Surface Water Quality

Surface water quality is generally considered in the context of water use, where water use includes both natural processes (such as maintaining healthy fish populations) and various human uses (e.g. source for drinking water, livestock watering, irrigation, industry, aesthetic-leisure activities, etc.). Specifically, water quality can be defined as a function of the properties and constituents within water in the context of the intended water use. Constituents within water include nutrients, oxygen, bacteria, metals, and salts. The appropriate assessment of water quality involves understanding and evaluation of natural processes, historic water quality, human impacts, and water use.

Reconciling the large number of constituents and the range of their concentrations within the context of various water uses represents the fundamental challenge in summarizing water quality. The need for a tool to summarize the state of water quality led to the development of the Canadian Water Quality Index (WQI). This index has been adopted and adapted for use by many provinces, including Saskatchewan. The WQI assesses concentrations of several indicator constituents relative to objective concentrations. These constituents include nutrients, dissolved oxygen, dissolved ions, heavy metals, pesticides and bacteria. Annual WQI values are calculated based on the number of constituents that exceed their objective during the year, the total proportion of all exceedances, and the amount by which objectives are exceeded.

The objectives used in the WQI for assessing water quality are based on the Interim Surface Water Quality Objectives (Saskatchewan Environment 2006a) and the objectives used by the Saskatchewan Watershed Authority in its assessment of source water quality. There are infrequent exceedances of these objectives observed in northern watersheds, resulting in high WQI ratings. This may suggest good water quality in northern Saskatchewan; this may also suggest that a general template of water quality objectives is not applicable across the entire province (i.e. there is a need for watershed-based objectives). In southern Saskatchewan there is greater variability in the number and magnitude of objective exceedances, leading to a larger range in WQI values. Identifying areas with lower WQI values (poorer water quality) enables further assessment to determine the causes – some of which may be natural (e.g. due to local geology), while others may result from human activity (Davies 2006) - and to determine the responses necessary to improve water quality of the system.

Surface water quality assessment

Water quality, as assessed using the WQI, varies geographically within Saskatchewan. Northern watersheds have relatively few constituents that exceed water quality objectives. In some southern rivers and lakes, concentrations of heavy metals are sometimes present in excess of their respective objectives. Not all exceedances are a result of human activity since baseline water quality is determined by regional geology, precipitation and biotic processes.

Surface water quality stressors
Factors resulting in deviations from the natural state threaten water quality and ecosystem function. This *State of the Watershed Report* analyzes a number of stressors that have the potential to reduce water quality in Saskatchewan. The actual impact depends on both the stressor and the intrinsic attributes of the waterbody. Surface waters in different geographical regions are exposed to different stressors. Major stressors to surface water in northern Saskatchewan occur from both localized industry and regional long-range atmospheric transport. Lakes in the north have intrinsically lower acid neutralizing capacity than southern lakes, which makes them more susceptible to atmospheric acid deposition. Lakes and rivers in southern Saskatchewan, meanwhile, may be vulnerable to further increases in nutrient loading as a result of various human activities.

Surface Water Quality Indicator

This indicator reports on the water quality of individual waterbodies within Saskatchewan's watersheds. The Water Quality Index is used to summarize how well individual waterbodies meet surface water quality objectives. This is done by assessing key chemical, biological, and physical constituents within the waterbodies.

Indicator	
Surface Water Quality	**Status:** The number of water quality sample locations increased from 37 in 2002 (Figure 26) to 65 in 2007 (Figure 24). The number of watersheds for which Water Quality Index values could be calculated increased from 11 to 14 between 2002 (Figure 27) and 2007 (Figure 25). The increase in the number of watersheds with Water Quality Index values is due to an increase in the number of sites with suitable analysis and sampling frequency to calculate the Water Quality Index. **Trend:** Between 2002 and 2007, the average Water Quality Index values increased in nine of the 11 watersheds that had Water Quality Index values in both time periods. The North Saskatchewan, South Saskatchewan, and Upper Souris River Watersheds, which were all classified as stressed in 2002, are classified as healthy in 2007.

The issue

Ensuring clean and safe water quality is critical for human health, and for sustaining economic growth and environmental protection (Davies and Mazumder 2003). Surface water quality is primarily affected by:

1) geology;
2) precipitation patterns;
3) point and non-point pollution;
4) land use and land management practices;
5) modifications to flow rates caused by control structures, such as dams, weirs and other man-made systems; and
6) in-lake or in-stream biological processes (i.e. activities of the biological community that affects water quality) (New South Wales Environment Protection Authority 2003).

The ability to assess the state of water quality is therefore a key component of evaluating watershed health.

Surface Water Quality Indicator in Saskatchewan

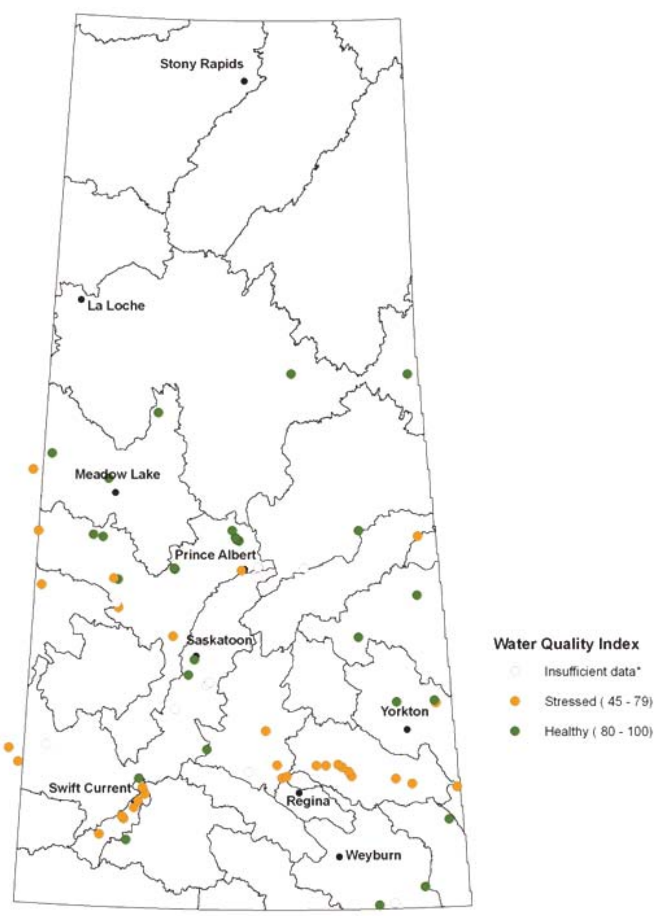

Figure 24. Water quality sampling locations and associated Water Quality Index values calculated by sample location: 2003-2007.

*Fewer than three of the five years have calculated Water Quality Index values.

Between 2003 and 2007, water quality samples were collected from 71 sites. Of these 71 sites, 11 sites had insufficient data to calculate a five-year average WQI value, as WQI values were available for fewer than three of the five years. Of the remaining 60 sampling locations, 32 had a WQI value that is classified as stressed, and 28 sites had a WQI value that is rated healthy.

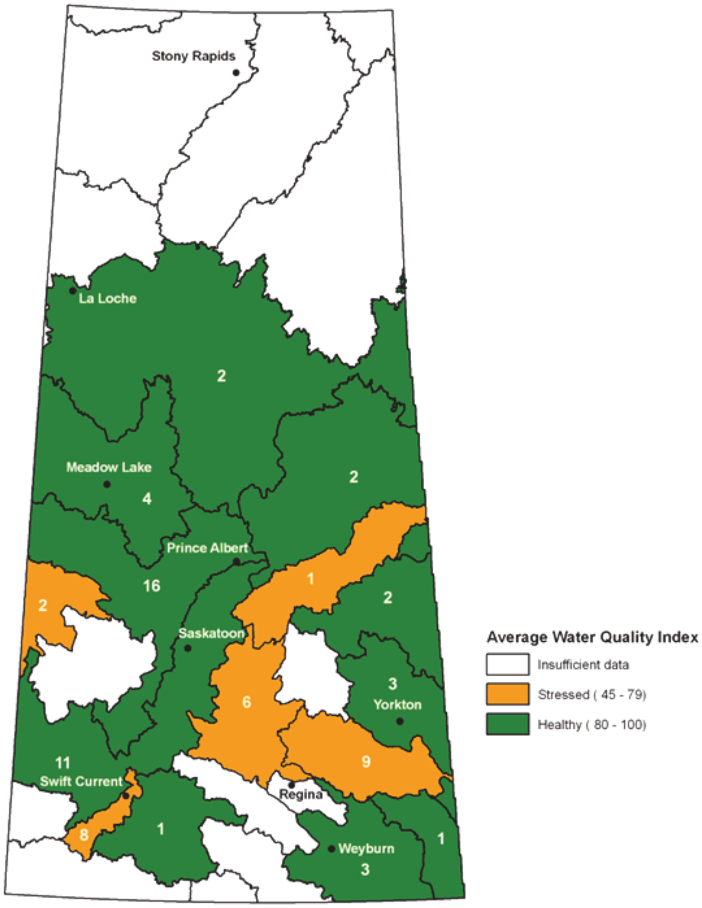

Figure 25. Five-year average of Water Quality Index values calculated by watershed: 2003-2007.
Note: numbers within the watershed boundaries represent the number of sites with WQI values that were used to calculate the five-year average WQI value for the watershed.

Among the 15 watersheds for which a five-year average WQI value could be calculated, the average WQI value is classified as healthy for ten watersheds and stressed for five watersheds. The remaining fourteen watersheds cannot be classified due to insufficient data (Figure 25).

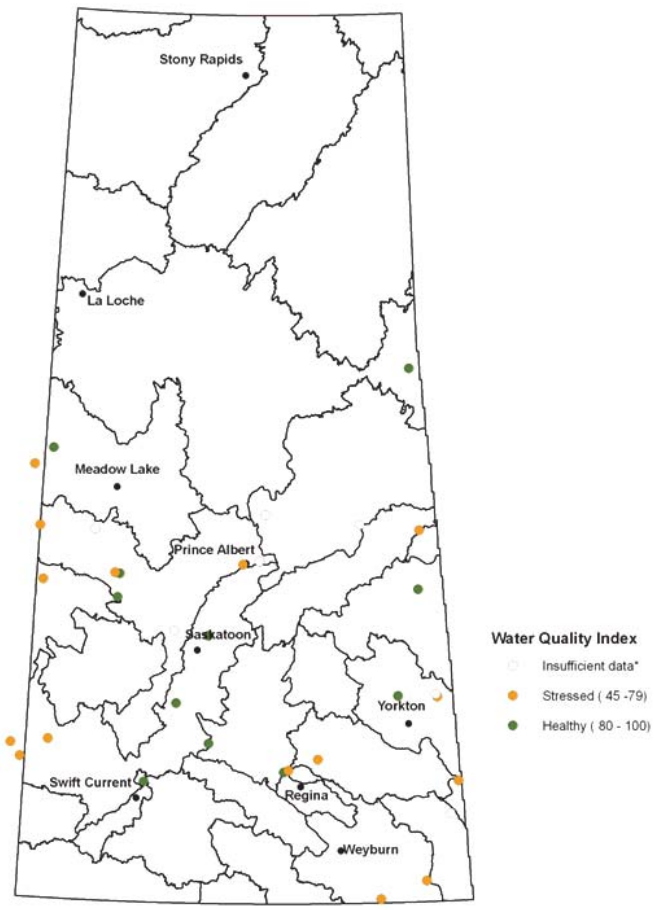

Figure 26. Water quality sampling locations and associated Water Quality Index values calculated by sample location: 1993-2002.
*Fewer than five of the ten years have calculated Water Quality Index values.

Between 1993 and 2002, water quality samples were collected from 35 locations in Saskatchewan. Of these 35 sample locations, seven had insufficient data to calculate a ten-year average WQI value, as WQI values were available for fewer than five of the ten years. Of the remaining 27 sample locations, 16 had a Water Quality Index value classified as stressed, and 12 sites had a WQI value that is classified as healthy.

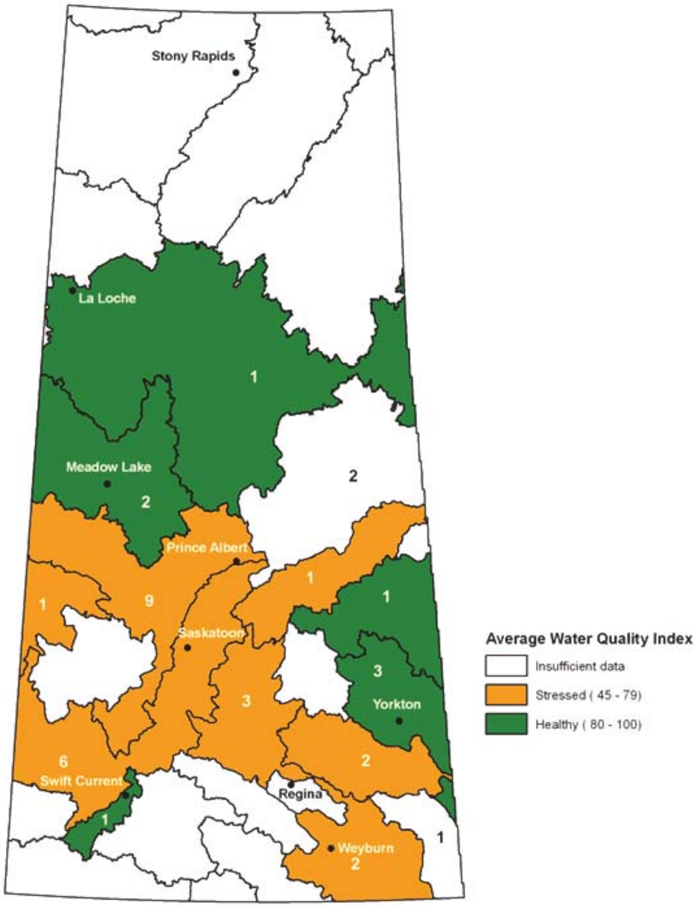

Figure 27. Ten-year average of Water Quality Index values calculated by watershed: 1993-2002.
Note: numbers within the watershed boundaries represent the number of sites with WQI values that were used to calculate the ten-year average WQI value for the watershed.

Among the 12 watersheds for which a ten-year average WQI value could be calculated, the average WQI value is classified as healthy for five watersheds and stressed for seven watersheds. The remaining 18 watersheds cannot be classified due to insufficient data (Figure 27).

The differences in water quality between Figure 27 (1993-2002) and Figure 25 (2003-2007) are:

- the number of water quality sample locations increased from 35 to 71;
- the number of watersheds with WQI values increased from 12 to 15 between 2002 and 2007;
- the average WQI values increased for three of the 12 watersheds that had WQI values in both time periods; and
- the average WQI value decreased for the Swift Current Creek Watershed between these two time periods.

Water Quality Index values change as a consequence of improved water quality; however watershed health values are also dependent upon the number and location of monitoring sites and the frequency of sampling.

Indicator

The Water Quality Index is an effective means for summarizing a large number of water quality parameters. The WQI was created in 1997 by the Canadian Council of Ministers of the Environment, and is based on a formula developed by the British Columbia Ministry of Environment, Lands and Parks (Canadian Council of Ministers of the Environment 2005).

In the application of the WQI, values for various water quality parameters (e.g. dissolved oxygen, nutrients, fecal coliform bacteria) are compared to the Interim Surface Water Quality Objectives for Saskatchewan (Saskatchewan Environment 2006a). The results of the comparisons are combined to provide a water quality ranking (e.g. Good, Fair, Poor) for individual water bodies. The advantages of this index are that it summarizes multiple water quality parameters into a single value, making it an effective communication tool. By using the same objectives and variables for all samples, the index can be used to convey relative differences in water quality between sites and over time. However, care must be taken when comparing among sites because of natural variability in water quality constituents (e.g. a naturally saline lake would have high concentrations of dissolved ions compared to a freshwater lake). The disadvantages of using the index include a loss of information, the sensitivity of the results to the formulation of the index, the reliance on objectives as a basis for assessing water quality, and the loss of information on interactions between variables.

The water quality parameters and associated objectives used for calculating WQI values are outlined in Table 6.

Table 6. Water quality parameters used for calculating the Water Quality Index.

Water Quality Parameter	Non-compliance if:	Unit
Arsenic Total	> 5	µg/L
Chloride Dissolved	> 100	mg/L
Chromium Total	> 1	µg/L
Mercury	> 0.026	µg/L
Unionized Ammonia	> 19	µg/L
Oxygen Dissolved (Field)	< 5.5	mg/L
pH	< 6.5 or > 9	Unit
Sodium Dissolved	> 100	mg/L
2`4-D	> 4	µg/L
MCPA	> 0.025	µg/L
Aluminum Total	> 0.1	mg/L
Sulphate	> 1,000	mg/L
Coliforms Fecal	> 1,000	units/100mL
Phosphorous Total	> 0.1	mg/L
Nitrogen Dissolved NO_3 & NO_2	> 2.9	mg/L
Escherichia coli	> 200	units/100mL
Chlorophyll *a* (for lakes only)	> 50	µg/L

Indicator

The index is calculated using three components that relate to water quality objectives:

Scope - How many? - The number of water quality variables that do not meet objectives in at least one sample during the index period, relative to the total number of variables measured.

Frequency - How often? – The number of individual measurements that do not meet objectives, relative to the total number of measurements made in all samples for the index period of interest.

Amplitude - How much? - The amount by which measurements which do not meet their objectives depart from those objectives (Davies 2006).

Rating Scheme
The Water Quality Index values range between 0 and 100, with zero representing the worst water quality and 100 representing the best water quality. Once the WQI value has been calculated, the value can be further simplified by assigning it to one of several descriptive categories (Canadian Council of Ministers of the Environment 2005):

> **Excellent:** (WQI value 95-100) – water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels. These index values can only be obtained if all measurements are within objectives virtually all of the time.
> **Good:** (WQI value 80-94) – water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
> **Fair:** (WQI value 60-79) – water quality is usually protected but occasionally threatened or impacted; conditions sometimes depart from natural or desirable levels.
> **Marginal:** (WQI value 45-59) – water quality is frequently threatened or impacted; conditions often depart from natural or desirable levels.
> **Poor:** (WQI value 0-44) – water quality is almost always threatened or impacted; conditions usually depart from natural or desirable levels.

For this document condition indicators are grouped into three categories: **healthy**, **stressed**, and **impacted**. Therefore, for this indicator the WQI categories have been grouped together into the following three categories:

Water Quality Index
Healthy: The Water Quality Index value is between 80 and 100.
Stressed: The Water Quality Index value is between 45 and 79.
Impacted: The Water Quality Index value is less than 45.

Data Source: Water Quality Index values are from: Saskatchewan Ministry of the Environment's Surface Water Monitoring Program; the Prairie Provinces Water Board's Monitoring Program; the Saskatchewan Watershed Authority's River and Lake Water Quality Monitoring; and the Saskatchewan Watershed Authority's Lake Stewardship Monitoring Program.

Data Handling: Water Quality Index values are based on multiple sampling dates per year. To ensure consistency of reporting, only sites with at least three water quality samples per year are included in this indicator. Yearly Water Quality Index values from 1993 to 2002 were averaged to obtain the ten-year values, and Water Quality Index values from 2003 to 2007 were averaged to obtain the five-year values.

Data Quality/Caveats: There are limitations in the representation of this indicator by watershed. The watersheds are shaded based on the average Water Quality Index value for all of the water quality sampling locations within that watershed. However, the Water Quality Index for any one watershed may be based on one water quality sampling location.

Response to the issue
A range of legislative tools, strategies and policies assist in protecting and improving water quality in Saskatchewan, including:

- *The Environmental Management and Protection Act, 2002,* administered by Saskatchewan Ministry of the Environment;
- *The Fisheries Act*, regulated by Fisheries and Oceans Canada;
- The Interim Surface Water Quality Objectives (Saskatchewan Environment 2006a); and
- Saskatchewan's Safe Drinking Water Strategy (see **Legislative Tools, Strategies, Policies and Guidelines** in Appendix C).

The Saskatchewan Ministry of Health administers *The Public Health Act, 1994*. This Act manages public health issues in Saskatchewan, including ensuring that there is potable water for use by the inhabitants of a hamlet, organized hamlet, town or other municipality, not including rural municipality or northern municipalities.

The Water Regulations, 2002, administered by the Saskatchewan Ministry of Environment, regulates the operation of public water systems to ensure adherence to the Canadian Drinking Water Quality Guidelines (Health Canada 2008) and Saskatchewan's Drinking Water Quality Standards and Objectives (Saskatchewan Environment 2006b).

There are no legally enforceable water quality regulations for private water sources in Saskatchewan. To assess the safety and suitability of private water sources for human consumption, the Saskatchewan Watershed Authority uses the Canadian Drinking Water Quality Guidelines (Health Canada 2008) and Saskatchewan's Drinking Water Quality Standards and Objectives (Saskatchewan Environment 2006b).

In addition to legislative tools, there are a number of federal and provincial government programs in the province that monitor the quality of surface and/or ground water for a variety of purposes. These monitoring programs include:

- the Saskatchewan Ministry of Environment's Surface Water Monitoring Program;
- the Prairie Provinces Water Board's Monitoring Program;
- the Saskatchewan Watershed Authority's River and Lake Water Quality Monitoring;
- the Saskatchewan Ministry of Environment's Intensive Livestock Operations' Monitoring Program;
- the Saskatchewan Ministry of Environment's Cumulative Effects Monitoring Program;
- Environment Canada's Environmental Effects Monitoring Program; and
- the Saskatchewan Ministry of Agriculture's Baseline Environmental Monitoring of Lower Order Streams in Saskatchewan (BEMLOSS) Program.

For a short description of these programs see the **Water Quality Monitoring and Management indicator** in Appendix C.

Geology and Hydrogeology of Saskatchewan

This section focuses on ground water resources in southern Saskatchewan, which includes the agricultural zone and the fringe areas immediately north of it. In northern Saskatchewan, ground water use is extremely limited and very little work has been done to investigate the resource. In southern Saskatchewan, where ground water is an important component of the water supply, a significant amount of work has been done.

