AGRI-ENVIRONMENTAL INDICATOR PROJECT

Agriculture and Agri-Food Canada

REPORT NO. 16

SOIL DEGRADATION RISK INDICATOR: SOIL SALINITY RISK COMPONENT

PROGRESS REPORT

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PREFACE

The Agri-Environmental Indicator (AEI) Project of Agriculture and Agri-Food Canada (AAFC) was initiated in 1993 in response to recommendations made by several agencies, organizations and special studies. The overall objective of the project is to develop and provide information to help integrate environmental considerations into decision-making processes of the agri-food sector.

The project aims to develop a core set of regionally-sensitive national indicators that build on and enhance the information base currently available on environmental conditions and trends related to primary agriculture in Canada. The salinity risk component of the Soil Degradation Risk indicator is an important part of the agri-environmental indicator set. Indicators are also being developed for other aspects of soil degradation risk and in relation to issues of water quality, agroecosystem biodiversity, farm resource management, agricultural greenhouse gases and agricultural production efficiency.

Research results in the form of discussion papers, scientific articles and progress reports are released as they become available. A comprehensive report is planned for fiscal-year 1998-1999 which will include data from the 1996 Statistics Canada Census of Agriculture.

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ABSTRACT

Agricultural land use can impact the sustainability of inherent soil quality by its influence on the extent, severity and dynamics of soil salinity. To assess this impact, a salinity risk index (SRI) has been developed and applied to the agricultural region of the Canadian prairies utilizing land use data sets for 1991 and 1981. The analysis, presented in map form, shows the current status of dryland salinity for 1991, the current risk based on land use in 1991, and an analysis of the change in risk due to the change in land use from 1981 to 1991. The total extent of moderate or more severe salinity (EC_e >8 dS/m) for the prairie region as determined from a summation of each provincial extent map, is 1.4 million ha. This area is depicted on a small scale extent map. The risk assessment using 1991 land use data indicates that 62.2% of the farm land has little to no risk of a change in salinity, 27.9% has a moderate risk and only 9.9% of the land has a high risk. A comparison of the risk index classes for the 1981 and 1991 land use data, indicates that risk of salinity for the majority of the land (92 %) has not changed, whereas less than 7 % of the land has a lower risk class and approximately 0.5 % has a higher risk class in 1991. These data are not presented in the context of trends but simply as observations at two points in time.

It is proposed that this approach could be utilized periodically in the future to track impact of changes in land use on a landscape basis and thus serve as an indicator of agri-environmental sustainability. This information will be utilized by upper levels of government to target programs and agricultural policy.

OUTLINE

1.0 INTRODUCTION [1]

Soil salinity is one factor which negatively influences soil quality and sustainable agriculture (Acton and Gregorich (eds) 1995). Defining an appropriate indicator for soil salinity in terms of soil quality is difficult. The indicator must be relevant, reproducible, and scientifically rigorous as well as feasible (McRae *et.al*. 1995). The salinity status of a soil is usually determined by measuring the electrical conductivity of a soil paste extract. This method, however, is not practical for assessing the salinity status of the prairies due to the wide spatial variability of dryland salinity and the large number of samples and labor that would be required. In addition, one time measurements of the extent and severity of saline soils as an indicator are not practical due to the temporal variability of salinity. On the other hand, assessments utilizing remotely sensed data are fraught with problems related to its correlation with ground truth data. Nevertheless, numerous attempts have been made over the years to document the type, extent and severity of soil salinity in Western Canada; however, these assessments have been based on different definitions, criteria and methodologies. Consequently it is not possible to quantitatively document the changes in salinity status that may have taken place over the last 30 years. Additionally the resources required to make such assessments are not available nor is the exercise practical on a continuing long term basis.

Recently, the issue of soil salinity has been addressed through the concerns for evaluating the status of soil quality in Canada and its impact on agricultural sustainability (Acton, (ed) 1994). This exercise focused attention on the need to establish acceptable definitions and to provide a systematic approach (methodology) for documenting soil salinity and predicting susceptibility to change in response to land use practices as suggested by Acton et. al. (1992). In response to that need Eilers *et al.* (1995) developed and applied a Salinity Risk Index (SRI) to the Canadian Prairies.

The objective of this paper is to describe the rationale, methodology and application of a Salinity Risk Index (SRI), as a standardized, systematic approach, to assessing the risk for changing the status of soil salinity on the Canadian prairies as a result of agricultural management practices.

2.0 SALINITY RISK INDEX

2.1 Concept and Approach

The SRI conceptually incorporates some of the more important physical and cultural parameters that control the processes of salinization. It is designed to facilitate assessment of the change in risk of dryland soil salinity based on monitoring the changes in the controlling components.

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[1] This paper was accepted on 26 June 1996 for publication as follows: Eilers, R.G., W.D. Eilers and M.M. Fitzgerald. 1996. A soil salinity risk index for the Canadian prairies. Hydrogeology Journal, Special Issue Vol. 5, No. 1 - Groundwater Processes in Land and Water Salinization - An International Perspective.

Specific emphasis has been given to assessing the role of land use as a dynamic component of the risk index. The land use factor will be utilized to predict the trend for potential impact of agricultural practices on the long term susceptibility (risk) to changing salinity.

The salinity risk index is based on the premise that functional relationships exist among the various components that affect the process of salinization, that these components can be given a relative numerical weighting for its influence and that each of these weightings can be combined in a simple multiplicative relation resulting in a dimensionless, numerical value which will be utilized as an index of salinity risk. Comparison of the index values for different map polygons will enable comparisons of relative potential for change.

