Soil Salinity Trends in the 90's.

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Introduction

Concerns about the sustainability of agriculture in Canada came to the forefront in the 1980's as questions arose about the impact of our land management systems on soil quality, in particular for the prairie region, soil erosion, organic matter and soil salinity (Fairbairn, 1984, Sparrow, 1984). Consensus regarding the deterioration of soil quality over time was general, however, regarding the issue of rate of decline and whether significant deterioration was continuing, opinion was less than unanimous, even among the scientific community. This was largely due to the fact that baseline data sets with which to make such evaluations were not available for many regions. Information on problem soils was largely study specific and not suitable for use as a basis for long term analysis and comparisons of trends with time.

In 1988 Agriculture Canada's Land Resource Research Centre (now Agriculture and Agri-Food Canada) initiated a project to establish long-term benchmark sites for investigating and monitoring salinity change. In 1990 the project was adopted by the National Soil Conservation Program (NSCP) as part of the Soil Quality Evaluation Project (SQEP). A network of seven SAMPS (salinity assessment, monitoring, and prediction system) sites were established on the Canadian prairies to assess the dynamics of soil salinity change with time, climate and land use. The monitored parameters at each SAMPS benchmark site include: climate, soil salinity, soil climate, and groundwater water levels.

The development of effective management practices for salinized soils requires improved capabilities to monitor and predict change in soil salinity as a function of applied management practices. The specific goals of this study were:

i) to assess the extent and severity of soil salinity at selected benchmark sites representative of typical agricultural landscapes and hydrologic settings on the prairies.

ii) to utilize simulation process models (SEEP/W and CTRAN/W) and field monitoring procedures to assess the impact of agricultural management practices on the status of soil salinity, and

iii) to determine the type and magnitude of the change in soil salinity under known conditions of weather and land use through annual and seasonal monitoring of benchmark sites.

This paper will deal with the first and third goals of the study - the dynamics of soil salinity on three sites in Saskatchewan and evaluate the change in salinity in terms of possible trends and potential impact on soil quality and agricultural sustainability.

Materials and Methods

Site selection criteria

Several criteria were considered in the selection of sites for this study. Since this was a prairie region study, consideration was given to selecting sites representative of large areas of agricultural land and salinization processes. Each of the sites occur in a different Agro-Ecological area which includes both saline and non saline soils. Hence a range of climatic conditions are encountered on these sites. Additionally, the sites were chosen to so that differing soil salinization processes could be investigated.

Three sites were chosen in Saskatchewan, two in the Dark Brown soil zone and one in the Brown soil zone (Figure 1.). The basic sahnization processes on the sites were discharge from a shallow, regional inter-till aquifer, (Cory site), saline ring surrounding a slough (St. Denis site), and ground water discharge from a shallow aquifer pinchout (Prairie View site).

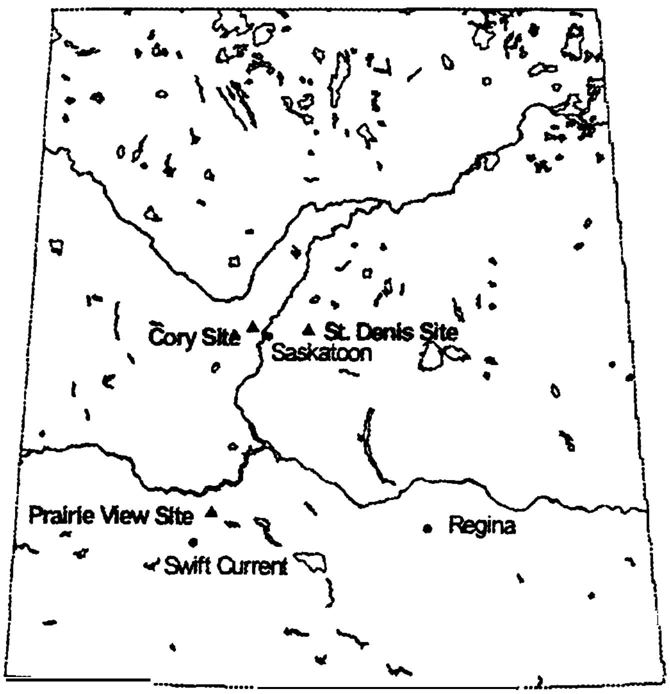

Figure 1. Locations of salinity monitoring sites in Saskatchewan.