Geologic units may be broadly divided into bedrock and Quaternary or glacial "drift", which can be differentiated based on their characteristics and geologic history. Bedrock describes rocks occurring below the base of the glacial deposits. Strictly speaking, this includes Pre-Cambrian rocks, but these have no practical influence on the province's ground water resources and will not be discussed further. For the purposes of this document, bedrock will refer to those sediments deposited prior to glaciation, which began approximately two million years ago. Therefore, the bedrock deposits relevant to the province's ground water resources are sedimentary rocks which were deposited by, or adjacent to, shallow seas which intermittently covered Saskatchewan. Drift refers to those sediments between the top of the bedrock and the present ground surface. The drift is formed by unconsolidated sediments deposited either directly by glaciers or via melt water associated with glaciation.

The bedrock and glacial deposits have been separated and classified into formations based on their history, characteristics and past depositional environment. Whenever a bedrock or glacial deposit is capable of yielding useable volumes of water to a water well, it is referred to as an aquifer. Both bedrock and glacial aquifers are commonly used as water sources. Glacial aquifers are broadly distributed throughout the province, while bedrock aquifers tend to be utilized primarily in the west central, southwest, south central and extreme southeast portions of the province.

Bedrock Aquifers
Bedrock formations were deposited prior to glaciation and are generally more extensive and consistent in thickness and characteristics than the glacial drift deposits. The deposits are marine and continental in origin. Deposits of bedrock sediments were contributed by slow regression of the sea interrupted by a rapid rise in sea level. Clay/shales were deposited in marine environments, fine sands near shore areas, and coal and interbedded sediments in the continental environments. The bedrock topography was formed by preglacial erosion and deposition, followed by glacial and fluvio-glacial erosion and deposition. The bedrock aquifers will be discussed in ascending order. For the most part, bedrock aquifers occurring below the Ribstone Creek aquifer would be saline and are not considered here. It should be noted that there are a number of bedrock aquifers occurring below the Ribstone Creek aquifer.

Ribstone Creek Aquifer

The Ribstone Creek Formation is a sand member of the Lea Park Formation. The aquifer, which is limited to the western portion of Saskatchewan, is formed by thin, fine grained saturated sands and sandstones. In general, the aquifer is either too deep or yields water with a quality that is unsuitable for domestic or municipal uses. The depth of the aquifer is approximately greater than 500 meters in the Cypress Hills area and less than 25 meters in the Lloydminster area. Due to its generally poor quality, water from the aquifer is primarily used by the oil industry.

Judith River Formation

The Judith River Formation consists predominately of continental clay, silts and fine sands. The Judith River does not form a single, discrete aquifer; rather, it forms an aquifer system consisting of a number of inter-related aquifers. The Judith River is a wedge-shaped deposit and occurs in the southwestern part of Saskatchewan. Figure 28 illustrates its spatial extent and distribution. It is a major regional aquifer and is thickest in the western portion of the province, thinning toward the east. Some of the thinning of the formation may be the result of erosion during the deposition of the Tyner Valley and Hatfield Valley Aquifers, which are incised into both the Bearpaw and Judith River Formations. In general, water from the aquifer is soft but is variable depending on the geologic structure and local recharge. Although the water is generally soft, it is still considered to be of relatively poor quality due to its high mineral content. Aquifer yields range from 10 to 60 imperial gallons per minute (igpm), but generally will be less than 20 igpm. Where the aquifer thickness is limited, yield will be correspondingly lower.

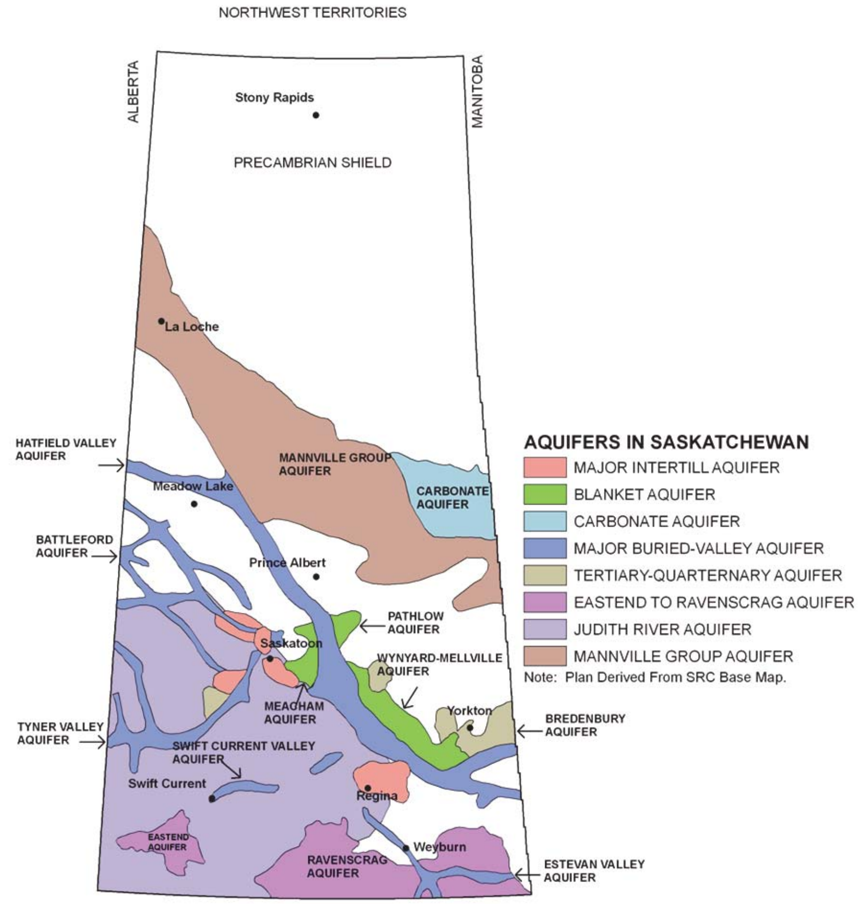

Figure 28. Major aquifers in Saskatchewan.

Bearpaw Sands and Silts

The Bearpaw Formation overlies the Judith River Formation and consists primarily of marine shales. The marine shales do not have potential as an aquifer, but sand deposits within the shale occur in some areas. These sand members may form locally significant aquifers capable of providing a water supply for domestic and small municipal users. In Saskatchewan, these members have been named (in ascending order) the Outlook, Matador, Demaine, Ardkenneth and Cruikshank members. The aquifers formed by the sand members are limited in extent due to a lack of lateral continuity. Of the various sand members, only the Demaine and Ardkenneth are important sources of water. Water from these sand members is soft, but generally of poor quality because it is highly mineralized.

Eastend, Whitemud, Frenchman, Battle, and Ravenscrag Formations

The Late Cretaceous Eastend, Whitemud, Frenchman, Battle, and Tertiary Ravenscrag Formations occupy the southern portion of Saskatchewan. The Eastend Formation represents the transition from marine to non-marine sedimentation. From the view of ground water resources, the separation of each formation could not be separated from geophysical logs, so the formations have been grouped as one unit. This unit is often referred to as the Eastend to Ravenscrag Formation forming the Eastend to Ravenscrag Aquifer. The spatial extent of the Eastend to Ravenscrag Aquifer is limited to the southern-most portions of the province and in the Cypress Hills uplands. Figure 28 illustrates its spatial extent and distribution. The sand faces of the Eastend to Ravenscrag Aquifer serves as an important regional aquifer for domestic and municipal users. As in the case of the Judith River, this unit consists of a number of discrete aquifers and must be considered as an aquifer system. The aquifer system has been further divided into five discrete units. From west to east, these units are the Shaunavon Aquifer System, the Coronach Aquifer System, the Ormiston and Bengough Aquifer Systems, and the Bienfait Aquifer Systems.

Quaternary Aquifers

Approximately two million years ago, Saskatchewan was subjected to a number of episodes of glacial advance and retreat. Glacial movement across the landscape resulted in erosion and the deposition of sediments on top of the bedrock surface. Sediments deposited during glacial episodes included sorted and unsorted material. The unsorted materials, which are mixtures of silt, clay and sand, are referred to as glacial tills. The sorted sediments were deposited from glacial meltwater at the ice front. These deposits consist of sand, silt and clay and gravel, with saturated sand and gravels forming glacial aquifers. Repeated episodes of glacial advance and retreat resulted in extremely complex geologic conditions. Glacial aquifers tend to be subject to rapid lateral and vertical changes in extent, thickness, and distribution. It is safe to say that they tend to be much more variable than the bedrock aquifers. The glacial drift has been divided into several till and intertill units representing the glacial and interglacial periods which occurred. The glacial drift aquifers in Saskatchewan, in ascending order, are the Empress Group Aquifers, the Sutherland Group and Saskatoon Group Aquifers, and the Surficial Drift Aquifers.

Empress Group

Deposits occurring between the bedrock surface and the glacial drift are referred to as the Empress Group. Where sand and gravel components of these deposits are saturated they form the Empress Group Aquifers, which may be broad, laterally extensive aquifers. However, the Empress Group most commonly forms what are known as buried valley aquifers. These buried valley aquifers were formed by deposition of sediments and glacial sand and gravel at the base of ancient river valleys which had been eroded into the pre-glacial land surface. The Empress Group consists of pre- and post-glacial stratified sand, gravel, silt and clay. These sediments are highly permeable and extend hundreds of kilometres. In general, these aquifers are long and narrow, similar to a modern valley, but due to repeated glacial activity they have been deeply buried and there is no surface expression of these ancient river valleys.

In Saskatchewan, the major aquifers formed by the Empress Group are the Hatfield Valley Aquifer, the Tyner Valley Aquifer, the Battleford Valley Aquifer, the Swift Current Valley Aquifer, and the Estevan Valley Aquifer. The Hatfield Valley Aquifer is the largest buried valley aquifer in Saskatchewan. The quality of water from these aquifers is variable, but is generally fairly poor to quite poor for anything other than industrial purposes. Yields are also variable, but may be suitable for large industrial and municipal uses.

Sutherland and Saskatoon Groups

The Sutherland and Saskatoon Groups occur above the Empress Group. Both groups consist mainly of till, but may contain interbedded sand and gravel within the till. The saturated sand and gravel form potential aquifers. The thickness, depth, and extent of these aquifers are extremely variable. They may occur at depths of up to 200 metres or more, or as shallow as a few metres. Water quality and yield from these aquifers are also extremely variable. These aquifers are used for everything from domestic to large municipal and industrial uses.

Surficial Drift Aquifers

The surficial drift aquifers are the uppermost ground water zone. These aquifers are formed by saturated sands and silts deposited by eolian (wind blown) processes and streams and rivers. Given their proximity to the surface, they are most likely to be directly influenced by climatic conditions. These deposits may be well-sorted and highly permeable. Water from the surficial drift aquifers is less mineralized than the deeper aquifers and may provide a water supply to domestic users and smaller municipal and industrial users. Wells completed in surficial aquifers are generally large-diameter bored wells. Recharge mainly originates from precipitation and spring runoff infiltrating into the water table. In general, these aquifers are typically more vulnerable to drought and contamination than the deeper aquifers.

Ground Water Quality Indicator

This indicator uses exceedances of Health Canada's Maximum Acceptable Concentrations for 12 water quality parameters to assess the quality of ground water in Saskatchewan. The indicator is based upon exceedances of human-influenced Maximum Acceptable Concentration parameters. The percentage of wells that have at least one exceedance is used to assess the health of Saskatchewan's watersheds in relation to ground water quality (Figure 30).

Indicator	
Ground Water Quality	**Status:** Typically, ground water found in Saskatchewan requires some treatment prior to human consumption in order to comply with health standards. For the purposes of this report, the water quality parameters used for calculating exceedances of Maximum Acceptable Concentrations, according to Health Canada's Drinking Water Quality Standards and Guidelines (Health Canada 2008), have been categorized into two groupings: human influenced and geologically influenced. Only the human influenced parameters are used for the purpose of rating this indicator. **Trend:** Trends in ground water quality cannot be assessed, as very few wells in the province are tested more than once.

The issue

The quality of ground water is a function of natural conditions and processes as well as human influences. Ground water quality in aquifers that have little connection with the surface typically reflect the natural condition, whereas ground water connected with the surface will reflect natural conditions but may also reflect human influences. Indications of human influences typically include high nitrate concentrations and high concentrations of coliform bacteria. High concentrations of arsenic, barium, boron, cadmium, chromium, fluoride, lead, selenium, and uranium in the ground water of many regions of southern Saskatchewan are reflective of natural geological conditions.

Ground Water Quality Indicator in Saskatchewan

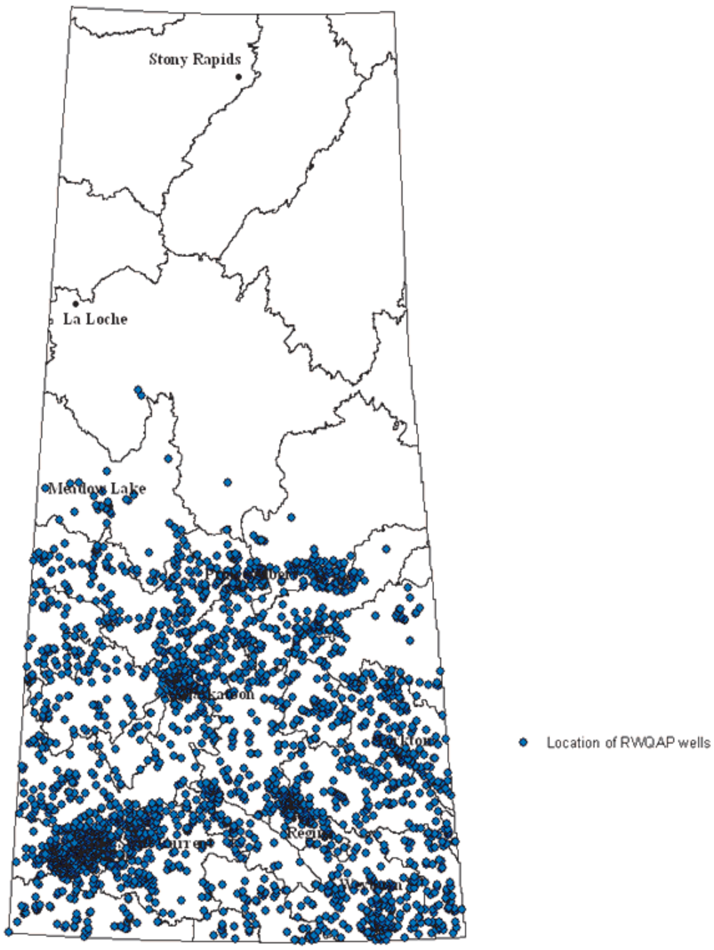

Figure 29. Location of ground water wells sampled for water quality through the Rural Water Quality Advisory Program.

Between 1996 and April 2009, the Saskatchewan Watershed Authority collected ground water quality samples from over 3,408 ground water wells through its Rural Water Quality Advisory Program. Of the 3,408 records that were in the database, 3,356 (98.5%) had sufficient location information to associate them with a watershed. Therefore, the results for this indicator are based on the ground water quality results from these 3,356 wells (Figure 29).

The water quality parameters used for calculating exceedances of Maximum Acceptable Concentrations, according to Health Canada's Drinking Water Quality Standards and Guidelines (Health Canada 2008), have been categorized into two groupings: human influenced and geologically influenced. Only the human influenced parameters are used for the purpose of rating this indicator.

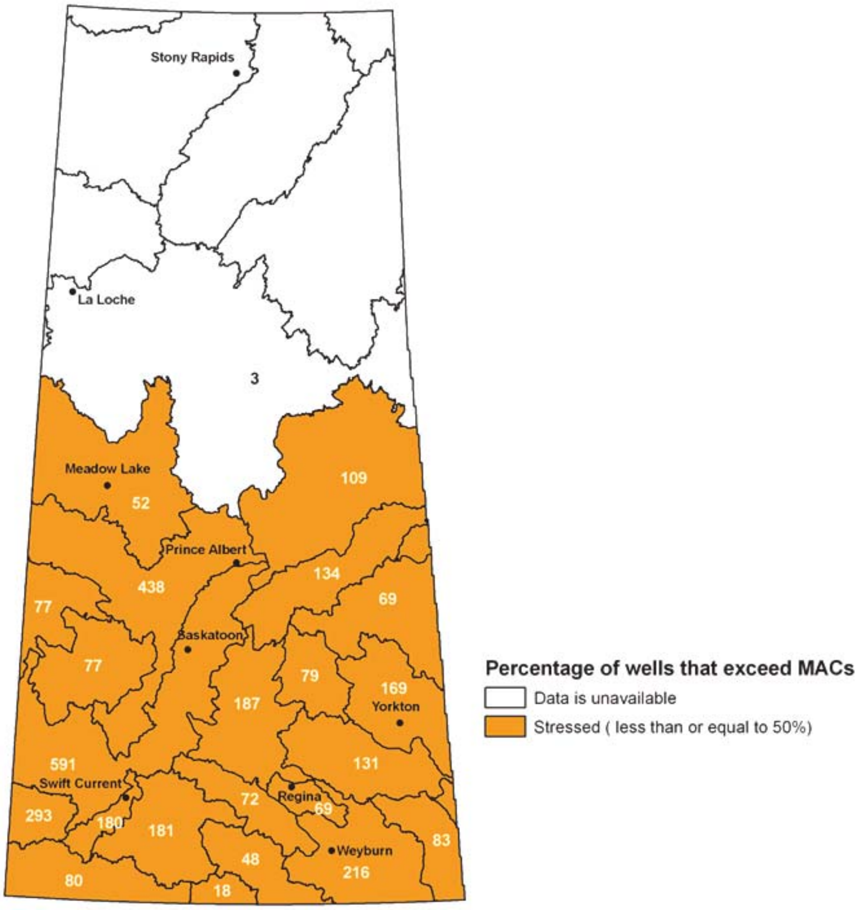

Figure 30. Percentage of wells that exceed at least one of the human influenced* Maximum Acceptable Concentrations according to Health Canada's Drinking Water Quality Standards and Guidelines.

*Human influenced Maximum Acceptable Concentrations include nitrate (NO_3^-), total coliform bacteria, and *Escherichia coliform* (*E. coli*) bacteria.

Note: numbers within the watershed boundaries represent the number of ground water wells sampled through the Rural Water Quality Advisory Program. The average percentage of wells that exceed at least one of the human influenced Maximum Acceptable Concentrations was not calculated for watersheds that had fewer than 10 ground water wells sampled.

Sufficient data were available to calculate the percentage of wells that exceed at least one of the Maximum Acceptable Concentrations for 22 of Saskatchewan's watersheds. All of these 22 watersheds are classified as stressed due to exceedances of the human influenced Maximum Acceptable Concentrations, which include nitrate (NO3-), total coliform bacteria, and *Escherichia coliform* (*E. coli*) bacteria. See Table 7 for the three water quality parameters and associated objectives used for calculating the exceedances of human influenced Maximum Acceptable Concentrations.

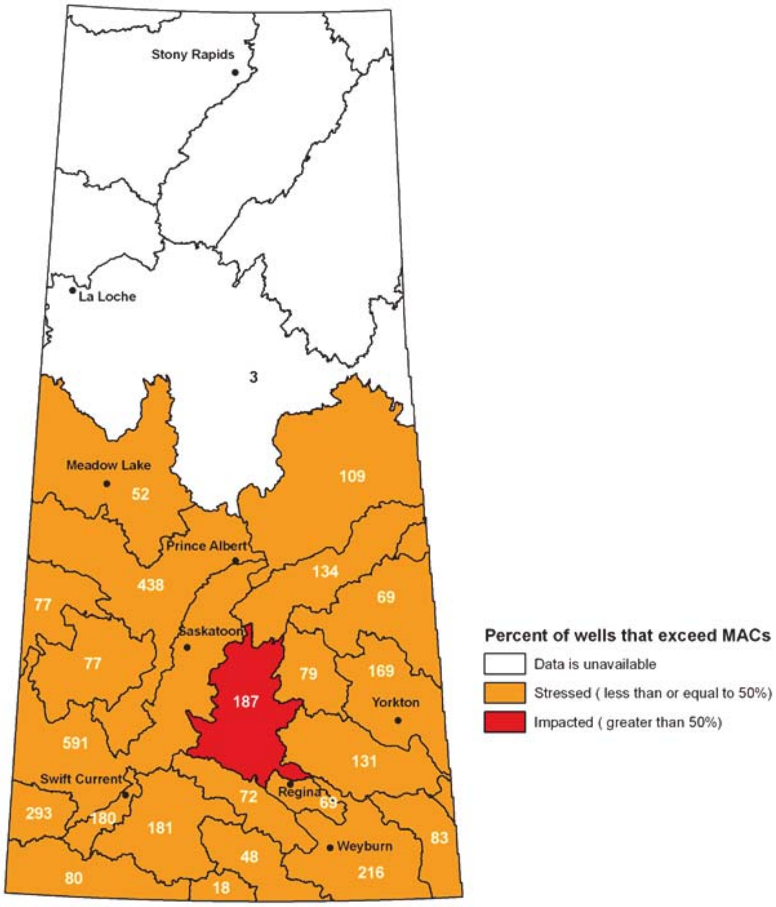

Figure 31. Percentage of wells that exceed at least one of the geologically influenced* Maximum Acceptable Concentrations according to Health Canada's Drinking Water Quality Standards and Guidelines.

*Geologically influenced Maximum Acceptable Concentrations include arsenic, barium, boron, cadmium, chromium, fluoride, lead, selenium and uranium.

Note: numbers within the watershed boundaries represent the number of ground water wells sampled through the Rural Water Quality Advisory Program. The average percentage of wells that exceed at least one of the geographically influenced Maximum Acceptable Concentrations was not calculated for watersheds that had fewer than 10 ground water wells sampled.