A further requirement for SRI is that it utilize data which is currently available or data which is being collected on an ongoing or periodic basis.

2.2 Assumptions

This evaluation of risk of change in the status of soil salinity assumes salinity is initially in a state of dynamic-equilibrium. That is, landscapes which have little to no salinity under current climatic and land use conditions are unlikely to suddenly develop salinity unless some major land use changes occur. On the other hand, landscapes which currently have a salinity condition are the ones most likely to show change.

The salinity status of the soil can change in three ways: 1) in terms of extent of area affected, 2) in terms of concentration or severity of affected area, and 3) in terms of both extent and concentration. The SRI does not distinguish which aspect of salinity might change.

2.3 Principles of the RISK Index

The procedure for developing and applying the SRI consists of five steps:

1. Identify the major components controlling soil salinity for use in the index.
2. Assign a relative risk rating to each of the components based on available information.
3. Combine risk ratings for each component to determine the SRI value.
4. Group the calculated values of SRI into classes to represent relative risk for change.
5. Apply risk index to a prairie region data base.

3.0 DESCRIPTION OF THE SALINITY RISK INDEX

A comprehensive SRI incorporates all of the parameters controlling or influencing the process of salinization. The first requirement was to identify each of the causative or influencing factors and to stratify these parameters to determine which might be appropriately used at very broad scales. The second requirement was to assign a suitable relative risk value to each of these major controlling parameters. The procedure for assigning a relative ranking was based on standard attribute classifications using "expert knowledge and intuition" to derive a consensus from senior soil scientists, conservationists and land use specialists across the prairie region. The ranking for relative risk was to reflect the influence that the specific component was expected to have on the processes of salinization. The following discussion will deal with the considerations and ranking of component factors in the SRI and their utilization and application to a small scale map of the Canadian Prairies.

3.1 Factors affecting salinity

Two major aspects of salinity were considered in this approach. One is related to identifying those attributes which comprise the physical framework of the landscape under which salinity develops and the second pertains to those attributes which act upon the physical framework to influence the status of salinity. The factors related to the physical framework of the landscape were considered sensitivity indicators and were comprised of:

a) the present status (Px) - extent, position and severity of soil salinity in the landscape, and
b) comparatively more static (STAT) factors including:

 i) the ecological setting - surface form, topography and material origin, and
 ii) the hydrologic circumstances - soil drainage, depth to regional water table, etc.

Those factors acting upon the physical framework of the landscape were considered to be dynamic (DYN) or more responsive to change and therefore would be potential trend indicators. They include:

a) aridity,
b) land use/surface cover and conservation practice.

The SRI can be represented simplistically by:

$$\textbf{SRI} = f(Px \bullet STAT \bullet DYN) \qquad (1)$$

3.2 Component Selection - Rationale and Ranking

The following discussion will identify each of the major factors influencing dryland salinity. Each will be discussed in terms of the rationale for their selection or deletion and the ranking procedure utilized.

Px - Presence and Extent - The SRI includes the presence of salinity in the landscape in recognition of the fact that landscapes with no salinity at the present time may have a combination of static (STAT) and dynamic (DYN) factors which are conducive to high risk salinity but low probability if the environment is essentially nonsaline.

The small scale Px or present extent map for the prairie provinces was compiled, coordinated and correlated by the land resource units in the provinces of Alberta, Saskatchewan and Manitoba, utilizing published soil landscapes maps at 1:1 m (million) scale (modified from Eilers, R. (1990), Eilers, W. (1988), and Pettapiece and Eilers, (1990)). These maps indicate presence, extent and position or location of moderate or greater levels (EC_e >8 dS/m, [deci-siemens per meter]; where Ec_e is the electrical conductivity of a saturated paste extract of a soil sample taken from the surface to a depth of 60 cm) of salinity in each of the landscape polygons in the agricultural regions of each province. These levels of salinity were considered to be relatively persistent in the landscape, and therefore provide a uniform standard base on which to conduct a risk assessment for the prairies. As these status maps serve as a reference for assessing impact it was necessary to assign a risk ranking to each of the mapped classes as follows:

Map Symbol*		Extent of Area Affected (%)*	Risk Rating**
Surface	N	<0.1	1
(0-60 cm)	S1	0.1 - 0.9	2
	S2	1.0 - 4.9	4
	S3	5.0 - 14.9	6
	S4	15.0 - 49.9	8
	S5	50.0 - 100	10
Subsurface	D3	5.0 - 14.9	2
(60-120 cm)	D4	15.0 - 49.9	5
	D5	50.0 - 100	10

* Map symbols and classes from published maps @ 1:1 million scale.

** For this assessment only the highest risk condition was utilized for either surface or subsurface.

The higher the number the greater the risk rating.

To facilitate a general overview of salinity on the prairies, the number of salinity classes were reduced to three (Eilers *et. al.* 1995). The following three classes were utilized to show the extent of area affected for the Canadian Prairies (1991) in Fig 1.

Map Unit Description	Extent of Area Affected (%)
Low	<0.9
Moderate	1.0 - 14.9
High	>15.0

a) Static Components

The static parameters identify those components of the environment which are subject to relatively slow change. These factors determine the sensitivity of the landscape and typically characterize the physical framework including topography, physiography, geology, and hydrology. Here, hydrology is included in the regional context and is therefore assumed to be relatively static within the comparatively short time frame for agricultural activities.