Salinity Monitoring

A plot of approximately **2-4** ha was gridded at 10 m intervals at each site. EM38 surveys in both horizontal and vertical instrument orientations were conducted each year in spring (May) and fall (September to October) on these grid points. Permanent sample sites were selected, which ranged in degree of salinity from non-saline to strongly saline, for laboratory soil salinity characterization and monitoring. Samples were taken from these sites at each monitoring interval. Each permanent sample site consisted of a central point which was accurately measured from some permanent benchmark structure to enable relocation at monitoring time. Three soil cores were sampled at equally spaced intervals around the circumference of a circle having a one metre radius from the central permanent site. At each subsequent monitoring interval this sampling protocol was rotated around the circle to avoid sampling in the same spot as previously sampled. The three soil cores were composited in depth intervals of O-15, 15-30,30-60,60-90 and 90-120 cm increments. Analysis of these samples was used to create a unique EM38 calibration equation using linear regression for each site and monitoring period.

Hydrology

At each site wells and piezometers were installed for monitoring ground water. Initially monitoring of these installations was done on a regular basis throughout the year. Later, pressure transducers were obtained, connected to the climate station data logger, and installed in several wells or piezometers on two sites. Manual monitoring of the groundwater was reduced, due to manpower constraints, to coincide with salinity monitoring periods and more reliance was placed on the continuous water record from the transducers.

Climate

Automatic on site climate stations were obtained and installed at two sites. These climate stations record hourly averages of wind speed and direction, precipitation in the form of rainfall, total solar radiation, air temperature and relative humidity and soil temperature at 10 and 50 cm depths.

Land use is monitored.

Results and Discussion

Cory site.

The Cory site was chosen to represent areas of Saskatchewan affected by regional groundwater discharge. The site occurs in an area in which a regional intertill aquifer pinches out and has potentiometric surfaces near the soil surface. Soils are Dark Brown Chemozemic developed on clayey textured lacustrine materials overlying glacial till at a depth of just over a metre. The landscape is undulating, gently sloping. It is located approximately 16 km northwest of Saskatoon, SK (Figure 1).

The saturated paste extract electrical conductivity (ECe) weighted for the 0 - 60 and 0 - 120 cm depth intervals at the Cory site are shown in figure 2. The depth weighted ECe of permanent sample site DP 1 for both depth intervals was relatively unchanged over the monitoring period with little variability from one time to the next. The low variability in salinity is to be expected as there are few salts in the profile that are available to move with water. In contrast, the permanent sample sites in more saline areas had an increasing degree of variation from one period to another, particularly for the 0 - 60 cm depth zone. The trend line through the data for the more saline sites, DP3 and DP4, shows a positive slope, indicating that salinity is potentially increasing in these sites.