For the geologically influenced Maximum Acceptable Concentrations, 21 watersheds were classified as stressed, and the Upper Qu'Appelle River Watershed was classified as impacted. The geologically influenced Maximum Acceptable Concentrations include arsenic, barium, boron, cadmium, chromium, fluoride, lead, selenium and uranium. See Table 7 for the nine water quality parameters and associated objectives used for calculating the exceedances of geologically influenced Maximum Acceptable Concentrations.

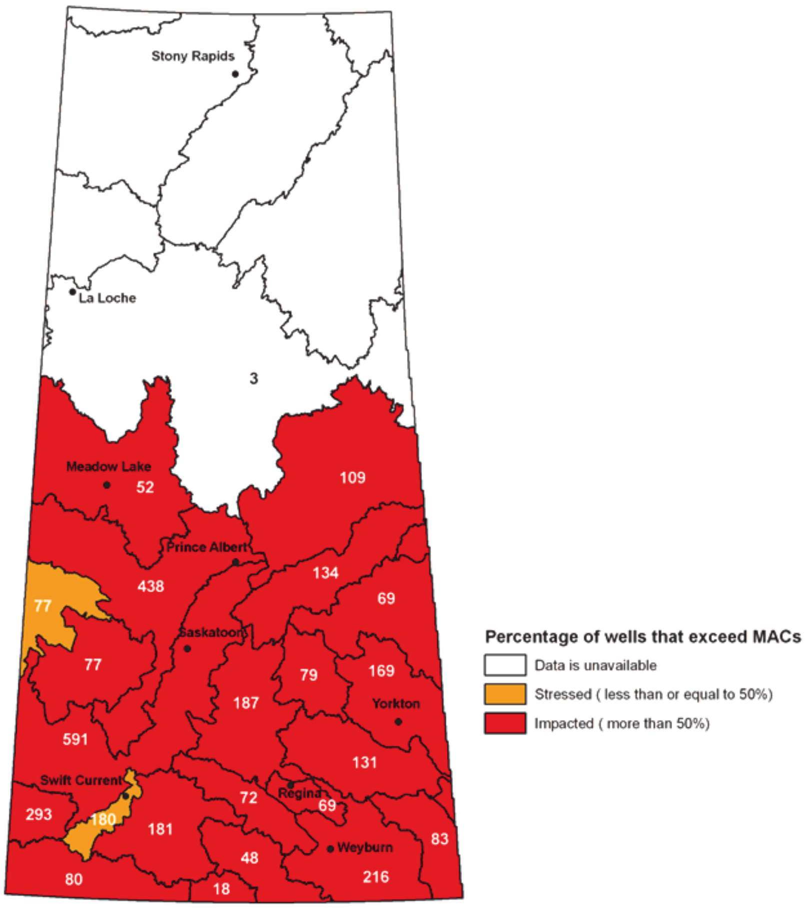

Figure 32. Percentage of wells that exceed at least one Maximum Acceptable Concentration according to Health Canada's Drinking Water Quality Standards and Guidelines.
All Maximum Acceptable Concentrations include arsenic, barium, boron, cadmium, chromium, fluoride, lead, selenium and uranium, nitrate (NO_3^-), total coliform bacteria, *and Escherichia coliform* (*E. coli*) bacteria.
Note: numbers within the watershed boundaries represent the number of ground water wells sampled through the Rural Water Quality Advisory Program. The average percentage of wells that exceed at least one Maximum Acceptable Concentrations was not calculated for watersheds that had fewer than 10 ground water wells sampled.

Of the 22 watersheds that were rated for the percentage of wells that exceeded all MACs according to Health Canada's Drinking Water Quality Standards and Guidelines, two watersheds are classified as stressed and 20 watersheds are classified as impacted (Figure 32).

See Table 7 for the 12 water quality parameters and associated objectives used for calculating exceedances of all Maximum Acceptable Concentrations (MACs).

Table 7. Water quality parameters used for calculating exceedances of Maximum Acceptable Concentrations according to Health Canada's Drinking Water Quality Standards and Guidelines (Health Canada 2008).

Water Quality Parameter	Objective	Unit	Objective Type	MAC type
Arsenic	10	µg/L	MAC	Geological influence
Barium	1.0	mg/L	MAC	Geological influence
Boron	5	mg/L	IMAC[1]	Geological influence
Cadmium	0.005	mg/L	MAC	Geological influence
Chromium	0.05	mg/L	MAC	Geological influence
Fluoride	1.5	mg/L	MAC	Geological influence
Lead	0.01	mg/L	MAC	Geological influence
Selenium	0.01	mg/L	MAC	Geological influence
Uranium	20	µg/L	MAC	Geological influence
Nitrate	45	mg/L	MAC	Human influence
Total Coliform Bacteria	0	MPN/100 mL	MAC	Human influence
Escherichia coli	0	MPN/100 mL	MAC	Human influence

[1] An *Interim Maximum Acceptable Concentration* has been set by Health Canada
mg/L = milligrams per litre
µg/L = micrograms per litre
MPN/100 ml = most probable number (MPN) of coliforms per 100 ml

Indicator		
Exceedance of a MAC	=	The concentration of a water quality parameter is greater than the concentration of that parameter's Maximum Acceptable Concentration according to Health Canada's Drinking Water Quality Standards and Guidelines.
Percentage of wells that exceed MACs	=	Number of unique well samples that exceed a Maximum Acceptable Concentration / Number of unique well samples that had water quality results

Rating Scheme

Percentage of wells that exceed human influenced MACs
Healthy: Percentage of wells that exceed MACs is 0%.
Stressed: Percentage of wells that exceed MACs is less than or equal to 50%.
Impacted: Percentage of wells that exceed MACs is greater than 50%.

Percentage of wells that exceed geologically influenced MACs
Healthy: Percentage of wells that exceed MACs is 0%.
Stressed: Percentage of wells that exceed MACs is less than or equal to 50%.
Impacted: Percentage of wells that exceed MACs is greater than 50%.

Percentage of wells that exceed all MACs
Healthy: Percentage of wells that exceed MACs is 0%.
Stressed: Percentage of wells that exceed MACs is less than or equal to 50%.
Impacted: Percentage of parameters that exceed MACs is greater than 50%.

Data Source: The ground water quality data parameters were obtained from well records in the Saskatchewan Watershed Authority's Rural Water Advisory Program Database, April 2009. Between 1996 and April 2009 the Saskatchewan Watershed Authority collected ground water samples from over 3,408 ground water wells.

Data Quality/Caveats: Of the 3,408 records that were in the database, 3,356 (98.5%) had sufficient location information to associate them with a watershed. Therefore, the results for this indicator are based on the ground water quality results from these 3,356 wells.

Data Discussion: The ground water quality data used for this indicator was assessed independent of well depth.

Response to the issue

The Saskatchewan Ministry of Health administers *The Public Health Act, 1994*. This Act manages public health issues in Saskatchewan, including ensuring that there is potable water for use by the inhabitants of a hamlet, organized hamlet, town or other municipality, not including rural municipality and northern municipalities.

The *Water Regulations, 2002*, administered by the Saskatchewan Ministry of Environment, regulates the operation of public water systems to ensure adherence to the Canadian Drinking Water Quality Guidelines (Health Canada 2008) and Saskatchewan's Drinking Water Quality Standards and Objectives (Saskatchewan Environment, 2006b).

There are no legally enforceable water quality regulations for private water sources in Saskatchewan. To assess the safety and suitability of private water sources for human consumption, the Saskatchewan Watershed Authority uses the Canadian Drinking Water Quality Guidelines (Health Canada 2008) and Saskatchewan's Drinking Water Quality Standards and Objectives (Saskatchewan Environment, 2006b).

In response to the Saskatchewan Watershed Authority's mandate to ensure safe drinking water sources for residents of Saskatchewan, the Rural Water Quality Advisory Program was initiated. The purpose of the program is to provide consultative water quality services to rural water users in Saskatchewan. In addition to sampling private wells when requested by the landowner, the Saskatchewan Watershed Authority also works with "communities at risk" serviced by private ground water wells. A "community at risk" is defined as a community that has had water quality issues identified in the past and a high density of private wells in the area. A health risk is associated with wells that exceed one or more of the 13 Maximum Acceptable Concentrations outlined in Health Canada's Drinking Water Quality Standards and Guidelines. The Saskatchewan Watershed Authority's work with communities at risk includes:

- In the spring of 2007, in response to historical water quality concerns and because of the Health Region's responsibility to enforce Section 14 of *The Public Health Act*, *1994*, the Regina Qu'Appelle Health Region, in cooperation with Saskatchewan Watershed Authority and the Saskatchewan Ministry of Health, completed a detailed survey to collect information on water quality and current water management practices in the town of Pilot Butte.
- In the fall of 2008, the Saskatchewan Watershed Authority, the Ministry of Health, and the Saskatoon Health Region cooperated to assess drinking water risk and explore risk management options with the village of Hepburn. The objective of this study was to assess the drinking water quality of private and public water sources in the village of Hepburn. This information can be used to inform the public and decision makers of the potential health risks associated with their water supplies. The study found that 75.3 percent of the water sources tested in Hepburn were above at least one of Health Canada's guidelines for human consumption at the time the water was sampled (Saskatchewan Watershed Authority 2009a).
- In the summer of 2009, the Saskatchewan Watershed Authority, the Ministry of Health, and the Regina Qu'Appelle Health Region worked together to assess drinking water risk and explore risk management options with the District of Katepwa. The objective of this study was to assess the drinking water quality of private and public water sources in the District of Katepwa, in addition to sewage disposal practices of select residences. Analyses of the collected water samples revealed that 52.1 percent of the water sources tested in Katepwa were above at least one of Health Canada's guidelines for drinking water quality (including turbidity) (Saskatchewan Watershed Authority 2010).

In 2007, the First Nations Agricultural Council of Saskatchewan (FNACS) contracted the Saskatchewan Watershed Authority to sample and report on the source water quality of three reserves whose water supplied to residents for human consumption was from ground water sources. The three reserves included: the Muskeg Lake Cree Nation, Sweetgrass First Nation, and Witchekan Lake First Nation. The objective of the study was to provide the First Nations Agricultural Council of Saskatchewan (FNACS) with ground water quality data and well management information for these reserves (Saskatchewan Watershed Authority 2008b).

In 2007, the Saskatchewan Ministry of Agriculture, the Saskatchewan Ground Water Association, and the Saskatchewan Watershed Authority jointly published a document entitled *A Landowner's Guide to Water Well Management* (Mance 2007). This document provides landowners with a list of preventative measures that they can follow to help reduce the risk of contaminating their well and associated aquifers. Some of these measures include ensuring:

- wells are constructed properly;
- inactive wells are properly decommissioned;
- onsite sewage systems are properly constructed;
- fuel is stored in properly installed, approved tanks that resist corrosion and that fuel storage tank dispensers meet legislated requirements;
- fuel tanks are regularly monitored for leaks;
- pesticides and fertilizers are handled carefully, and mixed and stored away from a well site;
- regularly testing soil and manure to reduce the risk of leaching of nutrients from excess application of fertilizer and manure;
- silage is stored at an appropriate moisture level to minimize seepage and that the silage storage site is in good condition;
- livestock yards are located away from nearby wells, and manure and runoff is collected and stored; and
- farm wastes are properly disposed of (Mance 2007).

Ground Water Quantity Indicator (under construction)

This indicator was developed to assess the condition of ground water quantity in Saskatchewan.

Indicator	
Ground Water Quantity	**Status:** Quantifying ground water is challenging due to the lack of available data. Therefore, this indicator is considered 'under construction." **Trend:** Trends in ground water quantity cannot currently be assesses due to the lack of available data.

The issue
Ground water is the primary source of drinking water for over 50% of rural consumers in Saskatchewan. An adequate supply of ground water is necessary to supply drinking water demands. It is also an important resource for industry, irrigation, and agriculture.

Ground Water Quantity Indicator in Saskatchewan
Quantifying ground water is challenging. The actual quantity of water available for use is difficult to estimate, and money available for ground water research is limited. Therefore, a secondary or surrogate factor such as total ground water allocation or observation well data is used to estimate the state of ground water sources. Ground water allocation data provide an indication of the stress put on the resource, while observation data indicate the state of the net available water (total available water less any uses) in the few aquifers for which data are available.

Response to the issue
In 2009, the Saskatchewan Watershed Authority initiated a four-year, $7.5 million Water Availability Study. The purpose of this study is to better understand Saskatchewan's water resources. Ground water mapping is one of the principal components of this study. Once completed, regional ground water maps will be compiled and will include information about aquifer boundaries, depth, and water quality. These maps can then be used to determine whether ground water use in different areas is being used in a sustainable manner, and to identify higher risk areas where ground water sources may be stressed.

The primary response to the pressures of ground water extraction is through the approval and licensing of water use projects. The Saskatchewan Watershed Authority is responsible for the management of ground water in the province through the approval and licensing of water use projects. Construction, alteration, extension or operation of works, and the right to use water, requires approval from the Saskatchewan Watershed Authority. The Authority issues approvals for the construction and operation of water works, and issues water rights for the sustainable use of ground water and surface water for domestic, municipal (source water only), agricultural, industrial, recreational and wildlife purposes.

A person owning or occupying land that adjoins a lake, stream, storage pond, dugout or ground water source is not required to obtain an approval for domestic purposes. Domestic water use is defined as water that is to be used for household and sanitary purposes, farm chemical spraying, watering lawns and gardens, and water used for non-intensive livestock and poultry operations.

Any surface or ground water use, with the exception of domestic use, requires approval pursuant to *The Saskatchewan Watershed Authority Act, 2005* and *The Ground Water Regulations* (see **Legislative Tools, Strategies, Policies, and Guidelines** in Appendix C).

Whether or not an aquifer can support a particular use is determined from test drilling, analysis of associated geologic and hydrogeologic information, and by pump testing the well. A ground water investigation is required by the proponent to ensure that the ground water source can sustain the proposed development without any adverse impacts on the source or on existing ground water users. The regulatory process ensures the sustainability and environmentally-sound management of ground water resources in Saskatchewan.

In addition to legislation, the Saskatchewan Watershed Authority and Saskatchewan Research Council have established an observation well network to monitor changes in specific aquifers around Saskatchewan (see **Water Quantity Monitoring and Management** in Appendix C). The network was established in 1964 with the initial intention of measuring natural fluctuations in ground water levels. Sites were selected based on their geohydrological variety and in aquifers where the Saskatchewan Research Council was involved in more detailed geohydrological activities.

Aquatic Benthic Macroinvertebrate Indicator

This indicator was developed to assess the health of aquatic benthic macroinvertebrates in Saskatchewan.

Indicator	
Aquatic Benthic Macroinvertebrates	**Status:** Comprehensive benthic macroinvertebrate sampling in Saskatchewan was initiated in 2006. The preliminary health assessment of aquatic benthic macroinvertebrates is based on data from 2006 - 2007. **Trend:** Currently, trends in the health of aquatic benthic macroinvertabrates cannot be assessed due to the lack of long-term data. As aquatic benthic macroinvertebrate data continues to be collected trends in the health of these communities will be conducted in the future.

The issue

Aquatic benthic macroinvertebrates are the bugs living in a waterbody, including insects such as midges and mayflies. These aquatic organisms are used because they are sensitive to the chemical and physical conditions in the habitats they reside. Examining organisms collected from a waterbody can indicate the quality of surface water.

Aquatic ecosystem health is an important indicator of the condition of watersheds, and setting water quality objectives should involve biological criteria in addition to traditional chemical surrogates (Canadian Council of Ministers of the Environment 2006). Biological characteristics, functions (such as filtering), and health all respond to changes in water quality, and are a valuable proxy for the ultimate consequences of human activity on ecosystems.

Benthic Macroinvertebrate Indicator in Saskatchewan

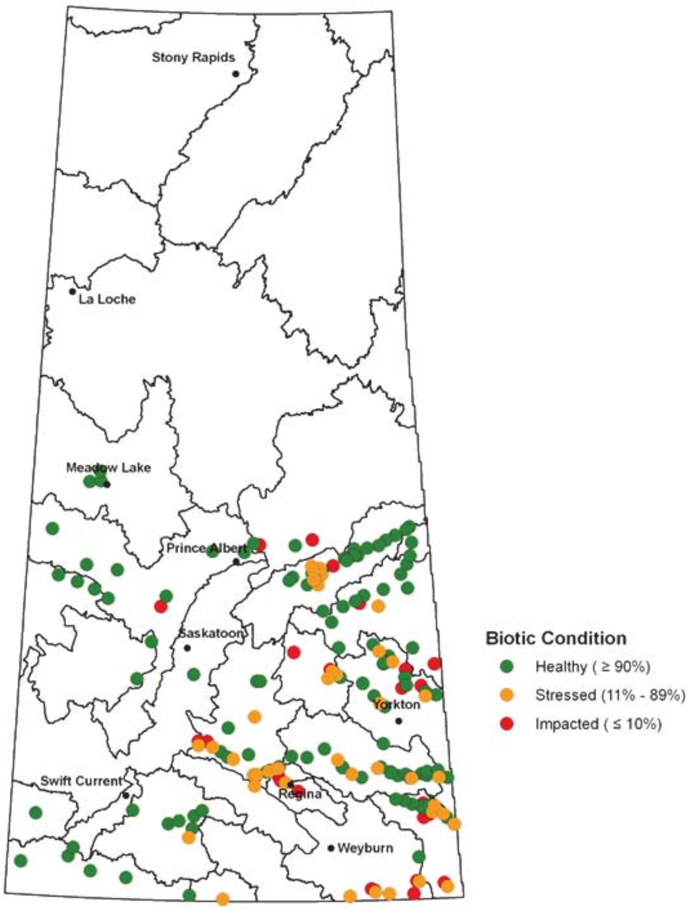

Figure 33. Biotic condition evaluated by sample location in the time period 2006-2007.

There are a number of watersheds in southern Saskatchewan that contain sample sites which have a biotic condition classified as stressed or impacted (Figure 33). Watersheds in the western half of the province have relatively few sites that are either stressed or impacted. However, there are many stream sites along the east side of the province that have a degraded condition and are classified as stressed or impacted (Figure 33).

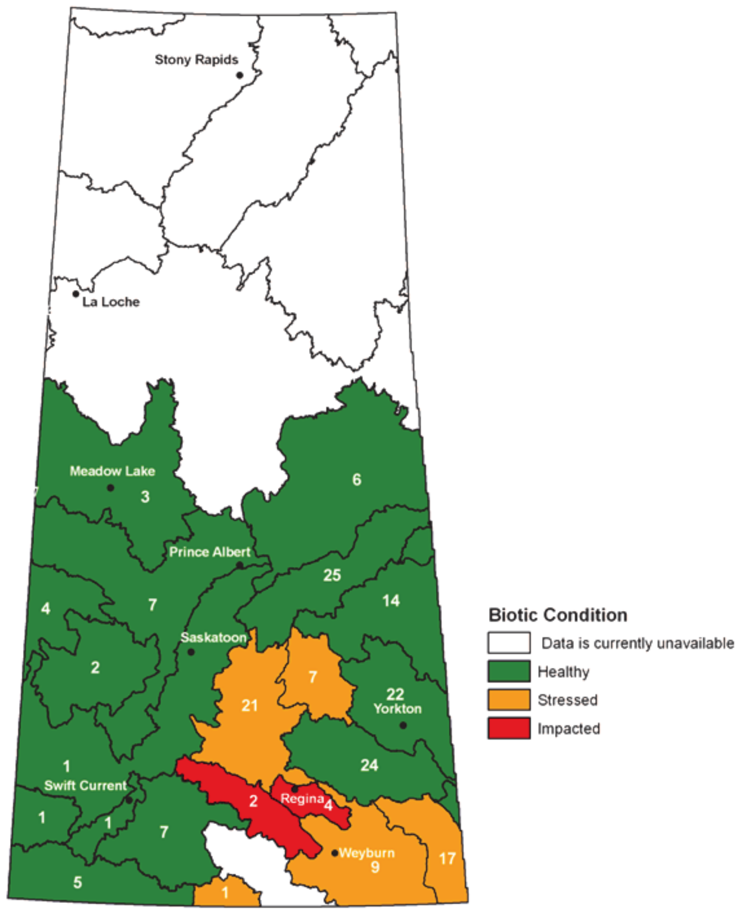

Figure 34. Biotic condition evaluated by watershed in the time period 2006-2007.
Note: numbers within the watershed boundaries represent the number of sites with biotic condition values that were used to calculate the average biotic condition for the watershed.

Data was available to calculate the biotic condition of 21 watersheds in Saskatchewan. At the watershed scale, the average biotic condition of 14 watersheds across southern Saskatchewan is classified as healthy (Figure 34). The five watersheds classified as stressed are the Lower Souris River, Upper Souris River, Poplar River, Upper Qu'Appelle River and Quill Lakes Watersheds. The two watersheds that were classified as impacted were Wascana Creek and Moose Jaw River watersheds (Figure 34).

Indicator

This biotic condition indicator reports on the overall ecosystem health at an individual site in a waterbody within a watershed. The indicator has been constructed to evaluate how human activities (e.g. addition of nutrients, sediment, etc.) change downstream biotic characteristics and ultimately impact the integrity of the ecosystem relative to 'reference' conditions. These 'reference' conditions were characterized using sites that have been influenced least by human activities. This method, known as the biotic integrity method, has been used elsewhere to: 1) differentiate healthy sites from degraded sites, 2) identify which ecosystem characteristics distinguish a particular site as degraded, and 3) identify the stressor(s) driving the degradation.

Indicator

The indicator is calculated using four components that respond to human activity in a predictable way:

- **Abundance:** The total abundance of benthic macroinvertebrates in a river typically increases with stressors such as organic pollution and decreases with stressors such as pesticides.
- **Richness:** The total number of species present at a site and is expected to decrease with stressors such as organic pollution and pesticides.
- **Diversity:** This measure incorporates both abundance and richness to provide a measure of balance in the community (i.e. Does the group of invertebrates have many organisms dominated by only one or two types of individuals?). Typically, disturbance drives a group of aquatic invertebrates to be composed of a few species that are tolerant of the conditions. These few species will increase in abundance relative to the other species present.
- **Aquatic Invertebrate Composition:** Similarity in the composition of species at a site of interest relative to reference sites is an overall gauge of change. This measure often identifies unexpected biological changes and is sensitive to a wide range of stressors.