For this application, the static components of the landscape are defined by functional relationships between topography, surface deposits, geology, and broad scale hydrologic circumstance.

$$\text{STAT components} = f(Tp \bullet Sd \bullet Ge \bullet Hc) \quad (2)$$

Each of the individual components are themselves functional relationships between various attributes of the landscape.

Where:	(Tp) =	Topography (land form, slope, aspect and position)
	(Sd) =	Surface deposits (texture, composition, origin)
	(Ge) =	Geology (type and depth to base rock)
	(Hc) =	Hydrologic circumstance (recharge, discharge, etc.)

Tp - Topography - as a component for the index, is described by the frequency and steepness of slopes in the landscape. For this study, only slope steepness has been utilized.

The risk of spread of salinity is inversely related to slope steepness. Typically, the steeper the slopes the less extensive the salinization (Stolte *et al.* 1992). Soil salinity occurs most extensively in landscapes with level topography. This is largely due to the close functional relationship between topography and depth to water table. A small rise in the shallow water table in level topography would result in a larger area being affected by salinity than in areas with notable local relief. In more steeply sloping areas a rise in water table would likely increase the degree of salinity, but the change in extent of affected area would be minimal. On this basis, the following ranking was applied to the generalized topographic classes for level, hummocky and undulating landscapes as defined for the Soil Landscapes of Canada (SLC) map series (Canada Soil Inventory 1989a, 1989b, and 1992.).

Slope Class	(% Slope)	Risk Rating
level	(1 - 3)	5
undulating	(4 - 9)	3
hummocky	(10 +)	I

Sd - Surface deposits - can be defined as the geologic materials from which soils have developed. For the Canadian Prairies they consist primarily of materials deposited by glacial ice and post glacial lakes. Surface deposits are typically characterized by texture, which determines hydrologic properties such as water storage capacity, drainability, hydraulic conductivity, etc: thickness over bedrock or over aquifers; mineralogical composition, that is, potential source of salts; and the origin of materials such as glacial, alluvial, lacustrine, aeolian etc., which may influence the chemistry and concentration mix of salts in the landscape.

Because of the general nature of this study, the surface deposits component was not included. The chemistry and origin of salinity was not as relevant as the severity or amount of salt present and its extent in the landscape (Fig. 1.).

Ge -Geology - strongly influences the hydrologic circumstance as well as the type of salinity present in the soils. Much of western Canada is underlain at various depths by saline, Cretaceous marine shales and sandstones. Therefore, some landscapes with shallow depth to bedrock may be more hydrologically responsive or susceptible to salinity change than others with a greater depth to bedrock. Also the chemistry of the surface soil salinity often reflects the geochemistry of the bedrock units. Again because of the broad scale of this study geology was not included in this application of the SRI. At a more local scale, the geological component will be very important in identification of the probable type of salinity and the responsiveness of the hydrologic system

Hc - Hydrologic circumstance - can be discussed as two components. groundwater hydrology and landscape hydrology. Groundwater hydrology encompasses conditions, applied at regional scales. simplistically categorized as recharge and discharge. Due to a lack of appropriate digital data for the prairie region it was not included as a separate condition in the index for this study.

Landscape hydrology, on the other hand, typically includes surface water, surface runoff, depth to water table, piezometric surface, soil drainage, infiltration, hydraulic conductivity, soil moisture storage capacity, water quality, etc. Functional relationships exist between all of these factors and generally culminate in the long term moisture status of the soil. In the pedological context the dominant moisture status of the soil landscapes is described and mapped according to the soil drainage classification (Expert Committee on Soil Survey 1982 revised). Some of these parameters might be considered dynamic attributes rather than static, however, for this application they were treated as standard characteristics of the landscape.

The soil drainage factor (**Dr**) of the hydrologic circumstance was included in the index for two reasons, firstly, because salts are deposited in the unsaturated soil zone as a result of water flow through the soil profile, and secondly, soil drainage information is available in the soil landscape data base. In addition, the status of soil drainage, i.e. imperfect to poor, is typically the result of a combination of other factors including the presence of surface water, ground water, high water tables, discharge hydrologic conditions, etc. Each of these aspects is important but for ease of application only the drainage classes were ranked for this study. Risk of salinity is simply based on well drained soils being low and imperfect to poorly drained soils being proportionately higher. A ranking scheme based on soil drainage is as follows:

Dr- Soil drainage - Dominant/Subdominant Landscapes (SLC maps)

Class	Map symbol	Description	Risk
1	W =	Well	1
2	I =	Imperfect	8
3	P =	Poor	10
4	VP =	Very Poor	5
5	zz =	surface water bodies	3

Very poorly drained soils were ranked with a lower risk because of their high degree saturation and persistence of surface wetness. The more common occurrence is for salt to accumulate in soils which are less wet and where the soil surface is actually the evaporative surface. Evaporation from a water surface does not actually leave salts in the soil. It is a very common occurrence (and thus higher risk) for salinity to develop in the poor and imperfectly drained soil zone surrounding and just slightly upslope from surface water bodies or wetlands.