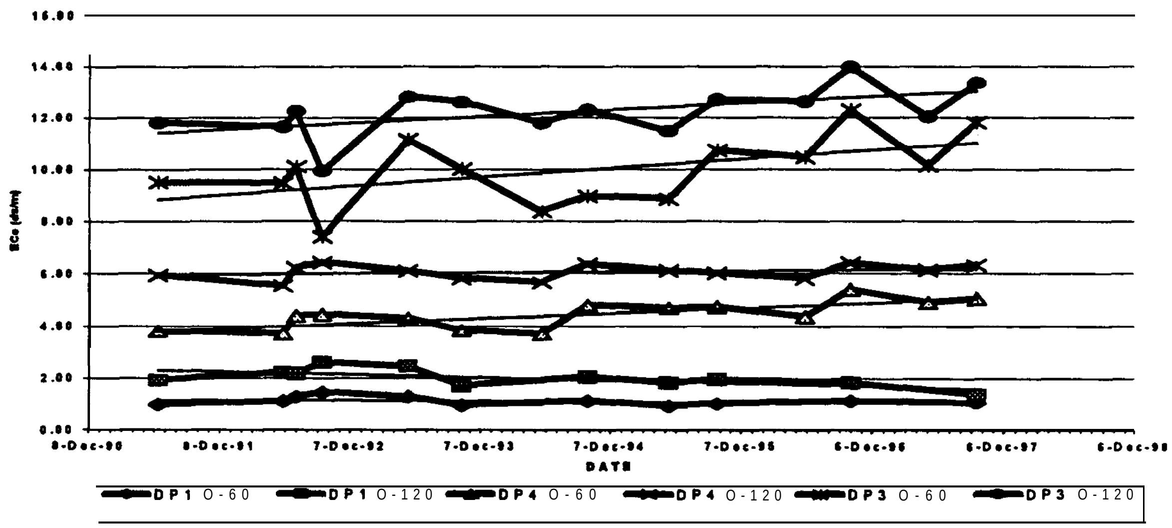

Figure 2. Depth weighted ECe of permanent sample sites at Cory site.

The area of saline soils at the Cory site (figure 3) was measured with the EM38 surveys which were converted to a saturated paste basis. The area of soils with an ECe greater than 4 ds/m for the O-120 cm depth interval (EM38V) remained relatively constant at around 80% of the plot area. The trend line through this data has a slightly increasing slope, due largely to a short term increase in the saline area in 1994. The area of saline soils based on the EM38 horizontal readings varied considerably from one period to the next, particularly in the early part of the monitoring period from 1991 to 1995. The variability of this data is in agreement with the permanent site data which showed more variability in the O-60 cm depth compared to the O-120 cm depth. A more consistent area of saline soils was measured since the fall monitoring of 1995. A trend line through the EM38 (H) data indicates a high potential increase in salinity of the O-60 cm depth zone with the greatest amount of this increase occurring early during the monitoring period.

St. **Denis Site**

The St. Denis site is approximately 50 km east of Saskatoon and 5 km north of St. Denis, Saskatchewan (Figure 1) in the St. Denis National Wildlife Area owned by the Canadian Wildlife Service. The area is characterized by intermittently ponded slough areas with sharp side slopes and gently sloping bottoms. Saline soils ring the outside edge of the slough and extend in towards the wet part of the slough area. Salinity decreases sharply with increasing elevations along the slough edge. The site is representative of large portions of

Saskatchewan having hummocky morainal landscapes.

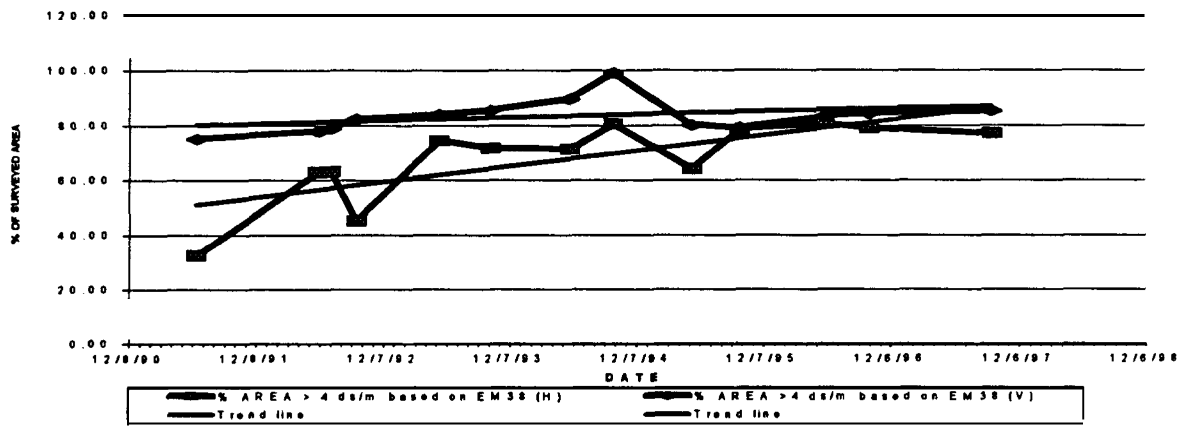

Figure 3. % Area of saline soils at Cory based on calibrated EM38 readings.