At each site, the value for each of the components (abundance, richness, diversity, and aquatic invertebrate composition) is compared to the values at reference sites that have comparable habitat (such surrounding soil type and geology). A value of total condition is used to summarize the four components at each site and is evaluated based on the degree to which it deviates from the average reference condition and the probability that it differs from the range of reference conditions (Bowman and Somers 2006).

Rating Scheme

Overall biotic condition was determined by calculating the magnitude of difference between a site of interest and the average reference condition and then statistically evaluating the probability that this difference falls outside the range of variation in condition at those reference sites. The degree of impact was categorized as follows:

Within Reference Condition: the test site of interest not significantly different than reference condition; has ≥ 90 % chance of being in reference condition.
Different from Reference: the test site of interest is not-significantly different than reference condition but shows signs of stress; has 11 - 89% chance of being in reference condition.
Significantly Different from Reference: the test site of interest is significantly different than reference condition; has ≤ 10 % chance of being in reference condition.

For the purposes of this report, biological condition indicators have been grouped into three categories: **Healthy**, **Stressed**, and **Impacted**. As such, the biomonitoring information has been summarized as follows:

Aquatic Benthic Macroinvertebrates
Healthy (Within Reference Condition): Site condition is typical of best available reference sites; has ≥ 90 % chance of being in reference condition.
Stressed (Different from Reference Condition): Site condition deviates from average reference condition; has 11 - 89% chance of being in reference condition.
Impacted (Significantly Different from Reference Condition): Site condition is impacted relative to the range at reference sites; has ≤ 10 % chance of being in reference condition.

Data Source: Indicator values are from the Saskatchewan Watershed Authority's ongoing monitoring and assessment activities around Saskatchewan.

Data Handling: Ecosystem Health indicator values are based on consistent sampling windows of time each year. To ensure appropriate biological comparisons, seasonal streams are separated from permanent streams, and are sampled in the spring and fall respectively. The values used to develop this indicator are from data collected in 2006 and 2007. The value for each sample site is determined from the most recent samples taken.

This assessment was based on 183 site visits across two years (Figure 33), more than700 aquatic invertebrate samples, and 267 benthic macroinvertebrate taxa. Using GIS information and land-use indicators developed in other jurisdictions, five preliminary criteria (e.g. percentage of the watershed that is cropland) have been developed to assess the best available reference streams in Saskatchewan. For each criterion, preliminary benchmarks have been established to identify least-impacted sites (e.g., <50% cropland). Invertebrate composition of best available sites is used as the benchmark to assess the relative condition of streams with more human activities in their watersheds.

Data Discussion: This biomonitoring tool allows condition to be assessed relative to reference sites and the range of variation found in reference sites. However, the accuracy and precision of this indicator to assess impairment is dependent on the number of reference sites, the criteria used to define reference condition, and the specific biological measures used to evaluate condition. Phase II of developing this biomonitoring tool will focus on sampling more reference sites that meet the criteria developed in Phase I, and sampling more potentially impacted sites in watersheds where there is limited data. Further, there are more measures of impairment than the four evaluated here (abundance, richness, diversity, and aquatic invertebrate composition) that respond to specific stressors. These measures will be evaluated for their applicability to Northern Great Plains waterbodies, and included in future evaluation of condition. Despite these necessary next steps, Phase I of stream biomonitoring identified areas of concern in agricultural watersheds of Saskatchewan and provided a solid foundation for future reporting.

Response to the issue

The Saskatchewan Watershed Authority Act, 2005, administered by the Saskatchewan Watershed Authority, promotes the adoption of research and conservation programs that ensure Saskatchewan's source water, watersheds, and related lands are managed and protected.

In Saskatchewan, as is the case with most provinces in Canada, biomonitoring activities are undertaken without legislated biocriteria targets (Canadian Council of Ministers of the Environment 2006). However, as part of its mandate under *The Saskatchewan Watershed Authority Act, 2005,* the Saskatchewan Watershed Authority has been evaluating the potential utility of a biomonitoring tool to assess the biotic integrity of aquatic ecosystems across southern Saskatchewan since the summer of 2006. The development of this biomonitoring tool mirrors that of Environment Canada's Canadian Aquatic Biomonitoring Network (CABIN) Program. Both the CABIN program and the Saskatchewan Watershed Authority's biomonitoring tool model the relationship between environmental variables and biological communities at least-impacted reference sites (Reynoldson et al. 2003). The CABIN program has not yet been applied to the Northern Great Plains regions and results presented here are a product of the first phase of developing a biotic condition tool for agricultural regions in Saskatchewan. Information provided by this tool will enable watershed managers to assess watershed health, target the highest priority stressors, reduce their impact, and monitor effectiveness by tracking recovery of the ecosystem. The community structure of benthic macroinvertebrates in least-impacted sites can be predicted using simple physical characteristics of a waterbody. Site-specific biological objectives can then be set for sites based on their habitat characteristics, providing an appropriate reference for identifying when degradation is occurring because of human influence.

Although a strong foundation for assessing the biotic integrity of riverine systems in southern Saskatchewan has been constructed, more research is needed to refine this tool. Future development of the biomonitoring tool, including the geographic scale, resolution, and ability to forensically identify particular stressors, needs to be improved as follows:

- include information gathered in 2008, 2009 and subsequent years;
- collect samples representative of all watersheds in southern Saskatchewan;
- increase the compliment of reference sites;
- evaluate and articulate the predictive capacity for particular stressors;
- develop new measures of the benthic invertebrate fauna for stressor-specific identification;
- re-sample sites of concern to identify changes through time; and
- publish findings in peer-reviewed forum.

Additional benthic macroinvertebrate collection to compliment other Saskatchewan Watershed Authority monitoring and assessment activities are as follows:

- Paired Watersheds Project – Pipestone Watershed – comparisons of pasture vs. crop impacts on water quality and aquatic ecosystem health, 2007 – present.
- Smith Creek Project – Smith Creek Watershed – in conjunction with the University of Saskatchewan, a project to evaluate the impact of ditching on aquatic ecosystem health, 2008 - present.
- Lake Sturgeon Habitat Requirement Assessment – North, South, and mainstem Saskatchewan Rivers – assessment of forage (benthic macroinvertebrate) resources and most valuable habitat for the lake sturgeon, a species at risk, 2007 – present.
- Fishing Lake Emergency Measures - Fishing Lake downstream to Whitesand Creek – assessment of emergency measures (e.g., berm construction) impacts on forage fish habitat and ecosystem services, 2007 – present.
- Ministry of Agriculture Water Quality Monitoring – across Saskatchewan – ongoing collaboration with the Saskatchewan Ministry of Agriculture to monitor ecosystem health at 17 stations across southern Saskatchewan, 2008 – present.
- Qu'Appelle Suspended Sediment Study – Qu'Appelle River Watersheds – collaboration with the Prairie Adaptation Research Collaborative (PARC) to research the effect suspended sediment associated with erosion has on the benthic macroinvertebrate assemblage, interactions with nutrients and estimated flow conditions under climate change forecasts, 2007 – present.

Riparian Areas Indicator

This indicator was developed to assess both the health and width of riparian areas within watersheds in Saskatchewan.

Indicator	
Lotic Riparian Health	**Status:** Data is currently available for 1,288 lotic health assessments which were conducted between 1996 and 2008 in 19 watersheds in Saskatchewan. **Trend:** Trends in riparian health over time cannot be currently assessed, as the site selection process is not always random for riparian assessments (See Data Quality/Caveats section), and seldom is the same location sampled repeatedly over time to allow comparisons to be made.
Lentic Riparian Health	**Status:** Data is currently available for 2,016 lentic health assessments which were conducted between 1996 and 2008 in 18 watersheds in Saskatchewan. **Trend:** Trends in riparian health over time cannot be currently assessed, as the site selection process is not always random for riparian assessments (See Data Quality/Caveats section), and seldom is the same location sampled repeatedly over time to allow comparisons to be made.
Riparian Buffer	**Status:** On average, watersheds in southern Saskatchewan continue to have a stressed health rating. **Trend:** Percent riparian buffer has remained relatively constant between 1993/1994 and 2001.

The issue
Riparian buffers, which are strips of permanent vegetation adjacent to a waterbody, are a widely recommended land management technique to protect source water. These areas represent the interface between terrestrial and aquatic ecosystems. This includes terrestrial areas located adjacent to surface water that are influenced by flooding or elevated water tables. Riparian areas can play an important role in movement of terrestrially-derived materials (e.g. sediment, nutrients) to surface water.

Healthy riparian areas can perform many functions, including: improving water quality through the filtration of nutrients and contaminants in runoff; reducing erosion by dissipating stream and wave energy associated with high water levels; trapping sediment and capturing streambed load; stabilizing streambanks and shorelines; ground water recharge; and enhancing aquatic and terrestrial habitat (Hansen et al. 2000).

To assess how well riparian zones can perform these various functions Hansen et al. (2000) developed riparian health assessment protocols for land adjacent to lotic (flowing water) and lentic (still water) waterbodies. These health assessments evaluate the status of vegetation, soil and hydrology in relation to their functional abilities. Current management activities and ecological factors within the riparian area are also considered. The biotic and abiotic information are weighted, combined, and rated to produce an overall assessment of riparian health. This assessment method has been widely adopted in the mid-western United States and in western Canada.

The effectiveness of riparian buffers in protecting water quality depends on many factors, including vegetation type, vegetation width, soil type, slope, and adjacent land uses. The majority of factors influencing the effectiveness of riparian buffers are site-specific and usually cannot be quickly assessed. Most scientific research and management recommendations focus on buffer widths to assess the effectiveness of a buffer for protecting water quality.

Riparian Areas Indicator in Saskatchewan

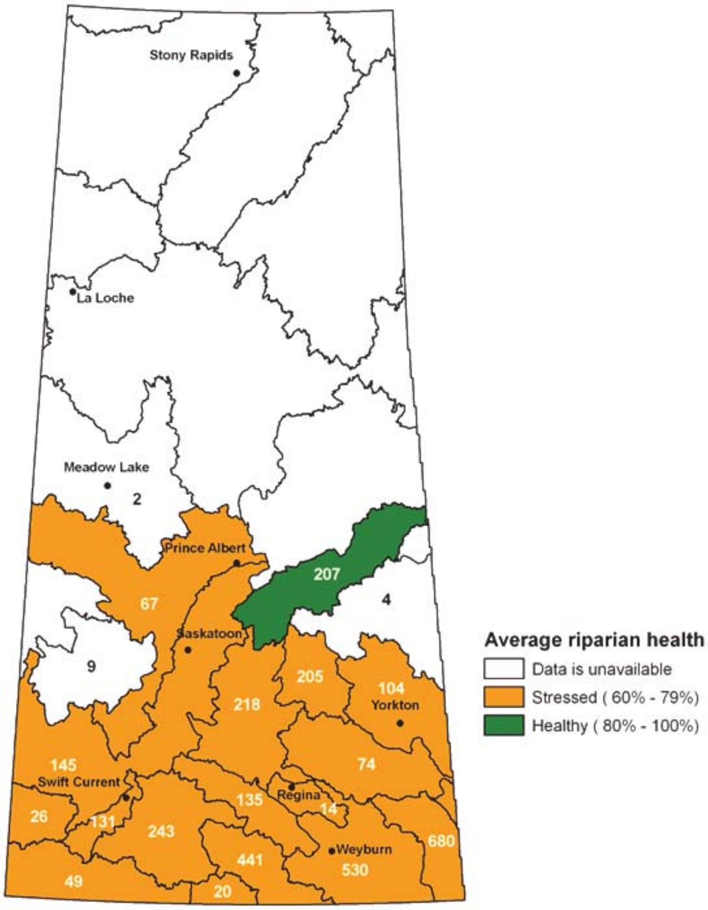

Figure 35. Average lotic and lentic riparian assessment scores by watershed: 1996-2008.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average lotic and lentic riparian health assessment scores. Scores were averaged across both lentic and lotic assessments. The riparian health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Lotic and lentic riparian assessments conducted between 1996 and 2008 are available for 3,304 riparian sites within 20 watersheds. Based on the average percent health value for riparian assessments within each of these 20 watersheds, the Carrot River Watershed is classified as healthy, 16 watersheds are classified as stressed, and three watersheds do not have an average score as fewer than 10 assessments were conducted during that period.

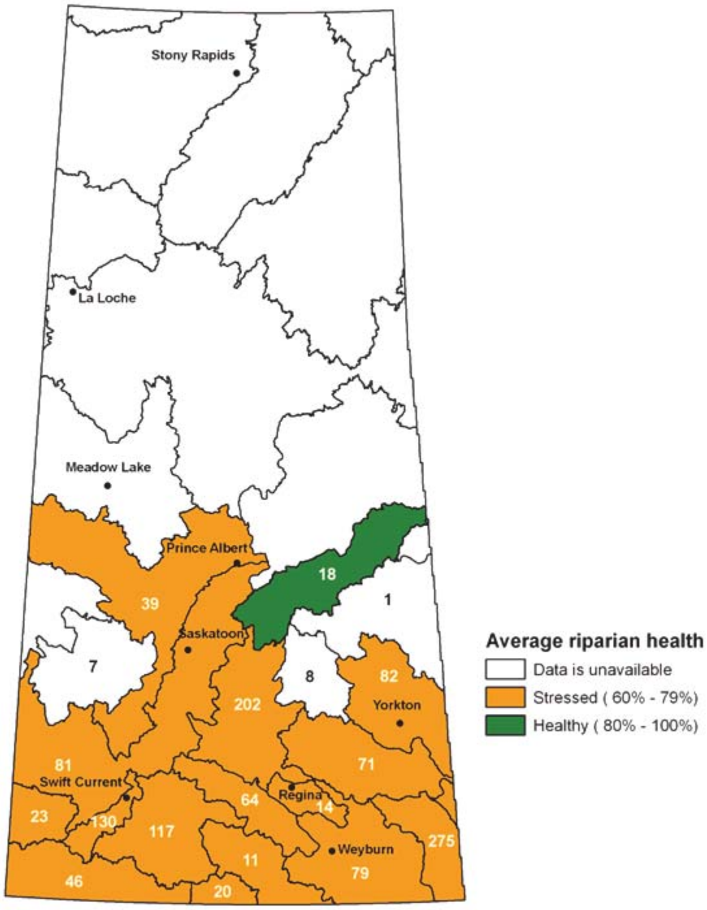

Figure 36. Average lotic riparian assessment scores by watershed: 1996-2008.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average lotic riparian health assessment scores. The riparian health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Data for riparian assessments conducted on lotic systems (flowing waterways, e.g. rivers or streams) between 1996 and 2008 are available for 1,288 sites, within 19 of the 29 watersheds in Saskatchewan. Based on the average riparian health for these 19 watersheds, the Carrot River Watershed is classified as healthy, 15 watersheds are classified as stressed, and three watersheds do not have an average score as fewer than 10 assessments were conducted within that period.

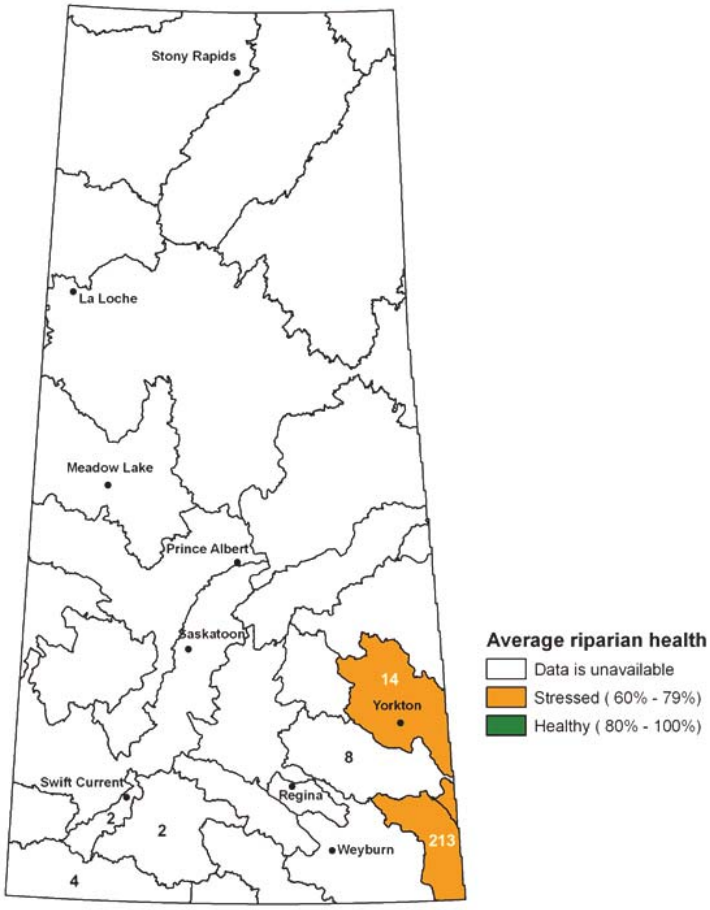

Figure 37. Average lotic riparian assessment scores by watershed: 2006-2008.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average lotic riparian health assessment scores. The riparian health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Lotic riparian assessments conducted between 2006 and 2008 are available for 243 sites within six watersheds. Four of the six watersheds do not have an average lotic health score, as fewer than 10 assessments were conducted within that period. The Lower Souris River and Assiniboine River Watersheds, meanwhile, are both classified as stressed.

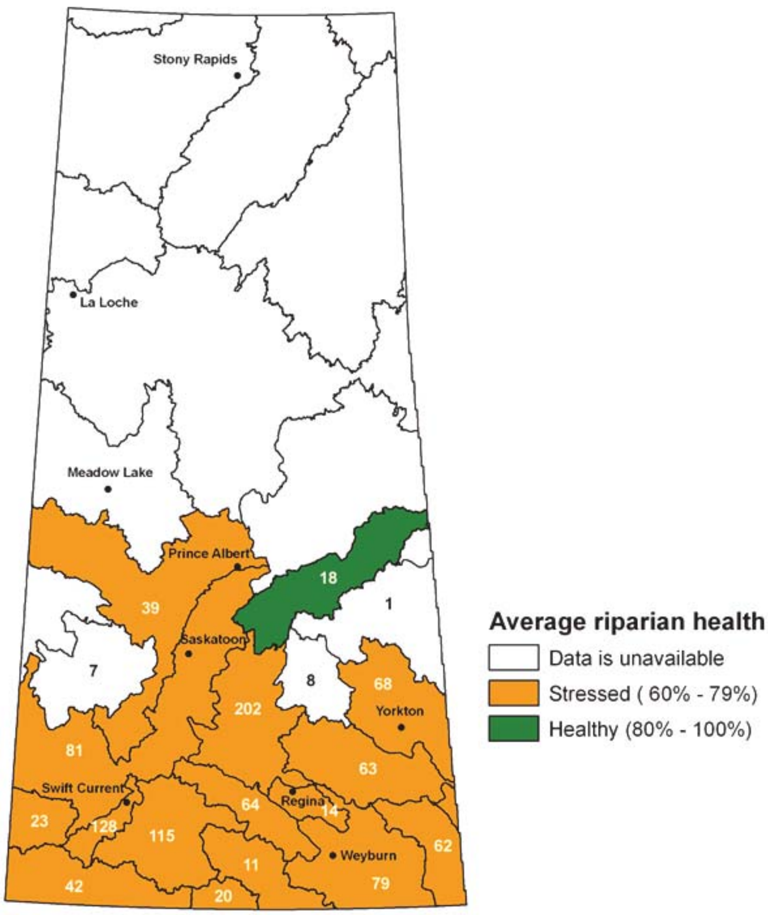

Figure 38. Average lotic riparian assessment scores by watershed: 1996-2005.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average lotic riparian health assessment scores. The riparian health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Lotic riparian assessments conducted between 1996 and 2005 are available for 1,045 sites within 19 watersheds. Based on average riparian health, the Carrot River Watershed is classified as healthy, fifteen watersheds are classified as stressed, and three watersheds are not classified as fewer than 10 assessments were conducted within that period.

Differences between Figure 38 (1996-2005) and Figure 37 (2006-2008), include:

- within the 10 years between 1996 and 2005, 1,045 lotic health assessments were conducted, compared to 243 lotic assessments that were conducted in the three years between 2006 and 2008;
- lotic health assessments were conducted in more watershed between 1996 and 2005 (Figure 38) than between 2006 and 2008 (Figure 37); and
- as of 2008, a revised lotic riparian health assessment method, specific to Saskatchewan, was implemented.

Trends in riparian health over time cannot currently be assessed, as the site selection process is not always random for riparian assessments (see the **Data Quality/Caveats** section on page 45), and seldom is the same location sampled repeatedly over time to allow comparisons to be made.

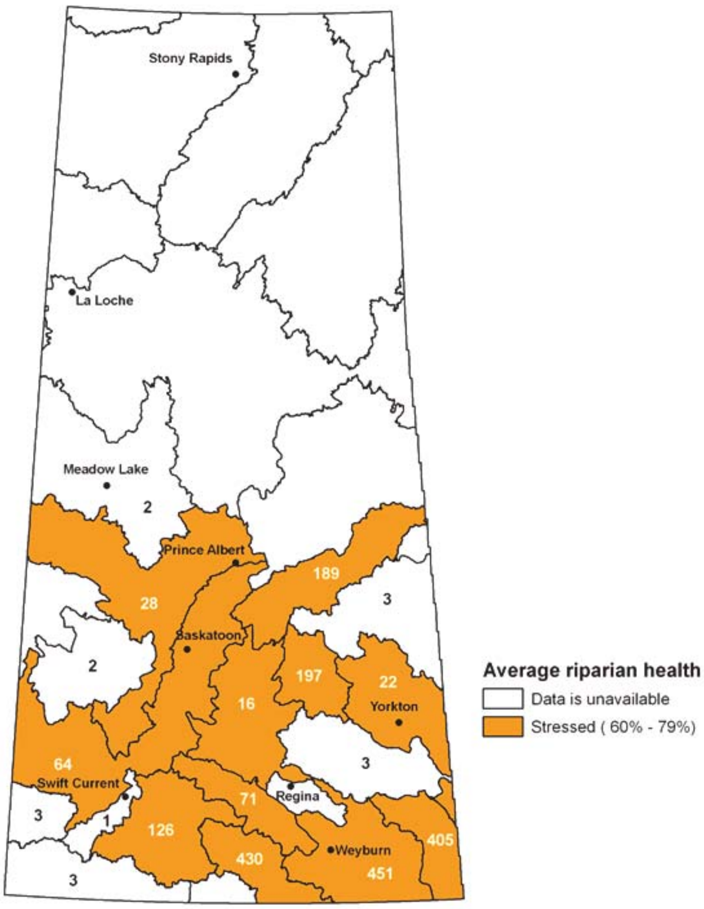

Figure 39. Average lentic riparian assessment scores by watershed: 1996-2008.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average lentic riparian health assessment scores. The riparian health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Data are currently available for 2,016 riparian health assessments conducted on lentic systems (still water, e.g. lakes or wetlands) between 2006 and 2008 in 18 of the 29 watersheds in Saskatchewan. Of these 18 watersheds, seven do not have an average health score as fewer than 10 assessments were conducted during that period, while eleven are rated as stressed.