3.3 Summary of static factors

This assessment is the first approximation of the Salinity Risk Index and therefore based on the above rationale, it utilizes those attributes currently existing in the data base. For this analysis only topography and soil drainage will be utilized and expression (2) may be simplified to:

$$STAT = f(Tp \bullet Dr) \quad (3)$$

(where all other factors = 1)

b) Dynamic components

The dynamic (DYN) components, considered to be indicators of trends, include those factors that vary over shorter time periods such as days, seasons, and years. These components impact on the sensitivity of the landscape to change and are typically related to aridity, land use and management practices. Defining these parameters in functional relationships will facilitate evaluations of salinity risk conditions for individual sites, fields, areas, landscapes or regions according to their respective aridity, land use and management conditions.

This functional relationship can be represented as:

$$DYN = f(Ar \bullet Sc \bullet Cp) \quad (4)$$

Where: (Ar) = Aridity (precipitation - potential evaporation)
(Sc) = Surface Cover (permanent cover, crops/fallow)
(Cp) = Conservation practice (tillage, drainage, etc.)

Ar - Aridity - is a major controlling factor for salinization. Salinity develops where evaporation exceeds precipitation. For this assessment of risk, long term (30 yr) average aridity values were derived from the difference between precipitation (P) and potential evapotranspiration (PE), i.e. (P-PE). The values used in this study were derived from Moisture Deficit Classes Map published by the Agronomic Interpretation Working Group (1995). The moisture component was calculated from P - PE for the May to August period. The working group used the methods of Baier and Robertson (1965) and Baier (1971) for calculating PE and the results were depicted on small scale iso-contour maps for Canada. These maps were then superimposed on the soil landscapes maps for each of the prairie provinces using a geographic information system and each polygon was assigned a value of Ar based on its proximity to the contour line.

The risk rating for aridity was assigned as follows:

Ar- ARIDITY - (Evaporative flux potential) - (mm).

Class	P-PE (mm)	Risk Rating
A	<199	1
B	200-249	2
C	250-299	3
D	300-349	5
E	350-399	6
F	400-449	7
G	450-499	8
H	500-549	9
I	>550	10

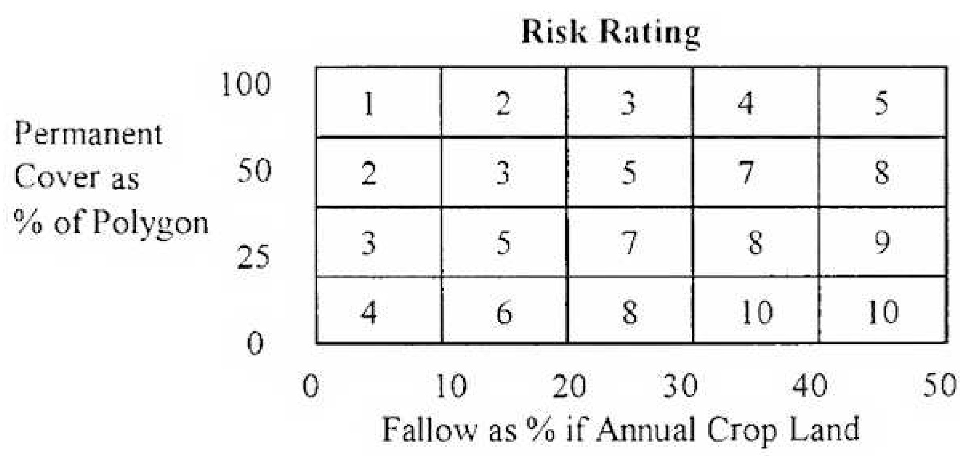
Sc - Surface cover (crop/vegetation) - is used to define land use. It is included in the index to evaluate the potential influence that agricultural practices might have on salinity risk. The extent and type of surface cover is included as an important dynamic variable in determining risk for salinity because of its effect on the soil water status.

Land use influences water partitioning in the landscape. Different types of land use consume variable amounts of soil water. Those practices which leave the soil bare and exposed for long portions of the growing season, or for an entire growing season (summer fallow) facilitate deep percolation of excess precipitation and an eventual increase in the water table. The end result may be the development of salinity in areas of high moisture status, usually in lower portions of the landscape. A widely held perception in western Canada is that summer fallow, leaving a field fallow (tilled and bare of vegetation) for one growing season with the objective of storing water, represents the highest risk to increasing soil salinity and that total coverage by permanent vegetation such as forage, pasture, or trees represents the lowest risk. Those practices which retain soil under continuous perennial cover minimize the possibility of deep percolation by consuming most if not all available precipitation and thus represent minimum risk of increasing water table levels and subsequent salinity. Considering that these two surface cover scenarios (land use practices) represent the extremes (for salinity risk), then all other practices represent some intermediary position. Using this concept in a risk assessment will enable us to evaluate in a systematic fashion the relative risk or impact of agricultural management practices. For example, the risk of salinity could be expressed in terms of land use as:

summer fallow > spring cereals > tame hay > rangelands >forest land

Surface cover was determined from Statistics Canada land use data for 1981 and 1991. The ranking of surface cover for risk of salinization was assigned using the following simplified matrix considering three cover types and their proportionalities:

summer fallow > annual crops > permanent cover



For example, polygons with 75 - 100 % permanent cover and 0 - 10% of annual crop land in fallow, were assigned a risk of 1, whereas, polygons with 0 - 25% permanent cover and 40 -50% of annual crop land in fallow were assigned a risk value of 10. This ranking system was designed so that regional assessments could be made to evaluate the risk posed by agricultural land use practices.

Cp - Conservation practice - is a function of tillage, and direct water management such as improved drainage and/or irrigation. Information on different conservation practices implemented specifically to control and manage saline soils can be used to discount salinity risk. The conservation practice component is interpreted as having a long term ameliorative influence on risk as well as status of salinity in landscapes. The conservation practice component has not been applied to this broad scale analysis due to scarcity of information.

