with more specificity).

Working Group members from all provinces provided personal responses. Three provinces (BC, ON, NS) conducted system testing with local agronomists in an evaluation of a variety of soil-site situations (for individual soil series as compared to complex map units)[[1]](#footnote-1). The procedures and formats were not identical but there was enough similarity to allow for a qualitative comparison.

A review of the NS results (Table 5.1) indicated:

1. in the comparison of the LSRS to the CLI:  
 - 4/10 had same Class, 5/10 were 1 Class lower, 1/10 was 1 Class higher.  
 - that is, 40% were same class and 100% were within 1 Class.  
 - Subclasses D and W were involved in all the cases where there were differences.

2. in the evaluation of consistence and useability:  
 - 70% of the participants rated the sites in the same Class as the LSRS (most with the same Subclass)  
 - at 9/10 sites, all had the ratings were within 1 Class of the LSRS (most used the same Subclasses).

3. they concluded:  
 - the LSRS was working well  
 - there was relatively good consistency  
 - there were several areas that needed to be looked at:  
 - problem assessing the D factor - particularly in conjunction with impeded drainage  
 - the climate maps were not convenient  
 - should consider a soil interaction (modifier) with the landscape assessment.

A review of the BC results indicated:

1. in the comparison of the LSRS to the CLI  
 - 2/6 were the same class, 3 were mixtures that included the same Class and a lower Class1 and  
1 was 1 Class higher,  
 - All were within 1 Class  
 - confirms that both the LSRS and CLI were doing a good job of assessing suitability.

2. they concluded:  
 - generally pleased with the results of the LSRS re CLI  
 - liked the quantitative aspect of the LSRS  
 - should review the bulk density-impedance issue (D)- might be too restrictive.  
 - the climate maps are hard to read and too general.

Table 5.1. Results of Nova Scotia testing.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Soil Name | Slope  % | CLI  Rating | LSRS  Rating\* | Participant rating (7) | | |
| Most common Class | % same Class | % within 1 Class |
| 1 | Cornwallis | 5 | 3M | 3M | 3M | 88 | 100 |
| 2 | Fash | 1 | 4DW | 5DW | 5DW (3D-6DW) | 63 | 88 |
| 3 | South Alton | 4 | 5R | 4RM | 4R (3R-5MR) | 50 | 100 |
| 4 | Hantsport | 6 | 3T | 4DW | 4DW (3WDT-5WD) | 67 | 100 |
| 5 | Queens | 4 | 3D | 4WD | 5WD (4WD) | 71 | 100 |
| 6 | Debert | 2 | 4W | 3DW | 4WD, 3D | 57 | 100 |
| 7 | Hansford | 5 | 2C | 2TH | 2TH (3T) | 86 | 100 |
| 8 | Pugwash | 2 | 2C | 3D | 3DW (2DW-4DW) | 57 | 100 |
| 9 | Hebert | 6 | 3MT | 3T | 3T (4TP) | 86 | 100 |
| 10 | Westbrook | 14 | 4T | 4T | 4T (5T) | 71 | 100 |

\* Rating by LRU staff

Table 5.2. Results of British Columbia (Peace River) testing

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Site | Soil Name | Slope  % | CLI  Rating | LSRS  Rating\* | Local Ranking |
|  | Rolla-Rycroft | 2 | 2D | 3 (2)DMH | 1 |
|  | Septimus Creek | 8 | 5M | 4MH | 4 |
|  | Donnelly (Esher) | 10 | 3D | 3 (4) DHT | 2 |
|  | Codner | 1 | 4W | 3-4 HW | 3 |
|  | Alcan | 7 | 4D | 4DHT | 4 |
|  | Snipe | 2 | 5W | 5 WD | 6 |

\* ( ) indicate a mixture, - indicates on the border

A BC office comparison of LSRS and CLI for 20 soils across the province indicated:  
 - 5 had same Class, 15 were 1 Class lower and 2 were 1 Class higher   
 - that is, 84% were within 1 Class.  
 - there were problems assigning climate values and with management of the 'surface soil'   
 characteristics of non-cultivated soils which accounted for much of the major differences.

The Ontario testing involved an office review of 50 soils in Wilmot Township.