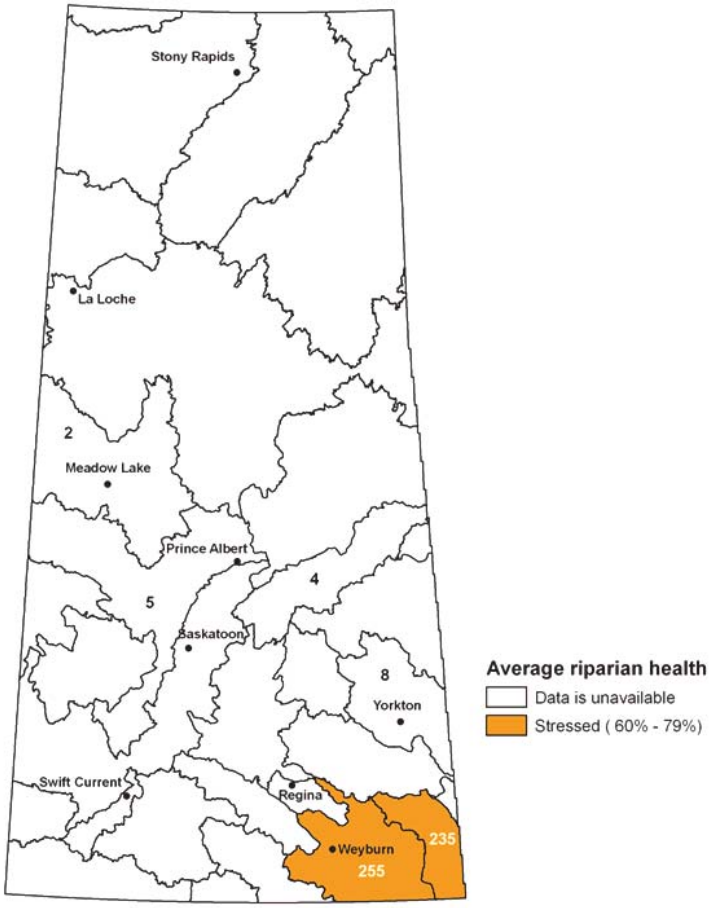

Figure 40. Average lentic riparian assessment scores by watershed: 2006-2008.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average lentic riparian health assessment scores. The riparian health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Data are currently available for 509 riparian health assessments conducted on lentic systems between 2006 and 2008 within six watersheds. The majority of the 509 assessments conducted were from the Moose Mountain Provincial Park and White Bear First Nations. The Upper and Lower Souris River Watersheds have an average lentic health score of stressed. The other four watersheds do not have an average lentic health score, as fewer than 10 assessments were conducted within their boundaries during this timeframe.

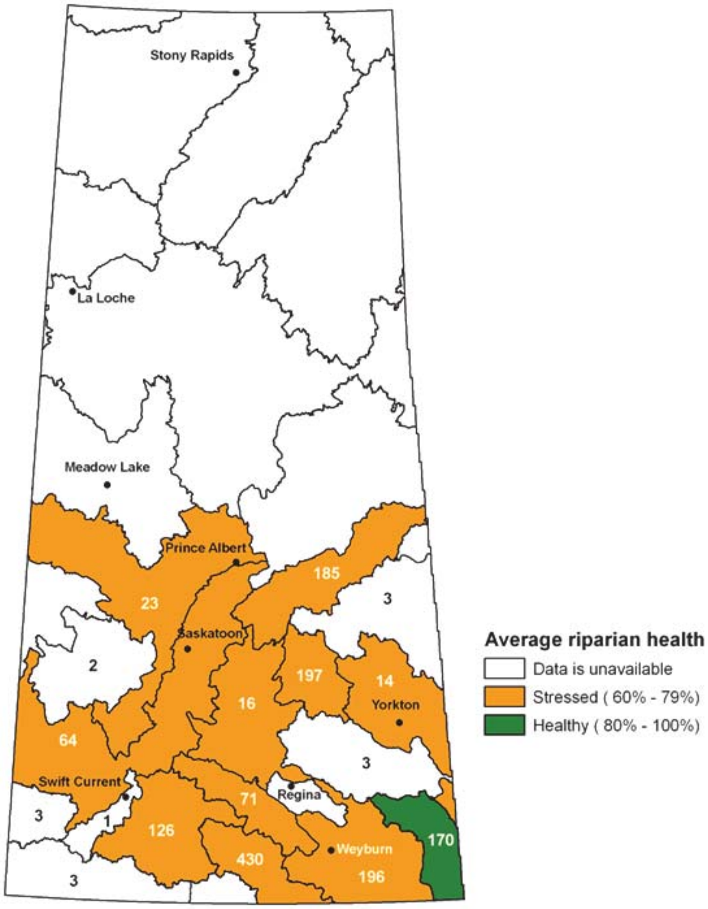

Figure 41. Average lentic riparian assessment scores by watershed: 1996-2005.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average lentic riparian health assessment scores. The riparian health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Lentic health assessment data is currently available for 1,507 assessments conducted between 1996 and 2005 within 17 watersheds. Of the 17 watersheds, six do not have an average health score, as fewer than 10 assessments were conducted within each of these watersheds during that time period. Meanwhile, ten of the watersheds have an average health score of stressed, and the Lower Souris River Watershed has an average health score of healthy.

Differences between Figure 41 (1996-2005) and Figure 40 (2006-2008), include:

- within the 10 years between 1996 and 2005, 1,507 lentic health assessments were conducted, compared to 509 assessments that were conducted in the three years between 2006 and 2008.
- lentic health assessments were conducted in more watersheds between 1996 and 2005 (Figure 41) than between 2006 and 2008 (Figure 40).

Trends in riparian health over time cannot currently be assessed, as the site selection process is not always random for riparian assessments (see the **Data Quality/Caveats** section on page 45), and seldom is the same location sampled repeatedly over time to assess change.

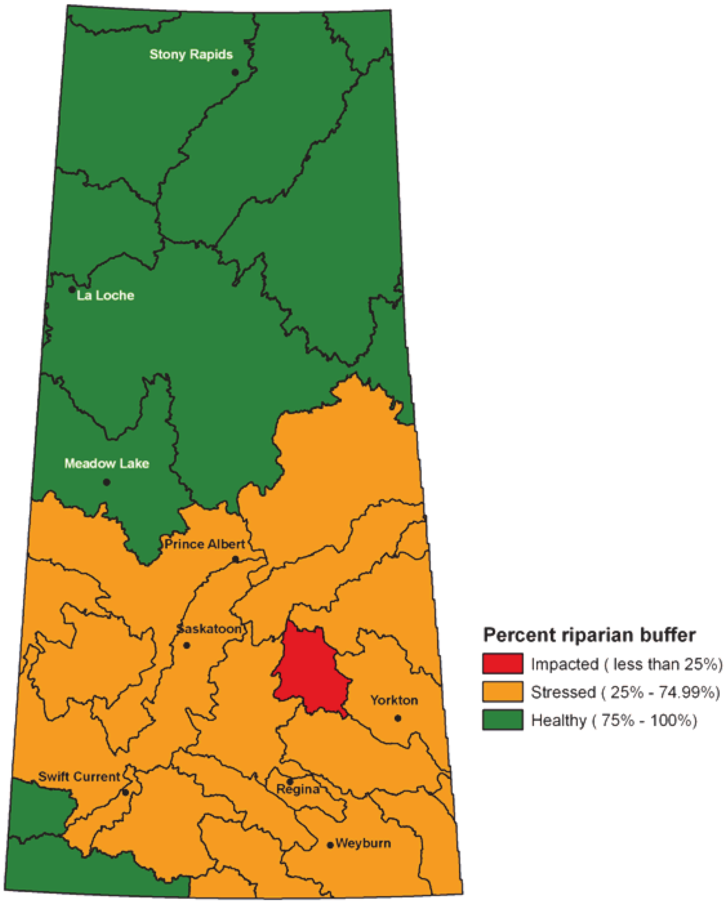

Figure 42. Percent of permanent cover within a 40 metre buffer of a waterway or waterbody: 2001.

The percent riparian buffer width for the majority of Saskatchewan's southern watersheds falls into the stressed category, with the exception of the Cypress Hills North Slope and Milk River Watersheds, both of which are rated as healthy. The Quill Lakes Watershed, at 18% permanent cover within the riparian buffer, had the least amount of riparian buffer. The Kasba Lake and Beaver River Watersheds had the highest percent permanent cover within the riparian buffer, at 87%.

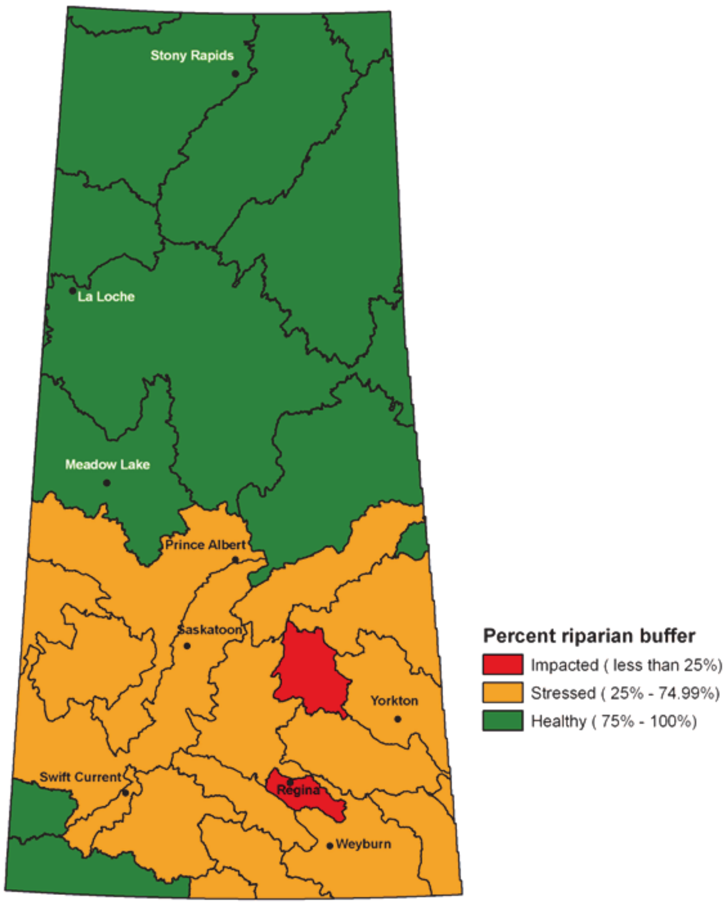

Figure 43. Percent of permanent cover within a 40 metre buffer of a waterway or waterbody: 1993-1994.

Using landcover data from 1993-1994, eleven watersheds are classified as healthy, 16 watersheds are classified as stressed, and two watersheds are rated as impacted. The two impacted watersheds are the Quill Lakes and Wascana Creek Watersheds.

The differences between Figure 43 (1993-1994) and Figure 42 (2001) include:
- the health of the Saskatchewan River Watershed changed from healthy to impacted; and
- the percent of permanent cover within the riparian buffer in the Wascana Creek Watershed increased, improving its watershed health rating from impacted to stressed.

Buffer width is the sole criterion used to measure Percent Riparian Buffer (i.e. soil type, slope, and vegetation type were not included in the calculation). It is possible that a riparian area with a Percent Riparian Buffer rating of excellent may have a riparian health assessment rating of unhealthy. Therefore, it is important that this indicator be validated with the Riparian Health indicator. Castelle et al. (1994) identify four criteria for determining appropriate buffer widths: 1) resource value; 2) intensity of adjacent land use; 3) buffer characteristics; and 4) specific buffer functions. Typically, a narrower buffer area may be adequate to protect a waterbody when the riparian area is healthy and the adjacent land use has a low impact potential (i.e. parkland, low density residential, shallow slopes, or non-erosive soils). Larger buffer areas may be required for high value resources where the riparian area is unhealthy, where soils are less permeable or highly erodible, where slopes are steep, or where the adjacent land use is intense (e.g. intensive agriculture).

Indicator		
Riparian Health	=	Measures vegetation, soil and hydrology to assess the functional ability, management and ecological considerations of the riparian area. The biotic and abiotic information are weighted, combined, and rated to produce an overall assessment of riparian health.
Percent Riparian Buffer	=	$\frac{\text{Area of permanent cover within a 40 m buffer of a waterway or waterbody (m}^2\text{)}}{\text{Total area of buffer (m}^2\text{)}}$

Rating Scheme
The lotic and lentic riparian health assessment ratings range from 0% to 100%, with 0% representing an impacted riparian area and 100% representing a healthy riparian area in proper functioning condition (Hansen et al. 2000).

The Percent Riparian Buffer ranges from 0% to 100%, with a value of 0% representing a riparian area that has been cleared of all vegetation within 40 metres of the waterway and 100% representing a riparian area that has permanent vegetative cover throughout the 40 metre buffer. The rating system is based on studies and literature reviews conducted by Osborne and Kovacic 1993, Castelle et al. 1994, Dosskey 2001, and Broadmeadow and Nisbet 2004.

Riparian Health
Healthy: (Proper functioning condition) (80-100%): The riparian area performs all of its functions and is considered to be stable.
Stressed: (Function at risk) (60-79%): The riparian area performs many functions, but signs of degradation are visible.
Impacted: (Non-functional) (Less than 60%): The riparian area has lost most of its ability to perform its functions and is now considered to be degraded.

Riparian Buffer
Healthy: (30 m and over): (PRB value 75 – 100%): A buffer width within this range maintains the physical, chemical and ecological components of many wetlands and streams, and has consistently high percent reduction of nutrients, sediment and pesticides.
Stressed: (Between 10-29 m): (PRB value 25 – 74.9%): A buffer width within this range has consistently high percent reduction of nutrients, sediment and pesticides, but it is not sufficiently wide to protect the ecological integrity of the waterbody.
Impacted: (Less than 10 m): (PRB value 0 – 24.9%): A buffer width within this range is considered unstable and unsustainable. It is unable to provide adequate shade and moderate stream temperatures, and it is highly variable in percent reduction of Nitrate, Total Nitrogen, Phosphate, Total Phosphorus, sediment, and pesticides.

Data Source: Lotic and lentic riparian health data is a compilation of data collected between 1996 and 2008 by the Saskatchewan Watershed Authority and partners. To collect this data 1,277 short-form lotic health assessments and 2,016 short-form lentic health assessments were conducted. A short-form riparian health assessment provides a rapid snapshot of the health of a riparian area. Long-form riparian health inventories have been conducted in the Upper Qu'Appelle River, Quill Lakes, and Upper and Lower Souris River Watersheds; and riparian habitat type classification has been done on 312 stands throughout Saskatchewan (Thompson and Hansen 2001). A riparian health inventory is a comprehensive ecological study of a particular site. The inventory documents detailed information about the plant community, soil and hydrology of the site.

For the riparian buffer, the Saskatchewan Stream Network was used to calculate the 40 metre buffer of the streamcourse. The Southern Digital Land Cover and Northern Digital Land Cover classification were used to determine the area of permanent cover within the 40 metre buffer for 1993-1994. The AAFC_30m_2000 raster file was used to determine the area of permanent cover within the 40 metre buffer for 2001 for watersheds south of the Churchill River Watershed. The Northern Digital Land Cover classification was used to determine the area of permanent cover within the 40 metre buffer for 2001 for the watersheds north of and including the Churchill River Watershed. The Southern Digital Land Cover classification was derived from 1993-1994 LANDSAT-TM imagery and the Northern Digital Land Cover classification was derived from 2000 LANDSAT-TM imagery at 30 metre resolution. The AAFC_30m_2000 raster file was created by Agriculture and Agri-Food Canada through the National Land and Water Information Service (NLWIS). The AAFC_30m_2000 raster file land cover classes were derived from Landsat 5 TM and/or 7 ETM+ multispectral imagery from circa 2000 (Agriculture and Agri-Food Canada 2008).

Data Handling: The percent permanent cover within the riparian buffer was measured by drawing a 40 metre buffer on either side of the streamcourse in the Saskatchewan Stream Network. The forage, grassland, shrub, and tree classes from the Land Cover data were lumped together into a class called permanent cover.

Data Quality/Caveats: The site selection process for the riparian health assessments is not always random. Assessments are conducted for a number of reasons, including a specific study in the area, a request for an assessment by the land manager, and to establish baselines for projects. Significant effort is required to determine riparian health and stream stability baselines and trends, as each riparian assessment requires one to two hours per site to complete. Current riparian assessments do not address forestry impacts and issues. Between 1996 and 2007, riparian health in Saskatchewan was assessed using the methods originally developed in the 1980's by Dr. Paul Hansen and William Thompson, and workbooks produced by Alberta's Cows and Fish Program (Ambrose et al. 2004 and Fitch et al. 2001). Since 2008, lotic riparian areas in Saskatchewan have been assessed following the methods outlined in the *Riparian Health Assessment: Streams and small rivers field workbook* (Prairie Conservation Action Plan 2008a), which was developed for Saskatchewan.

To reduce the inaccuracies in riparian buffer placement around lakes caused by the Saskatchewan Stream Network, the lake paths were removed from the stream network so as to no longer include large amounts of water within the buffer. Please note that forest operations, monitored by the Saskatchewan Ministry of Environment, have a set of riparian width standards used in the crown provincial forest. These buffer widths vary between 15m, 30m and 90m, depending on the sensitivity of the riparian area adjacent to the forest management activities. The more sensitive the riparian area the wider the buffer. These forest management riparian buffers are standards and guidelines for the crown forest. Within this document a coarse buffer width of 40m that could be applied across the entire province was used for both forested and non-forested areas.

Response to the issue

Sediment deposition caused by the removal of riparian vegetation can impact surface water quality and aquatic habitat. Surface water quality is protected under the Interim Surface Water Quality Objectives (Saskatchewan Environment 2006a). The *Fisheries Act* protects fish habitat from the deposition of deleterious substances, such as sediment. *The Environmental Management and Protection Act, 2002*, administered by the Saskatchewan Ministry of Environment, controls activities and the disposal of deleterious substances that are harmful to air, land and water resources.

Riparian areas within provincial crown forested areas are managed to Forest Management Agreement Area standards and guidelines or to Area Based Term Supply standards and guidelines, where specific conditions apply within riparian management areas.

The Prairie Conservation Action Plan (PCAP) has been actively involved in native prairie and Species at Risk (SAR) conservation in Saskatchewan. The PCAP is the only forum in Saskatchewan that brings together 28 partners representing producers, industry, provincial & federal governments, non-government organizations and research/educational institutes working towards a common vision of native prairie and Species at Risk conservation in Saskatchewan. The PCAP reduces redundancy, fills in gaps in native prairie research/activities, develops and implements actions to address conservation and sustainable management of native prairie, increases communication and sharing amongst partners and improves public understanding of native prairie and Species at Risk.

Some of the activities that the PCAP has been involved in include:

- Producing the *Riparian Health Assessment: Streams and small rivers field workbook* for Saskatchewan (Prairie Conservation Action Plan 2008a); and
- In January 2009, representatives from the PCAP's "A Working Prairie" working group initiated the Saskatchewan Range and Riparian Health Assessment Framework. The overall goal of the Framework is to increase the consistency of data collection for range and riparian health assessments. The objectives of the initiative are to:
  - develop consistent protocols for data collection
  - develop consistent data entry protocols (species names, ecological site names, etc.)
  - develop a consistent database structure.

Standardized data collection protocols and storage will increase the efficiency of data analysis and sharing. This will ensure 1) that agencies that monitor range health and riparian health in Saskatchewan get maximum use of collected data, 2) that no data is lost, and 3) that range and riparian health is monitored effectively throughout the province.

Some of the agricultural Beneficial Management Practices that can improve the health of riparian areas and reduce soil erosion along riparian areas, as promoted by the Environmental Farm Plan in the Guide to the Canada-Saskatchewan Farm Stewardship Program (CSFSP), include:

- riparian area management;
- erosion control structures (riparian); and
- land management for soils at risk.

The Prairie Stewardship Program, a partnership program coordinated by the Saskatchewan Watershed Authority, encourages stewards, through voluntary agreements, to maintain and protect their riparian areas to the best of their ability.

The Saskatchewan Soil Conservation Association has developed soil factsheets related to riparian areas, entitled "*Economical Alternatives to Cropping Adjacent to Riparian Areas*" This fact sheet can be found on the Saskatchewan Soil Conservation Association's website at: http://www.ssca.ca/agronomics/index.html.