3.4 Summary of dynamic factors

The dynamic components or trend indicators utilized have thus been reduced to two, aridity and surface cover and function (4) is reduced to:

$$DYN = f(Ar \bullet Sc) \qquad (5)$$

Combining ratings for each component:

The component rankings are combined in a simple mathematical expression to derive an SRI value. The expression was divided by 100 for convenience of smaller numbers.

$$SRI = (Px \bullet Tp \bullet Dr \bullet Ar \bullet Sc)/100 \qquad (6)$$

4.0 APPLICATION AND RESULTS

4.1 Dryland Salinity Risk

The salinity risk index was applied to the prairie region of western Canada utilizing the SLC data base as shown in Fig. 1. The numerous components of land, water and weather which have a relatively significant control or affect on the status of soil salinity in the landscapes were available from the SLC data bases.

4.2 Status of dryland salinity

The total extent of moderate or more severe salinity (EC_e>8 dS/m) as determined from a summation of each provincial extent map, is 1.4 million ha. This area is depicted on a small scale extent map Fig. 1. The majority (79 %) of the land within the agricultural area of the prairies has a low extent (less than 1%) of land affected by salinity. These areas are characterized by major uplands, major sand and gravel deposits, areas with well defined drainage by river channels, and in northern areas where the soils formed under more humid conditions with a forest cover. Approximately 20% of the land has a moderately (1-15%) extent affected by salinity. These areas are typically medium textured with locally restricted surficial and internal drainage. Landscapes with significant extent of salinity (greater than 15%) tend to be smaller in size and are geographically distributed throughout the southern prairies. These areas are typically associated with extensive wetlands with high water tables and discharging hydrologic conditions. Such areas occur in extensive flat basin areas and on nearly level plains near the base of major uplands and escarpments.

4.3 Risk of soil salinity

The risk of salinity was determined using the SRI with component data representative of 1991 conditions. The calculated SRI values were subsequently grouped into three classes representing relative risk of salinity change. The class intervals chosen for this broad scale analysis are somewhat large and were again based on expert opinion of soil specialists who had knowledge of salinization behavior in affected landscapes over a long period of time. The low and high risk classes have a very large range of possible values but in reality the extreme values are somewhat hypothetical. More risk classes have been utilized on a localized basis where more specific information was available for each of the components and thus a more valid distinction can be made for risk assessment.

RELATIVE RISK OF SOIL SALINITY CHANGE
For Application to the Canadian Prairie Region

SRI	Risk
<2.9	Low
3 - 8.9	Moderate
> 9	High

The salinity risk map for 1991 land use (Census of Agriculture) is shown in Fig. 2. Under this land use, 62.2% of the land in the agricultural area was at little to no significant human-made risk of increasing salinity. This area was characterized by significant permanent, perennial, or continuous annual cropping. The remaining land (27.9%) is at moderate and (9.9%) at high risk due to agricultural practices that promote the build up of soil and subsoil moisture. This does not indicate that salinity has actually increased but rather that management practices leave susceptible land at considerable risk for increasing salinity.

Also, at the small scale of this study, it does not mean that these entire landscapes are at risk. Within almost any landscape there are local conditions which affect the probability that salinity will increase. For example, local areas of moderate to high relief within a high risk polygon may have a very low probability of actually becoming saline due to local topography. Nevertheless the theoretical overall risk under current climatic conditions and land use circumstances remains high.

4.4 Change in risk

The change in risk of dryland soil salinity based on the change in agricultural land use between 1981 and 1991 is shown in Fig. 3. To be considered and mapped as a change, the difference between the 1981 and 1991 SRI values had to be equal to or exceed one class interval. Since each of the three classes are quite large, it was not possible to reflect all of the land use changes at the local level. The change in salinity risk was thus portrayed on a soil landscape basis. At the small scale of this assessment there has been no significant SRI change in the majority (92.8%) of the prairie landscapes. A small area (6.8 %) appears to be under a lower risk due to the prevailing agricultural practices in 1991 compared to those in 1981, while an even smaller area (0.4 %) appears to be at greater risk.

The authors do not suggest that these results represent a trend. Land use, specifically related to annual crops and summer fallow, can change very quickly and may only be typical of conditions for the year of observation. However, the mix of land use identified for any particular landscape in a given year can be considered indicative of the typical cropping pattern or crop rotations for the area. The change map therefore is only indicative of the difference in SRI's for two time periods.

5.0 FUTURE APPLICATIONS

5.1 Irrigated Salinity Risk

The concept of SRI could be applied to irrigated conditions since it is based on components in which change can be documented. The SRI has not been applied to assess irrigation salinity risk, however some of the factors and changes that would need to be considered under an irrigation impact assessment scenario would include: aridity, which would decrease; soil drainage, in which soil wetness might increase as a result of dykes, ditches, flooding etc.; topography, the land surface may be changed as a result of construction for purposes of land leveling, road grades, canals, ditches, etc.; the present status of soil salinity could be affected by the quality of irrigation water, and the type and permanence of surface vegetation cover may decrease or increase depending on the crops irrigated. In some cases the surface cover or land use component may be significantly changed since irrigation may bring lands into cultivation which were formerly not farmed.