The depth weighted ECe of permanent sample site PST4 (Figure 4) for both depth intervals is similar to that shown for the low EC site at Cory. It remained relatively unchanged over the monitoring period with little variability from one monitoring period to another. The data for sites in higher salinity zones however had more variability over time. The trend line for site PST2 shows a potential for increasing salinity over the period of monitoring while the trend line for PST1 shows a potential for decreasing salinity over time. The difference between the slope of the trend lines for these two sites is believed to be due to their position with regard to the water level of the slough. Site PST1 occurs on a slight convexity near the edge of the slough while site PST2 occurs some distance from the slough. The water level in the slough has risen considerably since the beginning of the monitoring and it is believed that the main zone of salt accumulation has moved outward from the slough in response to the rising water level.

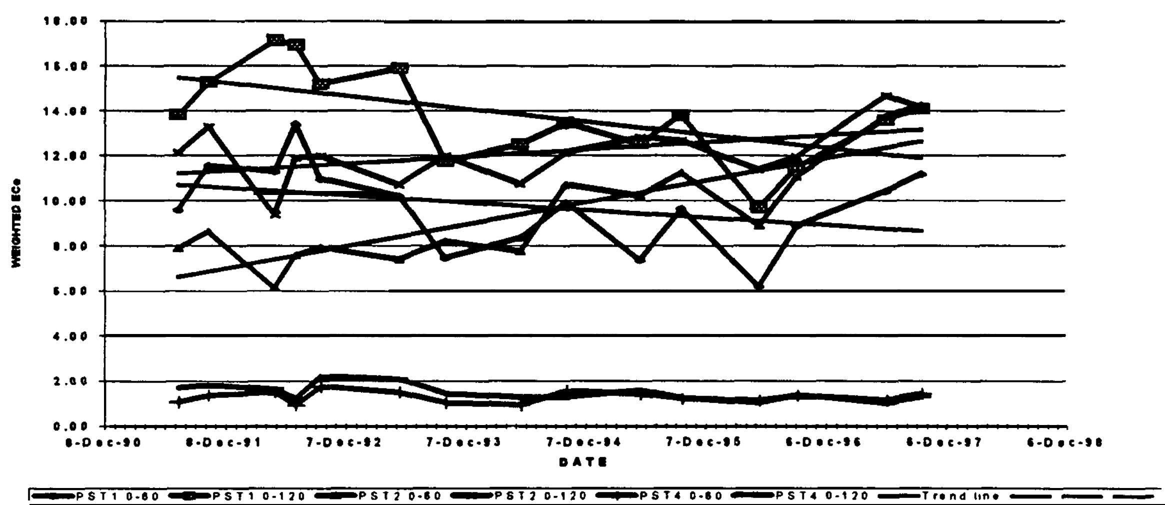

Figure 4. Depth weighted ECe of permanent sample sites at St. Denis site.

Figure 5 shows the % area of saline soils at St. Denis based on calibrated EM38 readings for both the horizontal and vertical instrument orientations. The extent of saline soils based on the EM38 (V) readings were relatively constant over the monitoring period with slight variability from one period to another. The extent of saline soils based on the EM38 (II) readings varied more than the EM38 (V), which is similar to that for the Cory site. The upper soil zone would be expected to have the greatest movement of salts due to this zone undergoing the largest variability in terms of soil moisture over time. The trend line is relatively flat although it does have a slope indicating a slight potential to increasing values over time.