A number of reports have been written on various riparian health assessment projects in the province. These projects include:

- In the summers of 2003 and 2004, the Saskatchewan Watershed Authority performed lotic riparian health assessments on the Qu'Appelle River and its major tributaries and creeks between Diefenbaker Lake and Buffalo Pound Lake (Saskatchewan Watershed Authority 2006).
- In the summer of 2006, the Moose Jaw River Watershed Stewards Inc., conducted 90 riparian health assessments in the Moose Jaw River sub-watershed (Moose Jaw River Watershed Stewards Inc. 2006).
- Between 2005 and 2006, short form and long form riparian health assessments were conducted on over 500 wetlands to help develop a Range Management Plan for Moose Mountain Provincial Park (Soulodre 2009).
- a total of 79 lotic and 118 lentic riparian assessments were conducted in the Lower Souris River Watershed in 2008 as part of the Lower Souris Watershed Ecological Goods and Services Project (Soulodre 2008).
- Ninety-eight riparian health assessments have also been conducted along the Wood River, in over six rural municipalities. The average riparian health score for the Wood River, based on these assessments, was 77% (Bradshaw and McIver 2001).

Rangeland Health Indicator

The rangeland health indicator reports on the health of native and tame rangelands, or the uplands, within a watershed. It summarizes rangeland health assessments and rangeland condition assessments that have been conducted in Saskatchewan. Rangelands consist of indigenous and/or introduced vegetation that is either grazed or has the potential to be grazed.

Indicator	
Native Rangeland Health	**Status:** Data is currently available for 2,086 native range condition and native range health assessments which were conducted between 2002 and 2008 in 17 of Saskatchewan's 29 watersheds. **Trend:** Trends in native range health over time cannot currently be assessed, as the site selection process is not always random for range assessments (see the **Data Quality/Caveats** section on page 57), and seldom is the same location sampled repeatedly over time to assess change.
Tame Rangeland Health	**Status:** Data is currently available for 426 tame range health assessments which were conducted between 2002 and 2008 in nine watersheds in Saskatchewan. **Trend:** Trends in tame range health over time cannot currently be assessed, as the site selection process is not always random for range assessments (see the **Data Quality/Caveats** section on page 57), and seldom is the same location sampled repeatedly over time to assess change.

The issue
Healthy rangelands maintain a diversity of plant species, including grasses, herbs, shrubs and trees, through the efficient cycling of nutrients and the capture and slow release of water. They also function to improve water quality by reducing sediment deposition and soil erosion (Adams et al. 2005).

Traditionally, rangelands have been evaluated using the Range Condition Method. This method compares the resemblance of the observed plant species composition to that of an ecologically desirable species composition. In the last few years, range health methods that measure ecosystem function have been widely adopted across North America (Pellant et al. 2000). Range health assessments evaluate tame (introduced) and native (indigenous) pastures using select indicators and a scoring system. Range health assessment indicators focus on:

- species composition;
- community structure;
- invasive species;
- site stability; and
- hydrologic function and soil protection (Prairie Conservation Action Plan 2008b).

Rangeland Health Indicator in Saskatchewan

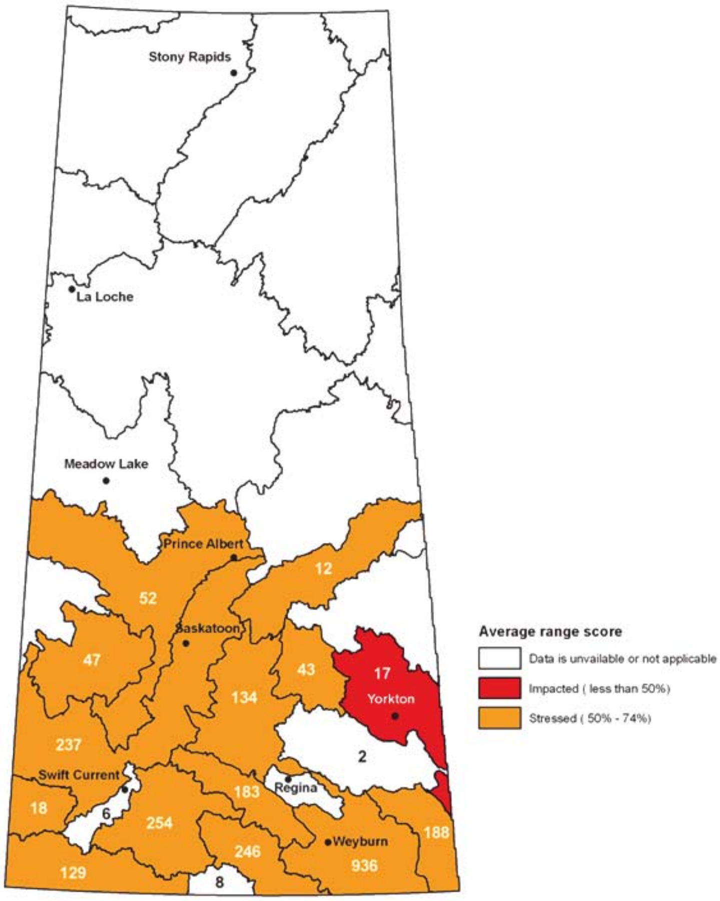

Figure 44. Average native range condition and native and tame health scores by watershed: 2002-2008.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average rangeland health assessment scores. The rangeland health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Currently, data are available for 2,512 tame and native range assessments that were conducted between 2002 and 2008 within 14 watersheds. The average health score for the rangelands assessed are categorized as impacted for the Assiniboine River Watershed and stressed for the remaining 13 watersheds. An average health score for the Lower Qu'Appelle River, Poplar River and Swift Current Creek Watersheds cannot be calculated, as fewer than 10 rangeland assessments were conducted in each of these watersheds within that period.

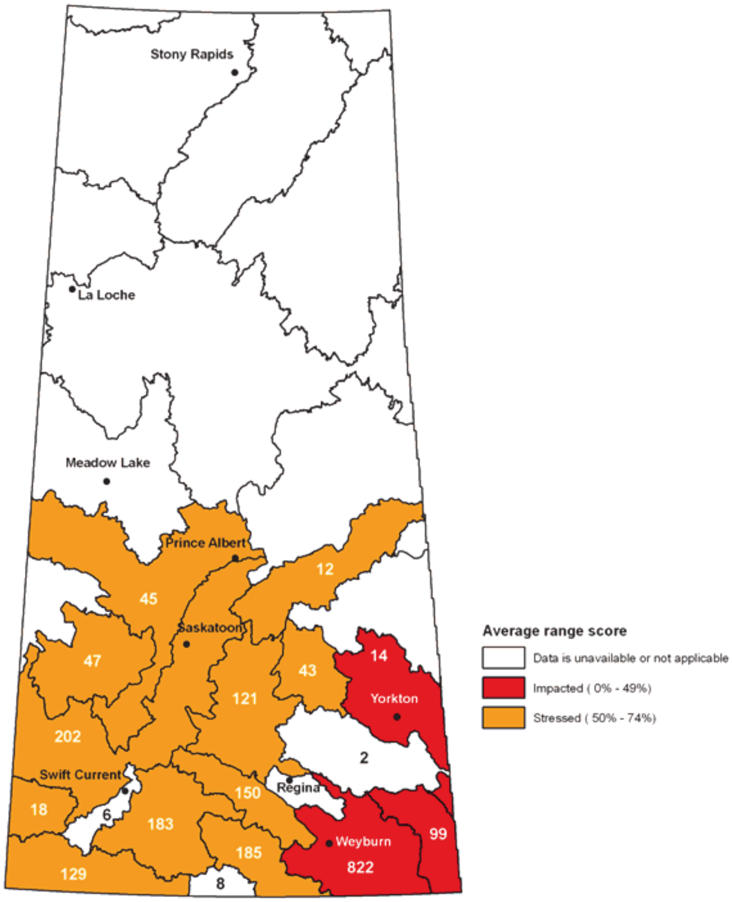

Figure 45. Average native range condition and health scores by watershed: 2002-2008.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average range assessment scores. The range scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Results from the native range condition and native health assessments conducted between 2002 and 2008 are available for 20 watersheds. The average health score for 14 of these 20 watersheds is classified as stressed, while three watersheds are classified as impacted. The average health score for the remaining three watersheds could not be calculated as data for fewer than 10 assessments in each of these watersheds is currently available. The three watersheds that are classified as impacted are the Assiniboine River, Lower Souris River and Upper Souris River Watersheds.

For the purposes of obtaining an average native range score for each assessed watershed, native range health assessment scores and native range condition scores were averaged. Caution needs to be exercised when interpreting the averages of condition and health scores, as the methods used to obtain range condition and range health scores are different. The method used to assess range condition is essentially a partial range health assessment, as it only looks at the soil type and plant species composition. In addition to the data collected for range condition assessments, range health assessments also include plant community structure, hydrologic function and nutrient cycling, site stability, and noxious weed information (Adams et al. 2005).

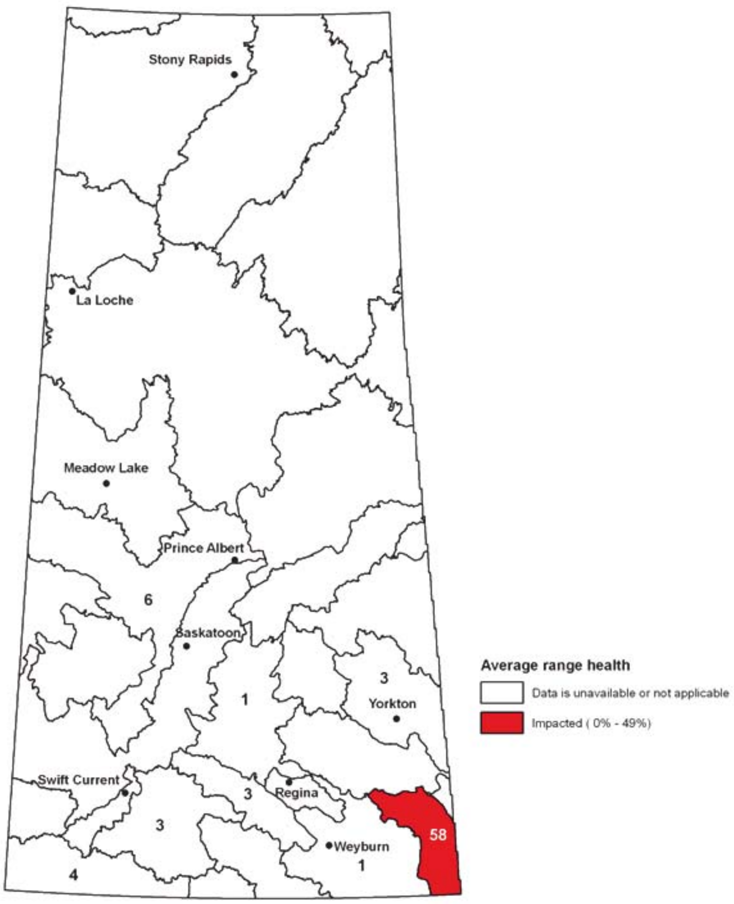

Figure 46. Average native range condition and health scores by watershed: 2006-2008.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average range assessment scores. The range scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Native range health assessments conducted between 2006 and 2008 are available for 79 sites within eight watersheds. The average range health is classified as impacted for the Lower Souris River Watershed. The average range health could not be calculated for the remaining seven watersheds, as fewer than 10 assessments were conducted during this time frame.

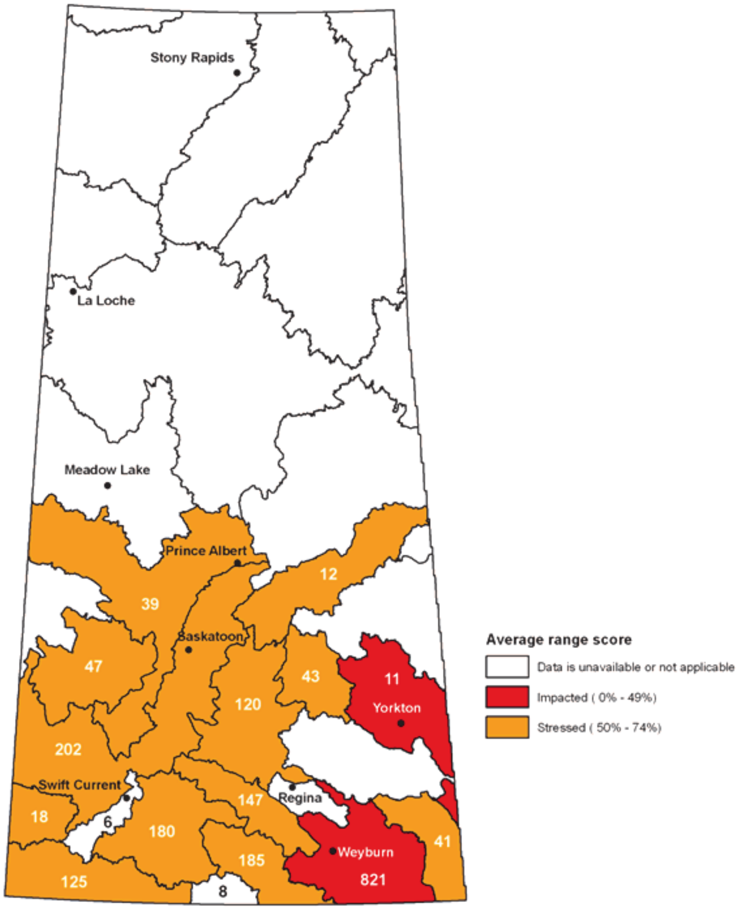

Figure 47. Average native range condition and health scores by watershed: 2002-2005.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average rangeland health assessment scores. The rangeland health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Data from native range condition and native health assessments conducted between 2002 and 2005 are available for 2,007 sites within 17 watersheds. Based on the average range score for these 17 watersheds, the Assiniboine River and Upper Souris River Watersheds are classified as impacted and 13 watersheds are classified as stressed. Fewer than 10 assessments were conducted in the Poplar River and Swift Current River Watersheds, and therefore they do not have an average range score.

The differences between the native range condition and assessments conducted between 2002-2005 (Figure 47) and 2006-2008 (Figure 46), include:

- 2,007 native range assessments were conducted between 2002 and 2005, compared to 79 native range assessments that were conducted between 2006 and 2008;
- native range assessments were conducted within 17 watersheds between 2002 and 2005, compared to only nine watersheds that had native range assessments conducted within them between 2006 and 2008; and

- a revised native range health assessment method, specific to Saskatchewan, was implemented in 2008 to calculate native range health.

It is difficult to discuss trends in range health over time, as the site selection process is not always random (see the **Data Quality/Caveats** section on page 57), and seldom is the same location sampled repeatedly over time to assess change.

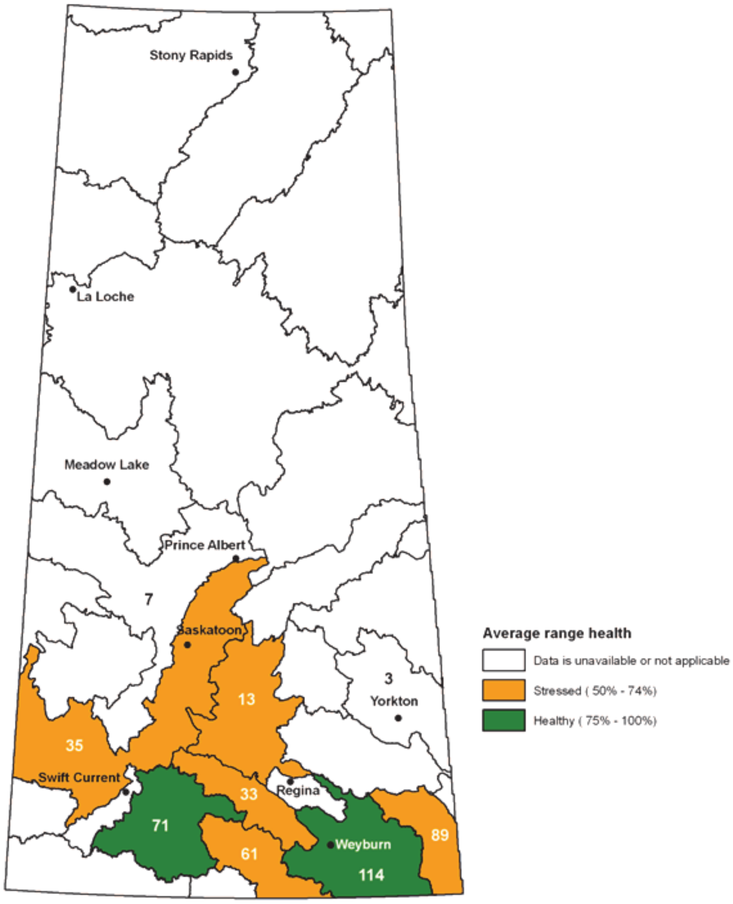

Figure 48. Average tame rangeland health assessment scores by watershed: 2002-2008.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average rangeland health assessment scores. The rangeland health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Data are currently available for 426 tame health assessments conducted between 2002 and 2008, in nine of the 29 watersheds in Saskatchewan. Of these nine watersheds, two do not have an average health score, five have an average health score of stressed, and the Old Wives Lake and Upper Souris River Watersheds have an average health score of healthy.

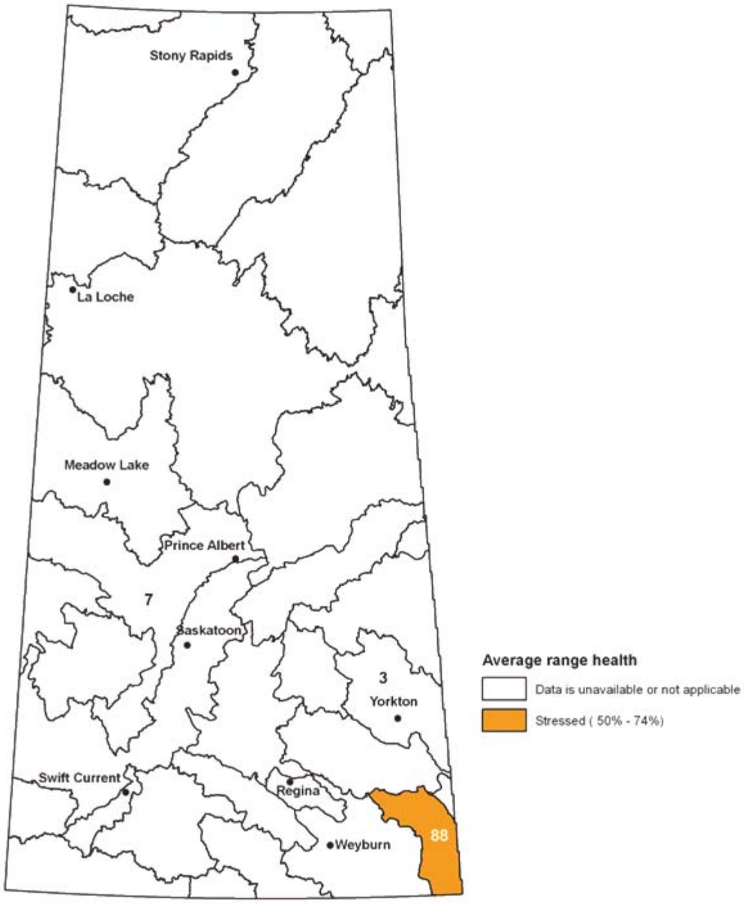

Figure 49. Average tame rangeland health assessment scores by watershed: 2006-2008.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average rangeland health assessment scores. The rangeland health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Currently, information is available from rangeland health assessments conducted between 2006 and 2008 in three watersheds in Saskatchewan. The tame rangeland in the Lower Souris River Watershed is categorized as stressed, while average health scores for the Assiniboine River and North Saskatchewan River Watersheds could not be calculated as fewer than 10 assessments conducted within them during this timeframe.

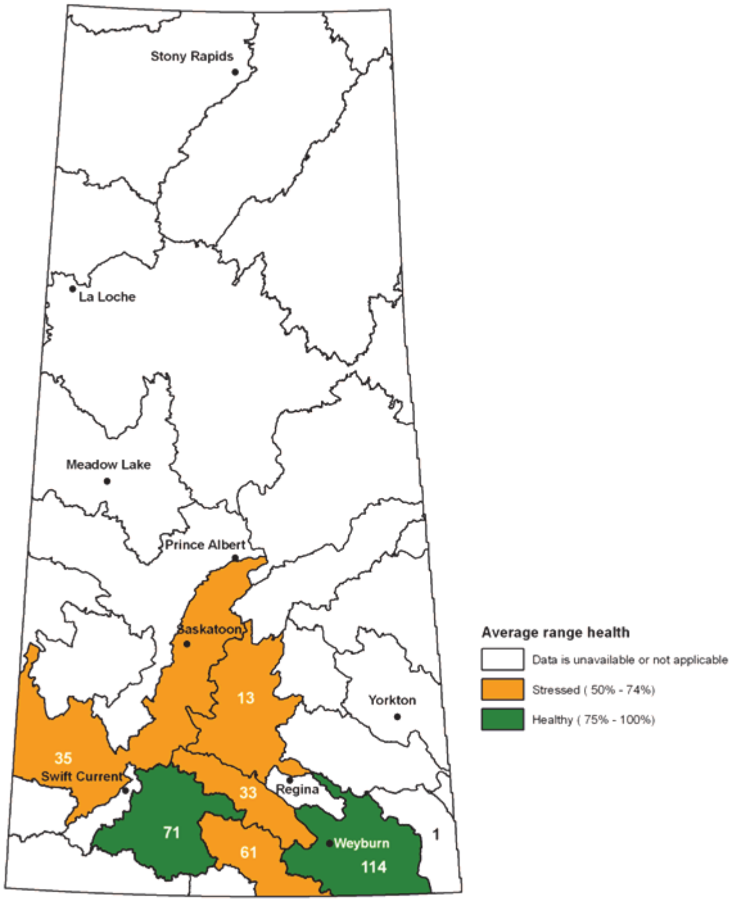

Figure 50. Average tame rangeland health assessment scores by watershed: 2002-2005.
Note: the numbers shown within the watersheds are the number of assessments used to calculate the average rangeland health assessment scores. The rangeland health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Data from tame range health assessments conducted between 2002 and 2005 are available for 328 sites within seven watersheds. The average range health score is classified as healthy for the Upper Souris River and Old Wives Lake Watersheds, and stressed for the Big Muddy Creek, Moose Jaw River, South Saskatchewan River, and Upper Qu'Appelle River Watersheds. The Lower Souris River Watershed has no average range health score as it has data for only one range assessment that was conducted during this timeframe.