5.2 Agri-Environmental Indicator

The SRI could also be utilized as a method of assessing, at a broad level, the agricultural impact on long term sustainability. in 1993, Agriculture and Agri-Food Canada initiated the "**Agri-Environmental Indicator (AEI) Project**" (McRae 1995). An AEI can be defined as:

> "A measure of change in the state of environmental resources used or affected by agriculture, or in farming activities which affect the state of such resources, preferably in relation to a standard, value, objective or goal" (McRae *et. al.* 1995).

The AEI for soil degradation risk, of which soil salinity is a component, attempts to do two things:

1. "... report trends in the extent, severity and vulnerability of agricultural lands to soil erosion, salinization, and change in soil organic matter levels", and
2. "... identify areas at higher relative risk of degradation and provide a measure of progress in managing agricultural lands sustainably".

The criteria for each AEI has been standardized so that each can be evaluated. The following list of characteristics (McRae et. al. 1995) show that the SRI could be a suitable mechanism to link soil salinity to AEI's:

Measurable Parameters
- electrical conductivity, (severity)
- topography
- net aridity
- land area (extent)
- drainage
- ratio of permanent cover to summer fallow

Numerical Units
- dimensionless index, grouped into three classes of risk - low, moderate, and high.

Spatial area
- Agricultural area of the prairies.

Temporal coverage
- 1981 and 1991 with updates every 5 years after.

Performance Objective
- To have low salinity risk related to agricultural activities (some high risk areas affected by geology may remain high).

Principle Data Sources
- Soil landscapes of Canada database,
- Atmospheric Environmental Service,
- Soil Quality Evaluation Program Research,
- Census of Agriculture,
- Geological Survey of Canada,

Activities
- **build -** on the research carried out under the Soil Quality Evaluation Project and related research.
- **focus** - on revision, sensitivity testing and extending temporal coverage of the soil salinity risk analysis reported in the Health of Our Soils Report, (Acton and Gregorich 1995 eds.)
- **contribute -** to an Environment Canada Environmental Indicator bulletin on Agriculture.

Outputs
- Report on soil salinity change in prairie region at SLC scale for 1981 and 1991.

6.0 ANALYSIS OF THE PROCEDURE

6.1 Advantages of a Salinity Risk Index

The concept of a SRI offers the following advantages:
easy to use

- based on available information
- provides (utilizes) a standard reproducible methodology
- based on components controlling or influencing salinization
- provides relative indices for landscape units
- can be revised readily with new information
- can be adapted to various scales of application
- can be used to rank relative impacts of agriculture

6.2 Disadvantages of a Salinity Risk Index

The following might be considered some of the disadvantages:

- simplistic
- expert based, requires a collective effort
- not quantitative

7.0 CONCLUSIONS

A methodology has been described for evaluating the relative risk of changing the status of soil salinity through changing agricultural practices. The methodology is based on the concept that salinity is a dynamic condition of the soil landscape which can be assessed by understanding the functional relationships between the major controlling or influencing components and that these relationships can be combined into an index for individual units of the natural landscape.

The SRI is composed of five components including the presence of salinity in the landscape. topography, soil drainage, aridity and land use. The index was applied to the prairie region of western Canada utilizing a recently published ecological base map. Land use information obtained from Statistics Canada for 1981 and 1991, was evaluated and compared to assess the change in relative risk of soil salinization. The majority (92.8%) of agricultural prairie land was found to be at a similar risk for both years, that is, showed no change. This may be due in part to the overall small change in agricultural practices for the two time intervals as well as in part to the broad class intervals utilized in this study. There was an apparent decline in salinity risk for about 6.8% of prairie farm land and about 0.4% had an apparent increase in risk in 1991 over that of 1981.

The use of a Salinity Risk Index based on controlling parameters provides a systematic approach for assessing the potential role of land use and agricultural practices on the status of soil salinity. Trends in land use as documented in census data can be utilized to predict potential long term impacts on soil quality as determined by soil salinity status.

Further development of a more comprehensive risk index is planned in the next two years as part of a national Agri-Environmental Indicators Study, for assessing the long term sustainability of land use and management practices.

The following areas will need further development and evaluation for more localized application:

1. Climate data analysis to assess the relative impacts of more local precipitation cycles and variation on the risk of salinity.

2. Land use data analysis to assess the relative impacts of conservation management practices on the risk of salinity.

3. Refinement of the components of the index to include other parameters and weighting factors which will be more important for more localized application.

4. Field testing for adaptation of the SRI to site assessment and integration into management considerations at the local level.