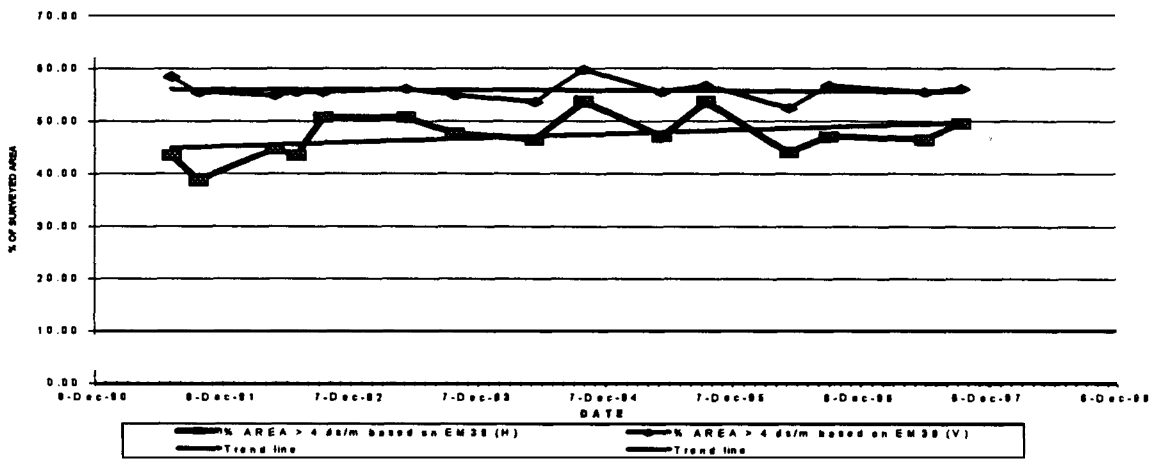

Figure 5. % Area of saline soils at St. Denis based on calibrated EM38 readings.

Prairie View Site

The Prairie View site occurs on a mile long slope between a glacial meltwater channel and an upland morainic plain. It occurs in the Brown Soil Zone northeast of Swift Current (Figure 1). The cause of the salinity at the site is a local shallow aquifer pinchout occurring along the slope of a meltwater channel. This represents a model of the salinization process, commonly referred to as 'sidehill seep'.

A similar trend to that of the other sites in the weighted ECe of the permanent sample sites is shown in figure 6. Sites which were essentially non saline PPV5 O-60 and O-120 cm) show little potential for change over time or variability from one monitoring period to another. Those sites which had appreciable salts within the profile show increasing variability with increasing degree of salinity. There does not appear to be an observable change in the degree of salinity at these permanent sample site over time as the trend lines are relatively flat.

The area1 extent of saline soils at Prairie View during the period of salinity monitoring is variable (Figure. 7). The area of saline soils based on the EM38 (H) readings had a large amount of variability near the beginning and end of the monitoring period. The trend line through the data has a positive slope indicating a potential for increasing salinity during this time. The area of saline soil based on the EM38 (V) readings is quite variable as well, however the variability extends throughout the monitoring period. The trend line through the data for the EM38 (V) readings has a greater slope and hence indicates a greater potential for increasing salinity in the lower part of the soil profile.