Differences between tame rangeland health assessments conducted between 2002-2005 (Figure 50) and 2006-2008 (Figure 49) include:

- 328 tame range assessments were conducted between 2002 and 2005, compared to 98 tame range assessments that were conducted between 2006 and 2008; and
- tame range assessments were conducted within seven watersheds between 2002 and 2005, compared to only three watersheds that had tame range assessments conducted within them between 2006 and 2008.

It is difficult to discuss trends in range health over time, as the site selection process is not always random (see the **Data Quality/Caveats** section on page 57), and seldom is the same location sampled repeatedly over time to assess change.

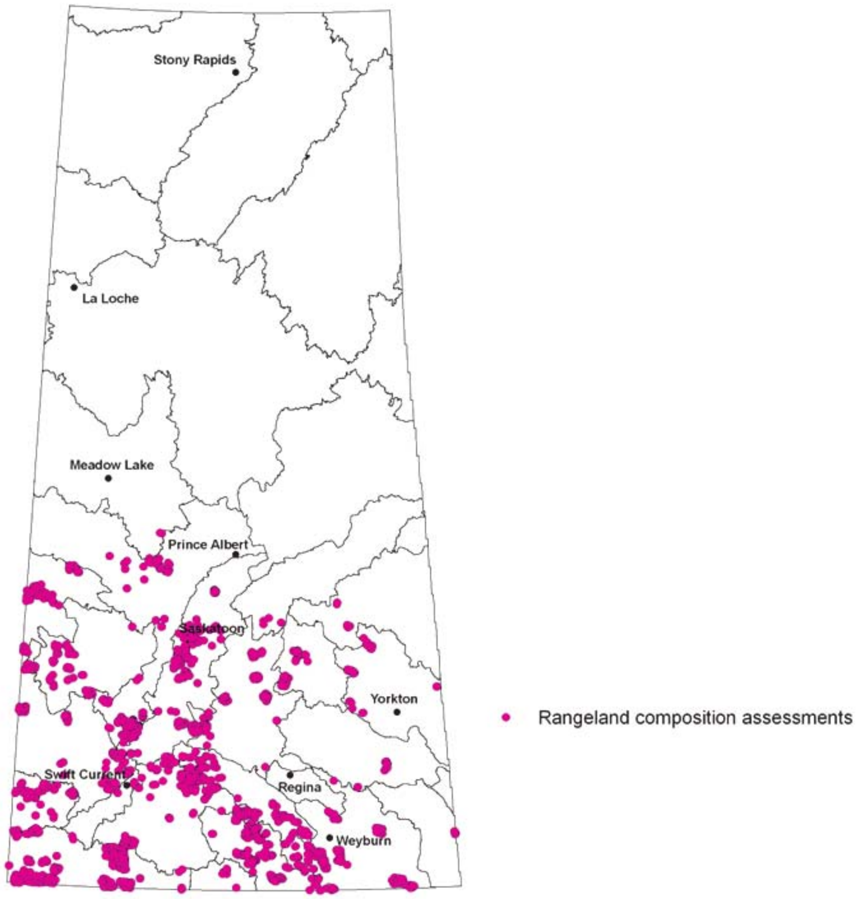

Figure 51. Location of rangeland composition assessments.
Source: Saskatchewan Research Council

Figure 51 summarizes the location of 3,916 rangeland condition assessment sites that have been conducted by a number of agencies. Range condition scores have not yet been calculated based on these assessments.

Rating Scheme
The rangeland health assessment ratings range from 0% to 100%, with less than 50% representing an impacted range and a score of 75% or more representing a healthy range (see Adams et al. 2005).

Rangeland Health
Healthy (A health score of 75 to 100%): All of the key functions of a healthy rangeland are being performed.
Stressed (A health score of 50 to 74%): Most, but not all, key functions of a healthy rangeland are being performed.
Impacted (A health score of less than 50%): Few of the functions of a healthy rangeland are being performed.

Data Source: The range scores summarized in Figure 44 are an average of 2,512 range assessments; 2,086 are native rangeland assessments and 426 are tame rangeland assessments. Figure 51 contains 3,916 sites that have been assessed for rangeland condition. These assessments were conducted by a number of agencies. Range condition scores have not yet been calculated for the assessments summarized in Figure 51.

Data Quality/Caveats: The site selection process for the rangeland health assessments is not always random. Assessments are conducted for a number of reasons, including: a specific study in the area, a request for an assessment by the land manager, and to establish baselines for projects. Most of the rangeland species compositional data available in the province are being compiled by the Saskatchewan Research Council into a single database. This information could be analyzed and used to assess range condition.

Data Discussion: For the last few years range health methods have been informally used to evaluate rangelands in Saskatchewan. The Saskatchewan Ministry of Agriculture's Lands Branch also has an in-house rangeland health assessment that they have been using for a few years.

Through the Prairie Conservation Action Plan (PCAP), nine different Saskatchewan agencies have been working together to adapt Alberta's range health assessment methods (Adams et al. 2005) for Saskatchewan. Once these methods are developed, many agencies within Saskatchewan will be using the same assessment methods (including the Saskatchewan Watershed Authority, Saskatchewan Ministry of Agriculture, Saskatchewan Ministry of Environment, the Nature Conservancy of Canada, Ducks Unlimited Canada, the Saskatchewan Research Council, the Saskatchewan Assessment Management Agency, Nature Saskatchewan, and Agriculture and Agri-Food Canada – Agri-Environmental Services Branch).

The basis of this range health analysis is the ecological site description/community classification (reference conditions). PCAP has obtained funding from the Technical Assistance Component of the Greencover Canada Program for the Saskatchewan Research Council to develop this site description. Several agencies have pooled data to assist the Saskatchewan Research Council in developing these ecological site descriptions. The pooled data that are being used to develop these ecological site descriptions will be compiled in a database with thousands of previously assessed sites ranging from the 1950's to present, allowing temporal changes to be observed. Most of the data will be species compositional data only and will not have the other variables needed to assess complete range health. This database will eventually be housed with the Saskatchewan Ministry of Environment. Figure 51 is a summary of this pooled data by location. Range condition scores have yet to be calculated for the assessments summarized.

Response to the issue
To promote rangeland health on Agriculture Crown lands in Saskatchewan, both the provincial and federal governments have established grazing programs:

- In 1922, the Saskatchewan Ministry of Agriculture initiated the Saskatchewan Pastures Program. This program promotes environmental and agricultural sustainability of marginal Crown lands through the incorporation of rangeland planning and forage management. The program provides grazing services for cattle, horses and sheep and a breeding service for cattle. The program consists of 54 pastures covering an area of 333,866 ha (825,000 ac) (Saskatchewan Ministry of Agriculture 2007).
- In the 1930's, Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration initiated the Community Pasture Program to reclaim badly eroded areas. The program provides grazing services for cattle and horses and a breeding service for cattle. Within Saskatchewan, the Program includes 62 pastures covering an area of 698,375 ha (1,725,714 ac). The primary objective of the program is: to manage healthy rangelands through the balance of environmentally responsible land use practices that complement livestock production (Agri-Food Canada - Prairie Farm Rehabilitation Administration 2009).

The Prairie Conservation Action Plan (PCAP) has been actively involved in native prairie and Species at Risk conservation in Saskatchewan. The PCAP is the only forum in Saskatchewan that brings together 28 partners representing producers, industry, provincial & federal governments, non-government organizations and research/educational institutes working towards a common vision of native prairie and Species at Risk conservation in Saskatchewan. The PCAP reduces redundancy, fills in gaps in native prairie research/activities, develops and implements actions to address conservation and sustainable management of native prairie, increases communication and sharing amongst partners and improves public understanding of native prairie and Species at Risk.

Some of the activities that the PCAP has been involved in include:

- Producing the *Rangeland Health Assessment: Native grassland and forest field workbook* for Saskatchewan (Prairie Conservation Action Plan 2008b); and
- In January 2009, representatives from the PCAP's "A Working Prairie" working group initiated the Saskatchewan Range and Riparian Health Assessment Framework. The overall goal of the Framework is to increase the consistency of data collection for range and riparian health assessments. The objectives of the initiative are to:
  - develop consistent protocols for data collection
  - develop consistent data entry protocols (species names, ecological site names, etc.)
  - develop a consistent database structure.

Standardized data collection protocols and storage will increase the efficiency of data analysis and sharing. This will ensure 1) that agencies that monitor range health and riparian health in Saskatchewan get maximum use of collected data; 2) that no data is lost; and 3) that range and riparian health is monitored effectively throughout the province.

Some additional sources of information for Saskatchewan producers include:

- an annual two-day Saskatchewan Pasture School, offered since 2004. This is a forum for grazing managers to gain practical knowledge and expand their management skills through seminars, producer panels, hands-on exercises and pasture tours. Participating organizations are Agriculture and Agri-Food Canada-PFRA, Ducks Unlimited Canada, the Saskatchewan Forage Council, the Saskatchewan Ministry of Agriculture, the Saskatchewan Watershed Authority and the Western Beef Development Centre;
- a number of documents produced by the Saskatchewan Forage Council, including:
  - a study entitled *Development of Perennial Native Species Stands in the Black Soil Zone of Manitoba and Saskatchewan* (Saskatchewan Forage Council 2008);
  - a factsheet entitled *Revegetation of Saline Soils using Salt Tolerant Grasses* was developed, printed and is being distributed to government departments of agriculture, non-government organizations, seed companies and dealers (Saskatchewan Forage Council 2007a);
  - a CD entitled *Dryland forage species adaptation: an interactive tool to assist in the selection of suitable forage species* (Saskatchewan Forage Council 2007b); and
  - three field guides entitled *Identification of Common Range Plants of Northern Saskatchewan*, *Identification of Common Range Plants of Southern Saskatchewan*, and *Common Seeded Plants for Forage and Reclamation in Saskatchewan* (Saskatchewan Forage Council 2007c, 2007d, 2007e).
- The Sustainable Grazing Mentorship Program, which is an opportunity for producers to receive individual input and suggestions from a producer peer on how to improve their profits, efficiency, forage productivity as well as land and water resources through improved grazing management. The Saskatchewan Forage Council is delivering this program.
- The Fairlight Grazing Project, which is a demonstration project to showcase grazing techniques and the use of non-bloating legumes and native grasses initiated on a research farm near Fairlight, Saskatchewan.

Environmental Acidification Indicator

This indicator was developed to assess which watersheds in Saskatchewan have an acid deposition rate that may be impacting surrounding ecosystems.

Indicator	
Critical Load of Acidity [CL(A)] Exceedance	**Status:** Research continues to be done in northern Saskatchewan to assess environmental impact of acid deposition. "A critical load for acid deposition is the highest deposition of acidifying compounds that will not cause chemical changes leading to long term harmful effects on ecosystem structure and function" (Nilsson and Grennfelt 1988). Acid deposition (measured or modelled) can be assessed in relation to critical load of acidity layers for aquatic (e.g. lakes and ponds) or terrestrial (soils) components. Acid deposition greater than the critical load of acidity represents an exceedance. Two map scenarios are presented for this indicator, according to data availability: (1) Aquatic critical load of acidity map, with exceedances depicted according to either steady-state assumption (all S and N deposition acidifying) or N-leaching assumption (all S deposition and an empirical fraction of N acidifying); (2) Combined aquatic and/or terrestrial critical load of acidity map, with exceedances calculated using the steady-state assumption only. Map scenario (1) for Saskatchewan is spatially restricted to where appropriate lake sampling has occurred, whereas scenario (2) affords a more spatially extensive map. **Trend:** Currently the trend in the impact of acid deposition on the environment cannot be assessed as data are still being gathered to look at change in acidification over time. However, information on trends in emissions is available for a ten-year period, between 1990 and 2000. The five-year averages for nitrogen oxides and sulphur dioxide emissions in Saskatchewan increased by 22% and 25%, respectively, between the time periods 1990-1994 and 1996-2000. In addition to emissions generated in Saskatchewan, prevailing winds move a variable portion of emissions from Alberta into Saskatchewan (Sandhu and Blower 1986). Within Saskatchewan, the primary point sources of sulphur dioxide emissions are from thermal electric power generation in the southern half of the province. The geographic distribution of nitrogen oxides emissions is similar to that of sulphur dioxide. Ammonia (NH_3) emissions have been found to be high in southern Saskatchewan in areas where intensive farming and livestock operations occur (Niemi 2005).

The issue
The deposition of compounds containing sulphur dioxide and nitrogen oxides, the precursors of acid deposition and environmental acidification, to terrestrial and aquatic systems may result in the acidification of these recipient systems. The primary activities in Saskatchewan that lead to the emission of these compounds include the production and refining of oil and natural gas, coal and natural gas-fired power generation, transportation, and agriculture.

Changes in the chemical properties of soil and water occur when acid deposition exceeds the buffering capacity of the receiving system. Such chemical changes may impact nutrient cycling, biological composition, and the functional ability of the system.

To determine ecosystem responses to the deposition of sulphur and nitrogen in a given area, critical load values are calculated. Critical load values can be used as a tool to identify ecosystems that are sensitive to acid deposition (i.e. have low acid neutralizing capacity).

Environmental Acidification Indicator in Saskatchewan

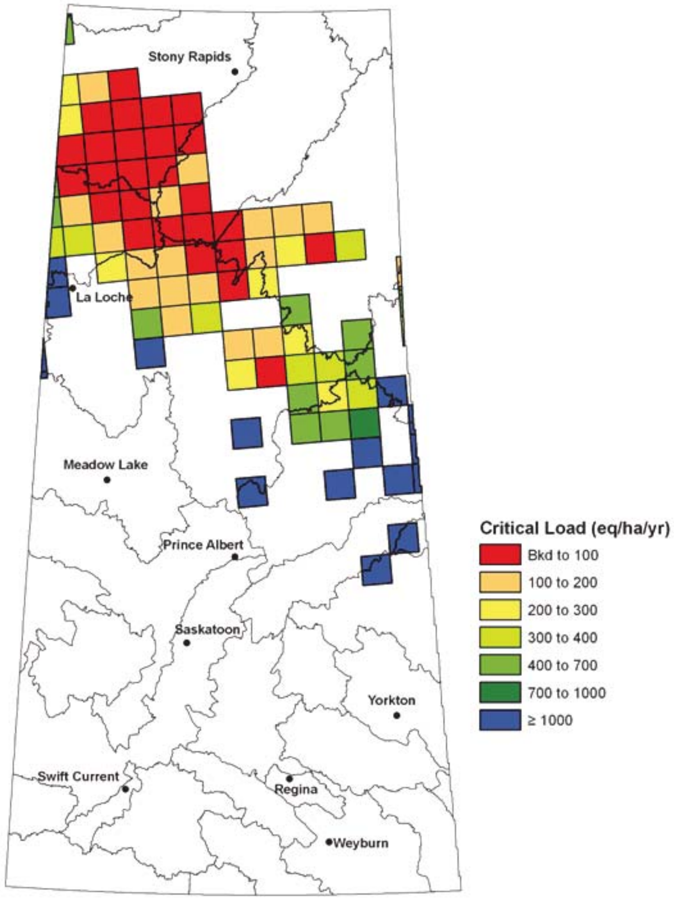

Figure 52. Aquatic critical loads of acidity calculated using either the SSWC or SMB models: 2008.
Source: Jeffries and Ouimet (2005); Jeffries and Wong (Unpublished).
Note: Watershed boundaries are overlying critical load grids.

Figure 52 indicates that aquatic critical load of acidity [CL(A)] are low in northwest Saskatchewan. A low CL(A) (e.g. Background to 100 eq/ha/yr) indicates that the ecosystem has a very low buffering capacity for acid deposition. Soils and surface waters with a high CL(A) (e.g. equal to or greater than1,000 eq/ha/yr) have a high buffering capacity and are not as impacted by acid deposition. Ecosystems that have a CL(A) in the four lowest classes (Background to 400 eq/ha/yr) are progressively more sensitive to acid deposition.

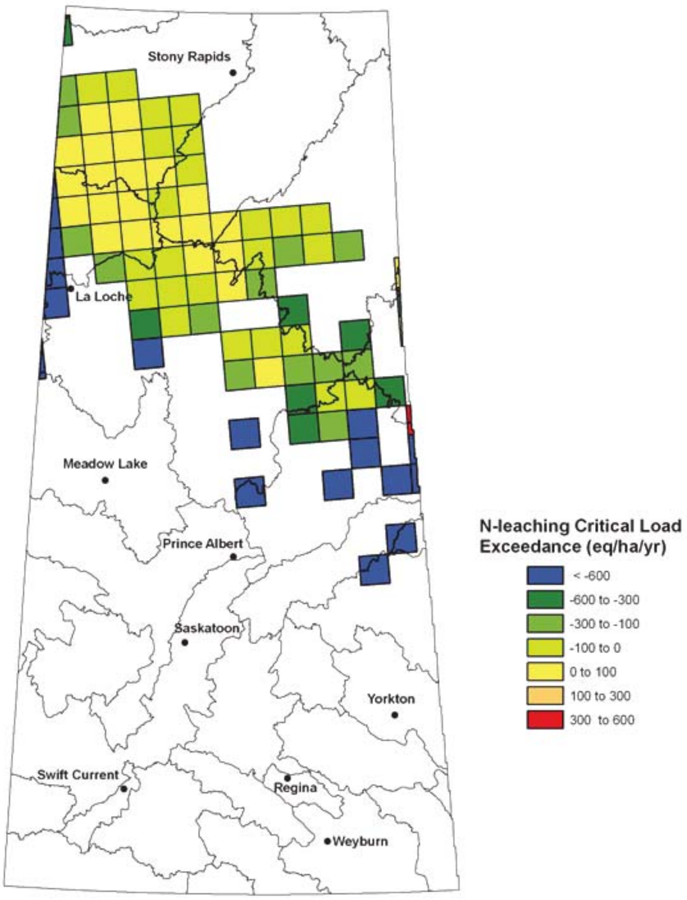

Figure 53. Aquatic Nitrogen-leaching critical load exceedances (eq/ha/yr) based on acid deposition estimated for 2002 using AURAMS.
Source: Jeffries and Ouimet (2005); Jeffries and Wong (Unpublished).
Note: Watershed boundaries are overlying the exceedance grid.

The aquatic N-leaching exceedance map, shown in Figure 53, reveals that some lakes in the northwest region of Saskatchewan (the grid squares with a positive N-leaching critical load exceedance value) are receiving acidic deposition in excess of their ability to neutralize it in the long-term. All of the grids in the 0 to 100 category had N-leaching exceedance values greater than zero.

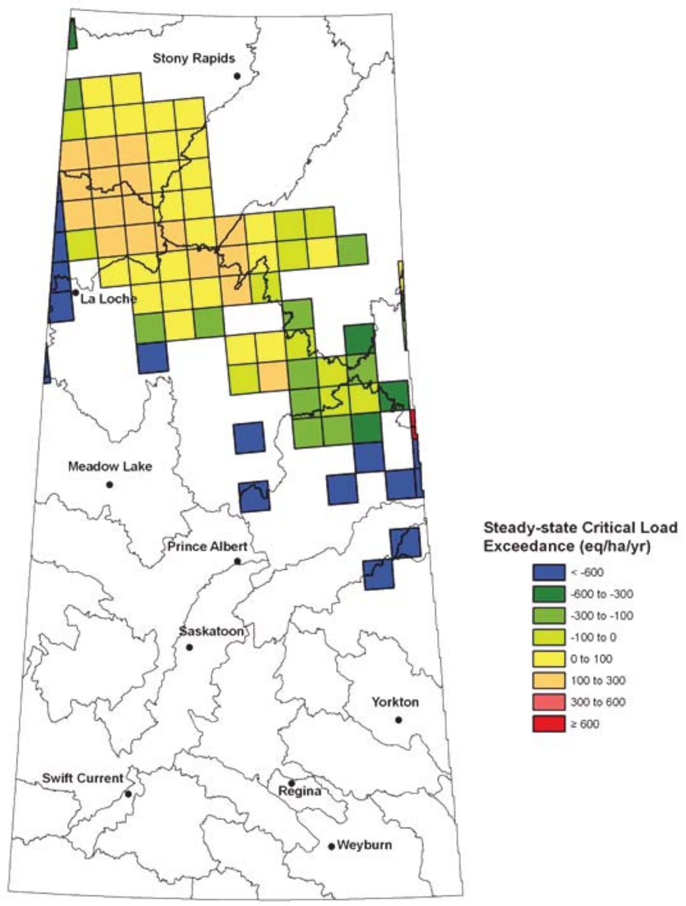

Figure 54. Aquatic Steady-state critical load exceedances (eq/ha/yr) based on acid deposition estimated for 2002 using AURAMS.
Source: Jeffries and Ouimet (2005); Jeffries and Wong (Unpublished).
Note: Watershed boundaries are overlying the exceedance grid.

Figure 54 shows CL(A) exceedance if it is assumed that all S and N deposition will ultimately become acidifying, which is the Steady-state assumption. Note that all of the grid cells have been bumped up an exceedance category compared to the N-Leaching exceedance map shown in Figure 53 (i.e. grids which were in the 0 to 100 eq/ha/yr category in Figure 53 are now in the 100 to 300 eq/ha/yr exceedance category in Figure 54).

In addition to maps of Saskatchewan that depict the estimated CL(A) for aquatic ecosystems, maps have also been created that depict the estimated grid cell CL(A) derived from a combination of aquatic and upland forest soils data.