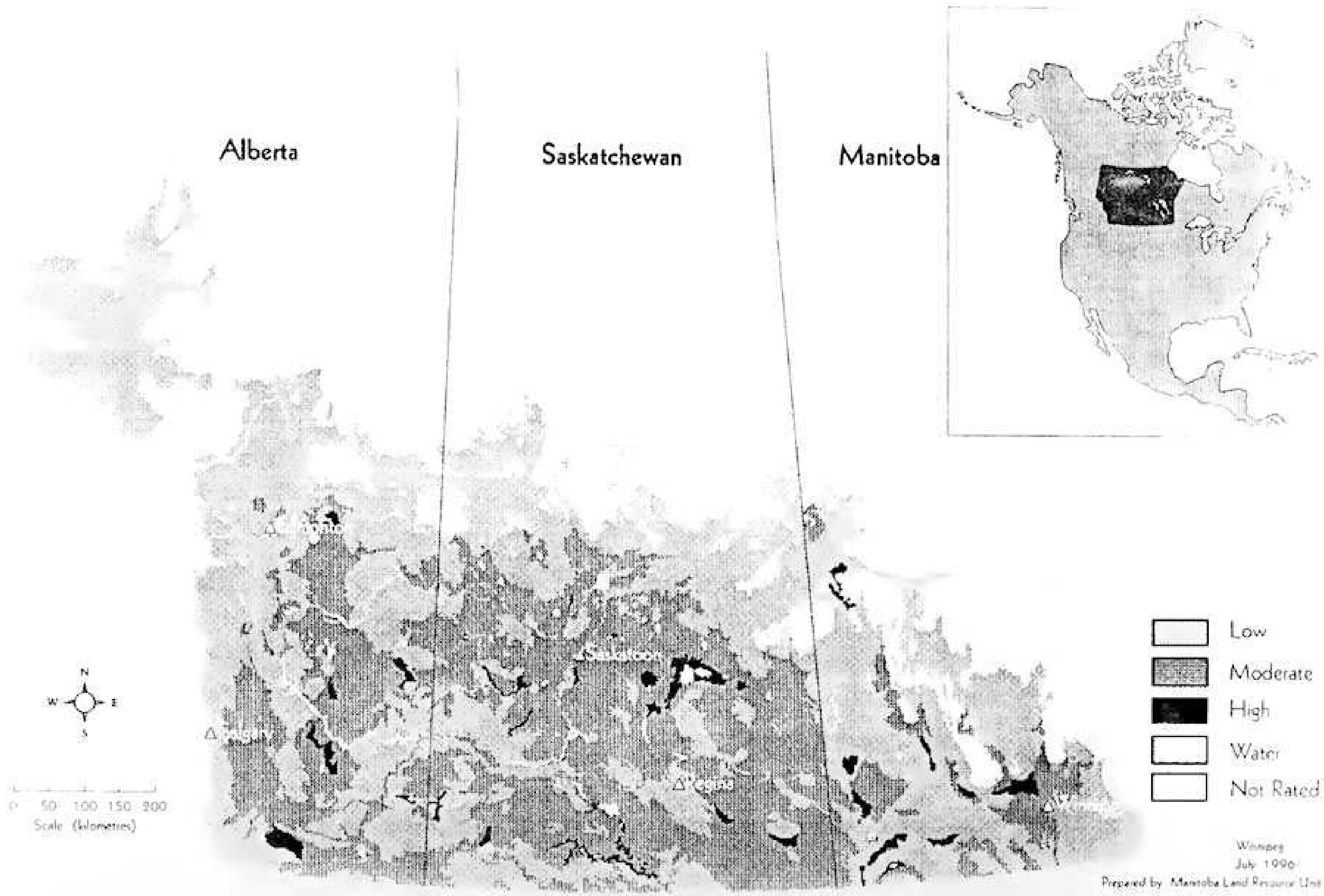


Fig. 1. Presence and extent of surface salinity for 1990 on the Canadian Prairies.