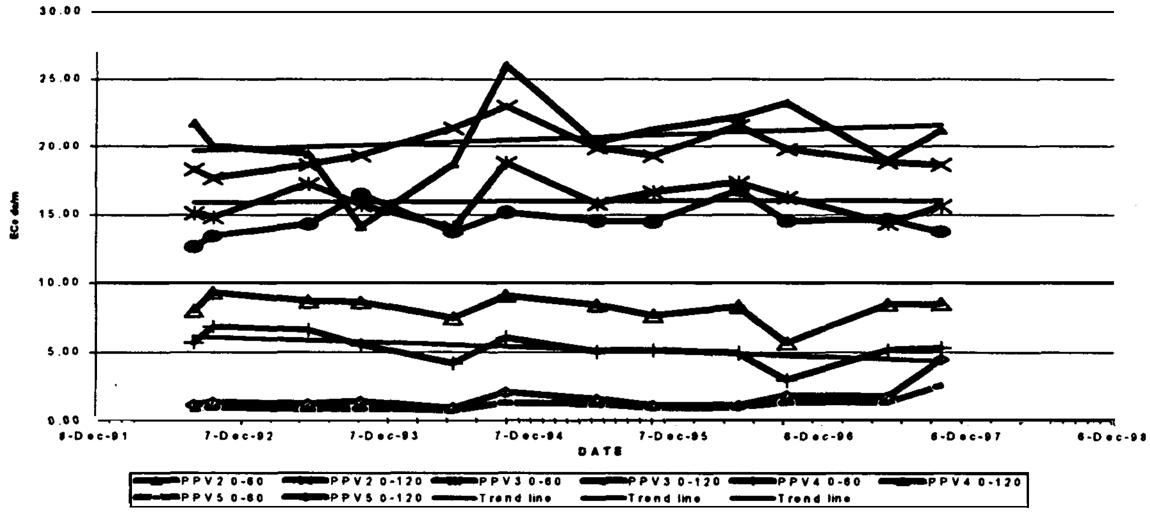

Figure 6. Depth weighted ECe of permanent sample sites at Prairie View site.

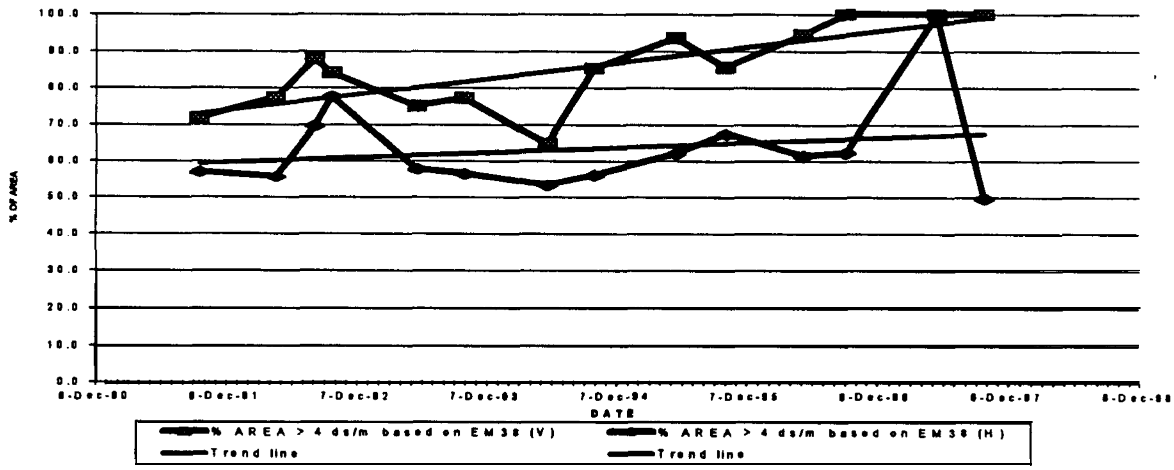

Figure 7. % Area of saline soils at Prairie View based on calibrated EM38 readings.

Conclusions

Assessing the trend in the status of soil salinity must be done over a sufficiently long time to incorporate the short term seasonal and yearly variation. Soil salinity is so dynamic that changes from one season to the next can be substantial. Assessments, regarding the amount of change in salinity, made from a limited set of data could result in estimates of the rate of change much higher or lower than assessments using longer term data.

Soil salinity is dynamic with short term and long term changes which can be related to physical conditions such as the presence of salts in the soil, climatic factors, hydrology, and land-use.

Saline soils have not gone away and are unlikely to go away, but will respond to changes and/or trends in the factors which control or influence soil salinity. The physical factors that have acted on the environment to produce saline soils are still operating and will continue to operate. The status of soil salinity at a site will change in response to variations in these physical conditions.

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