The report indicated that :  
 - 16 had the same Class, 16 were 1 Class lower and 10 were 1 Class higher  
 - a total of 84 % were within 1 Class  
 - 7 were 2 Classes lower and 1 was 3 Classes lower  
 - W (wetness or drainage) and D (bulk density) were involved in 16 out of the 24 lower ratings

They concluded that:  
 - ratings using LSRS were generally similar to the CLI  
 - "a clear advantage of the LSRS is the replicable and 'traceable' end result"  
 - they had trouble applying the flooding/inundation component   
 - the density and wetness components seemed a be somewhat harsh

Summary of the testing.

1. The LSRS ratings were similar to the CLI ratings.

2. The quantitative approach did promote a good degree of uniformity (consistency) in application and was well received.

3. There were a number of areas that required attention:  
- the subsurface density (root restriction) component was considered too restrictive,   
 (particularly when restricted drainage was also involved)  
- the wetness and inundations sections required clarification,  
- the handling of the surface layer component needed clarification,   
- a better method of managing the climate information should be pursued,

# 6 Summary and Conclusions

This report discusses the basic reasoning and actions associated with addressing the weaknesses identified in the Canada Land Inventory: Soil Capability for Agriculture

The LSRS publication (AIWG 1995) provides protocols for the consistent, national application of a suitability rating process based on fundamental climate, soil and landscape characteristics that are known to affect crop production and for which there are available databases across the country. It was developed using spring-seeded small grains with an emphasis on barley, as this crop is grown in virtually every agricultural region of Canada.

Benefits of the LSRS

1. The system is national in scope.

2. The system explicitly deals with climate, soils and landscape components.

3. The system accommodates all of the land base including organic soils.

4. Individual factors are identified and explicitly rated.

5. The system provides for documentation of the process.

6. The system is independent of scale.

7. The input requirements are commonly available in most natural resource inventories or soil surveys. but it can use site data or nationally available soil and climate data. There is also an allowance for the use of defined proxies.

8. The system is flexible. The separation of climate, soils and landscape components facilitates adaptations to a variety of climate, crop, soil quality or land use analyses.

9. The assessments can be converted to algorithms and the final ratings automatically generated.

10. It can be easily updated (modified) as new information or objectives are identified.

By placing climate, soil and landscape Factors in separate modules, changes to any one can be made without affecting the others. This is particularly useful for specific crop requirements that only require changes to one or two of the components. For example, Canola or Corn may have the same soil and landscape requirements but have markedly different climatic requirements. Therefore, only the climate module needs to be modified to address each of these crops. On the other hand, a modification for forage production, particularly a grazing regime, would clearly need to address the landscape module as well as the climate module. Major management modifications such as irrigation can be accommodated by simply setting the moisture limitation to 0.

Placing the rating system into a national framework does have some implications. For example, some of the prairie provinces may no longer have any Class 1 when compared to the CLI which was developed using regional assessments. In Alberta, for example, there is always at least a minor climatic limitation for crop production, either a moisture deficit or a heat deficit or both, which results in a Class 2 rating. This is a problem for realtors who deal in a local setting but does not impact land use decisions which use a more general 'prime' farmland designation that includes classes 1, 2 and 3. the CLI and LSRS give essentially the same information: good or prime agricultural land (Classes 1, 2 and some 3) is still prime land, marginal land (Class 4 and some 5) is still marginal and poor land (Classes 5, 6 and 7) is still poor.

The limited testing suggested that :  
- The LSRS initiative had met its goals of devising a system that resembled the CLI and had   
 successfully added specificity and rigor to the system.   
- there were several areas in the draft document that needed to be reviewed.

In conclusion:

The Land Suitability Rating System (LSRS) represents the continued evolution of the land capability concept. It describes a new nationally consistent system which has many improvements and advantages over the older CLI while maintaining the original framework and producing closely correlated outputs.

- it has an improved systematic and documented methodology that is more reproducible and defensible than the CLI.

- it includes several features such as scale independence and flexibility that will allow for a variety of future planning functions.

- it provides results very similar to the CLI and any changes resulting from the substitution of the present system for the CLI will be minor and there should be no substantial impact on current municipal land use legislation.

# 7 Recommendations

1. There should be an immediate effort to automate the calculation process to facilitate further applications.

2. The climate data should be updated to standard, electronically available data sources.

3. There is a positive opportunity to develop suitability ratings for the complete range of agricultural crops (and forest crops) under present and future climate scenarios.   
This could be critical for climate change planning.

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# Appendices

## Appendix 1 Definitions of Classes and Subclasses

### 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). |

### 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 (0) | 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. |

1. \* Alberta also conducted some tests but because that province had been used extensively for the development process the use of those tests were not considered appropriate. [↑](#footnote-ref-1)