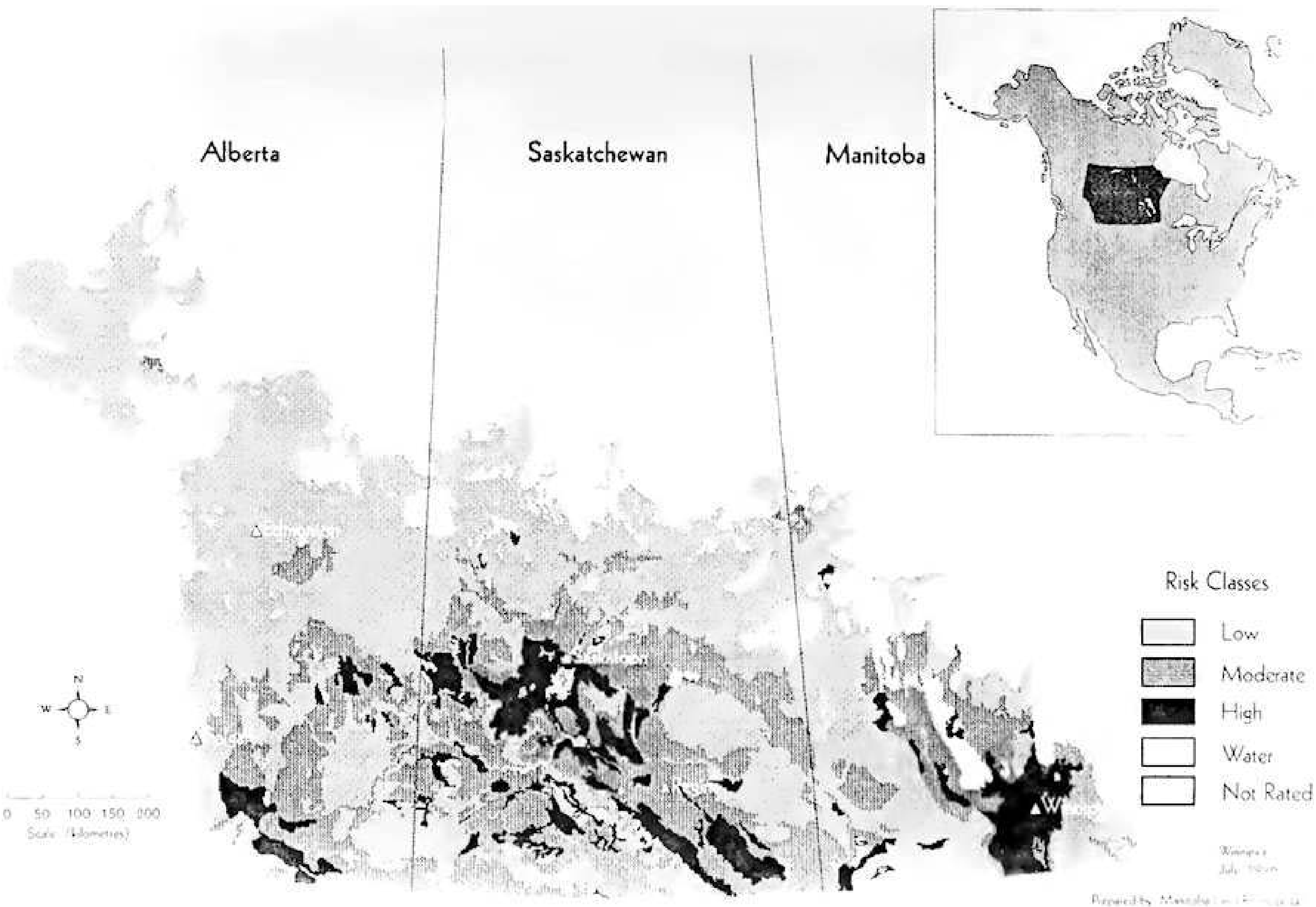


Fig. 2. Salinity Risk Index based on 1991 land use on the Canadian Prairies.

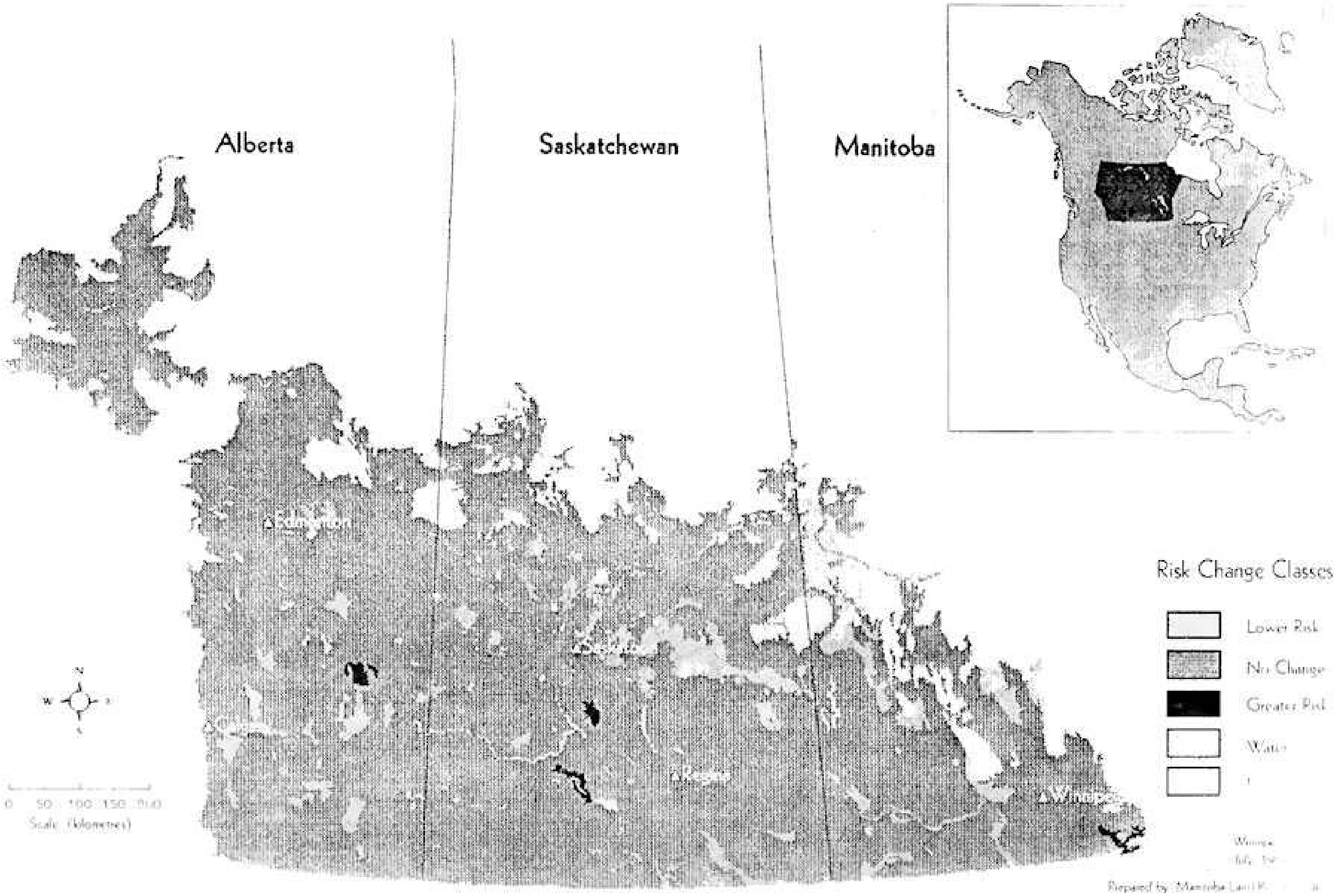


Fig. 3. Salinity Risk Index change for 1981 to 1991 land use on the Canadian Prairies.

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