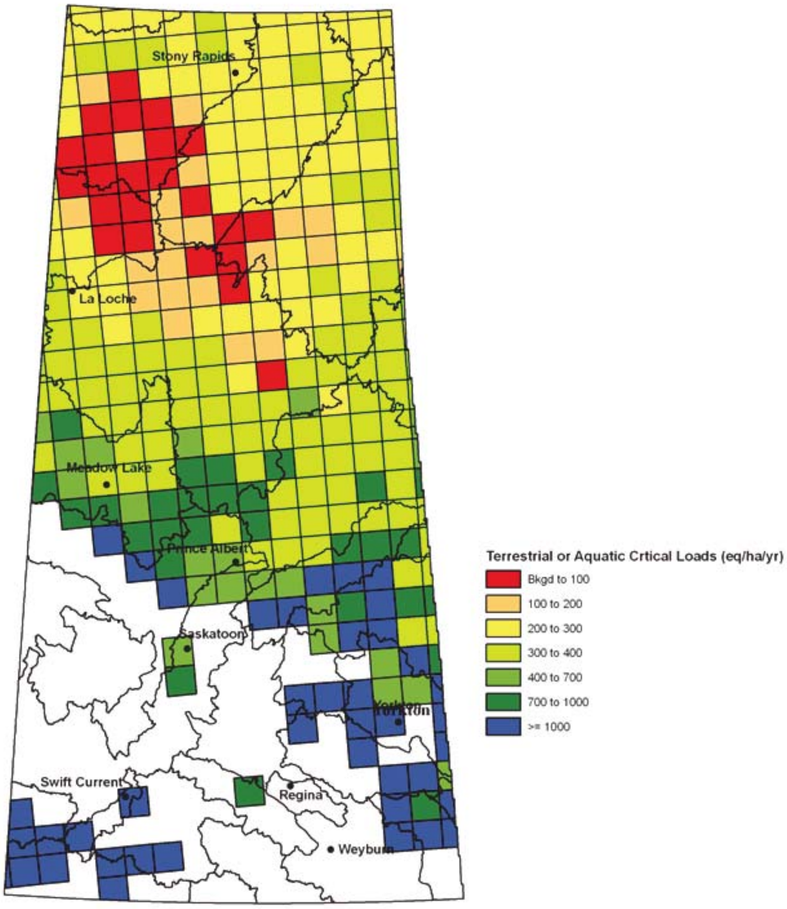

Figure 55. Aquatic and/or terrestrial critical loads of acidity calculated using either the SSWC or SMB models: 2008.
Source: Jeffries and Ouimet (2005); Jeffries and Wong (Unpublished); and Aherne (2008).
Note: Watershed boundaries are overlying the critical load grid.

Figure 55 indicates that the combined CL(A) for aquatic and/or terrestrial ecosystems are low in northern Saskatchewan, especially on the west side of the province.

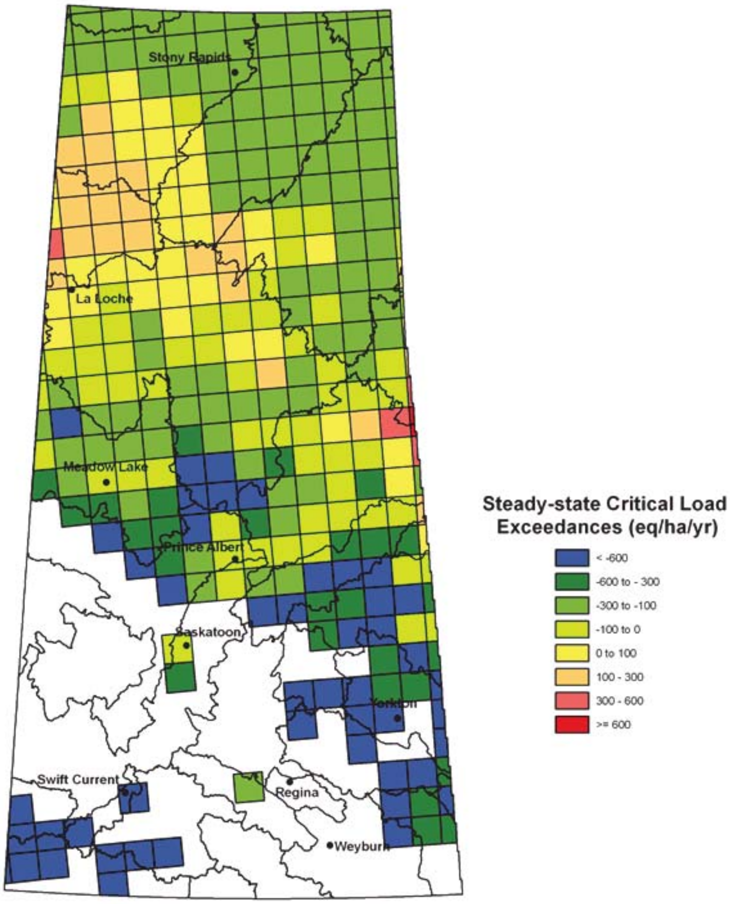

Figure 56. Aquatic and/or terrestrial Steady-state critical load exceedances (eq/ha/yr) based on acid deposition estimated for 2002 using AURAMS.
Source: Jeffries and Ouimet (2005); Jeffries and Wong (Unpublished); and Aherne (2008).
Note: Watershed boundaries are overlying the exceedance grid.

Figure 56 reveals that some of the lakes and forest soils in the northwest region of Saskatchewan (i.e. the grid squares with positive Steady-state critical load exceedance values) are receiving acidic deposition in excess of their ability to neutralize it in the long term.

It is important to note that, due to data limitations, Steady-state exceedance values are being used in relation to the combined CL(A) for aquatic and/or terrestrial ecosystems in Saskatchewan. The Steady-state exceedance considers all sulphur and nitrogen deposition as acidifying and is the maximum possible exceedance that will occur in the future (relative to modelled 2002 S and N deposition levels) should ecosystems become N saturated. There is little evidence of N saturation in Canada at this time. In eastern Canada, fewer data limitations have permitted calculation of Nitrogen leaching exceedances that better estimate the current situation (Jeffries and Ouimet 2005). A CL(A) exceedance does not imply any time-to-effect (i.e. how much time it is predicted to take to reach the specified critical limit on which CL(A) is based). To predict the time it will take an ecosystem to reach a critical limit, dynamic modelling needs to be utilized.

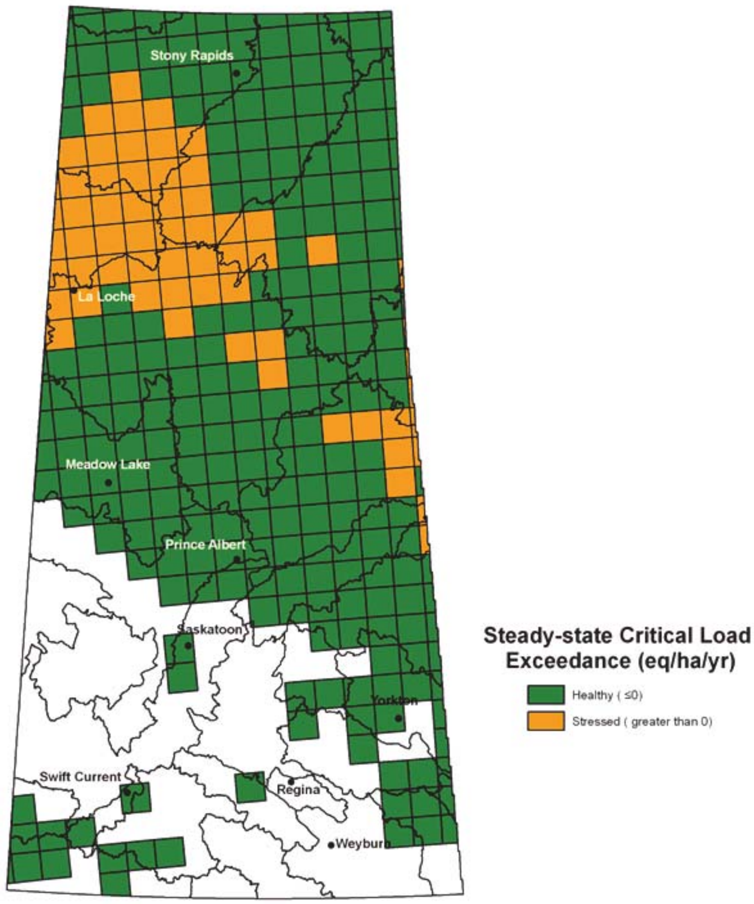

Figure 57. Depiction of a binary acidification health rating for Saskatchewan based on critical load of acidity exceedance (eq/ha/yr), estimated for 2002 using AURAMS.
Note: Watershed boundaries are overlying the exceedance grid.

Figure 57 identifies grid cells in Saskatchewan that are rated as healthy (i.e. have a critical load exceedance less than or equal to zero) or stressed (i.e. have a critical load exceedance greater than zero). Of the twenty-nine watersheds in Saskatchewan, eight had at least one grid cell that was stressed. By summing up the area of the stressed grid cells within each watershed, six of the eight watersheds had at least 10% of their area where the critical load of acidity was estimated to have been exceeded. These six watersheds and the percentage of their total area where the critical load of acidity was exceeded include the Reindeer River / Wollaston Lake (12.4%), Black Lake (20.7%), Saskatchewan River (21.8%), Churchill River (27.5%), Lake Athabasca (40.0%), and Athabasca River (99.6%) Watersheds.

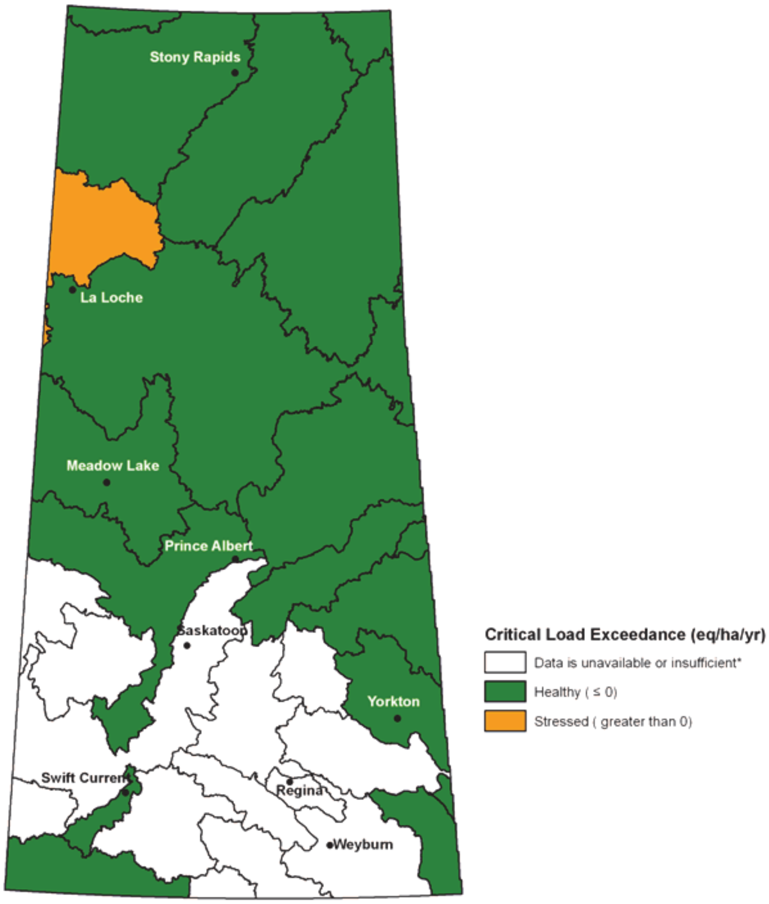

Figure 58. Aquatic and terrestrial exceedance (eq/ha/yr) of critical loads for acid deposition by watershed: 2008.
*Less than 50% of the watershed had Steady-state Critical Load Exceedance values.

Figure 58 provides a summary of the critical load exceedance ratings by watershed. Sixteen of the watersheds in Saskatchewan are classified as healthy. However, the Athabasca River Watershed was classified as stressed under both the N-leaching and steady-state exceedance assumptions, with greater than 50% of the area classified as stressed by acid deposition. As noted in Figures 53 and 56 there are a few exceedances in other watersheds, but when averaging the health rating across the entire watershed these have a rating of healthy for acid deposition.

Indicator							
Steady-state Exceedance (eq/ha/yr)	=	(Total S Deposition (eq/ha/yr)	+	Total N Deposition) (eq/ha/yr)	-	Critical Load (eq/ha/yr)

Rating Scheme

Aquatic or terrestrial Steady-state critical load exceedances
Healthy: Steady-state critical load exceedance value is zero eq/ha/yr or less.
Stressed: Steady-state critical load exceedance value is greater than 0 eq/ha/yr.

Data Source: The aquatic or terrestrial critical load and Steady-state exceedance maps (data current as of September 2008) were obtained from Jeffries and Wong (Environment Canada, Unpublished). Data used to create these maps are a compilation of:

- Lake chemistry data collected between 2007 and 2008 by the Saskatchewan Ministry of Environment and Environment Canada. Critical loads were calculated using the Steady-State Water Chemistry Model (Henriksen et al., 2001, 2002) and exceedances were calculated using S and N deposition for 2002 estimated using the Environment Canada AURAMS model (Moran et al. 2008).
- Upland forest soil data collected between 1994 and 1998. Critical loads were calculated using the Steady-State Mass Balance Model (Aherne and Watmough 2006, Aherne 2008) and exceedances were calculated using S and N deposition for 2002 estimated using the Environment Canada AURAMS model (Moran et al. 2008). The methods used to collect and map this data followed the protocol established by the New England Governors and Eastern Canadian Premiers (NEG-ECP) Environmental Task Group on Forest Mapping (NEG-ECP 2001).

For further information on the methods used to derive the aquatic or terrestrial critical load and Steady-state exceedance maps, refer to Jeffries and Ouimet (2005).

Response to the issue
Provincial legislative control of emissions is under *The Clean Air Act*, administered by the Saskatchewan Ministry of Environment.

Saskatchewan is a participant in the implementation of The Canada-Wide Acid Rain Strategy for Post-2000. The strategy was signed in 1998 by all 26 of Canada's Federal/Provincial/Territorial Ministers of Energy and Environment. The primary goal of the strategy was to reduce SO_2 and NO_x emissions to ensure that critical loads for acid deposition are not exceeded within Canada [Federal/Provincial/Territorial Ministers of Energy and Environment (Canada) 1999].

The Acid Rain Task Group (ARTG), consisting of representatives from federal and provincial governments, industry associations, and non-government environmental organizations, reports to the Air Management Committee of the Canadian Council of Ministers of the Environment (CCME) on the progress made on the commitments laid out in The Canada-Wide Acid Rain Strategy for Post-2000. Annual progress reports on activities related to the strategy are available online at http://www.ccme.ca/ourwork/air.html?category_id=31#249. In 2007, the ARTG released two documents, entitled *The Acid Rain Task Group Long-term Strategic Plan to Implement The Strategy* and *A National Acid Rain Science Plan* (Acid Rain Task Group 2007a, 2007b). To ensure the goals of the strategy are met, the ARTG developed the Long-term Strategic Plan, which assigns action items to each of the commitments outlined in the strategy up to the year 2012. The recommendations in the ARTG's Science Plan focus on addressing high priority needs, including:

- improving the spatial coverage of acid deposition and aquatic and terrestrial chemical and biological measures across Canada; and
- further understanding ecosystem functions, including the effects of acidification and the rates of recovery.

In 2002, Saskatchewan and Alberta signed a Memorandum of Understanding on Acid Deposition Management. The purpose of this agreement is to establish a framework for co-operation between Saskatchewan and Alberta in their respective management of acid-forming substances subject to long-range aerial transport processes between the two provinces. The objectives of the agreement are: 1) to maximize the efficient use of resources and the effectiveness of both provinces' efforts to monitor and manage the impacts (air, aquatic and terrestrial) of acid deposition; 2) to facilitate the exchange and analysis of environmental data on acid forming substances, the receiving environment and the impacts of acid deposition; 3) to share perspectives on the environmental effects and appropriate management strategies for acid-forming substances subject to long-range aerial transport; and 4) to manage the release of acid-forming substances subject to long-range aerial transport.

Aherne and Watmough (2006) estimated that the critical load of S and N was exceeded in approximately 2% of the forested land modelled in Saskatchewan.

In 2007, the Saskatchewan Ministry of Environment commenced a lake survey project in northwest Saskatchewan to monitor headwater lakes for acid deposition. The objectives of the project are: 1) to gather baseline data on small headwater lakes in Saskatchewan within a 300 km radius of Fort McMurray, Alberta; and 2) to use the data collected to further justify the inclusion of select lakes in future monitoring programs.

In the first year of the project, a total of 148 lakes were sampled. Of these, 143 were small (i.e. less than 350 ha) headwater lakes, and five were larger lakes. Primarily headwater lakes were sampled as part of this project, because they are more sensitive to acid deposition than lakes further downstream. In 2008, the second year of the project, 200 lakes were sampled. Of the 200 lakes, 86 had previously been sampled in 2007 and 114 were lakes that were not previously sampled (Figure 59). The results of the study have confirmed that many of the lakes sampled have a low acid neutralizing capacity and are more sensitive to acid deposition compared to lakes in southern Saskatchewan. The low buffering capacity of these lakes is due to the silicate geology of the Precambrian Shield, where these lakes are located (Scott 2008 and Scott 2009, Personal Communication).

In 2006, Environment Canada initiated a multi-year project to survey lakes in areas where there was insufficient information to calculate critical loads of acid deposition. This initiative was recommended in the 2004 Acid Deposition Science Assessment (see http://www.msc-smc.ec.gc.ca/saib/acid/acid_e.html). As part of this project, Environment Canada staff have sampled lakes in the following areas:

- northwest Manitoba in 2006;
- north of the Shield boundary and south of 58N latitude in Saskatchewan in 2007; and
- north of Lake Superior in Ontario in 2008.

Environment Canada staff plan to return to Saskatchewan in the autumn of 2009 to sample between 58N and 60N latitude. Future work will also be done in Quebec, Atlantic Canada and British Columbia.

In 2007, as part of this project, 297 lakes were sampled in Saskatchewan (Figure 59). Currently there is no plan to re-sample these 297 lakes. However, it is possible that in the future a small number of the 297 lakes may be more intensively and routinely sampled to determine inter-annual chemical variation and trends. The 297 lakes were chosen from pre-selected sampling blocks according to a random-stratified survey design, with a few extra lakes added that had been or were going to be sampled by other agencies (Jeffries 2009, Personal Communication).

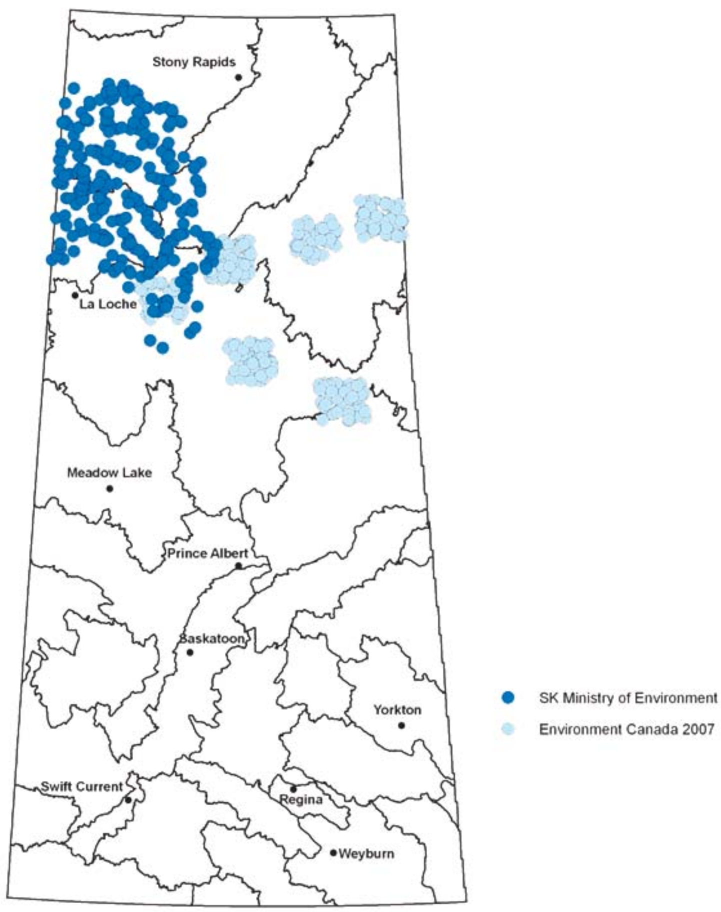

Figure 59. Location of lakes in northern Saskatchewan sampled by the Saskatchewan Ministry of Environment and Environment Canada.

Figure 59 shows the location of lakes sampled by Environment Canada in 2007 and by the Saskatchewan Ministry of Environment in 2007 and 2008. It should be noted that there are differences in the federal lake survey design (all lake sizes) and the Ministry of Environment's survey design (headwater lakes).

Permanent Cover Indicator (under construction)

The Permanent Cover indicator is under construction, as thresholds have not yet been developed to allow it to be assessed using scientifically defensible criteria. Therefore, the watershed health values for this indicator are preliminary and will not be used in this report to assess the health of watersheds in Saskatchewan.

Indicator	
Permanent Cover	**Status:** Producers are continuing to convert marginal cropland to permanent cover. **Trend:** Permanent cover increased between 2001 and 2006. Annual cropland decreased within this same time-period.

The issue

Permanent cover can be defined as patches of native and/or tame vegetation that are never, or land that is infrequently cultivated (i.e. less than once every 10 years). In southern Saskatchewan, cropland represents the majority of watershed area without permanent cover. While differences exist among types of permanent cover, in general permanent cover in Saskatchewan maintains higher levels of biodiversity and supports more Species at Risk than cultivated cropland. Permanent cover is also linked to a watershed's capacity to provide functions such as reducing flooding potential and improving water quality.

While significant relationships between permanent cover and water quality and flood reduction have been demonstrated elsewhere, the relationships between these parameters and the magnitude of their effect have not been investigated in Saskatchewan. Similar relationships may exist between permanent cover and aquatic habitat, but require further research in Saskatchewan. Documenting the critical thresholds for the relationships between permanent cover and these parameters would enable managers to identify and target permanent cover goals appropriate to individual watersheds.

Permanent Cover Indicator in Saskatchewan

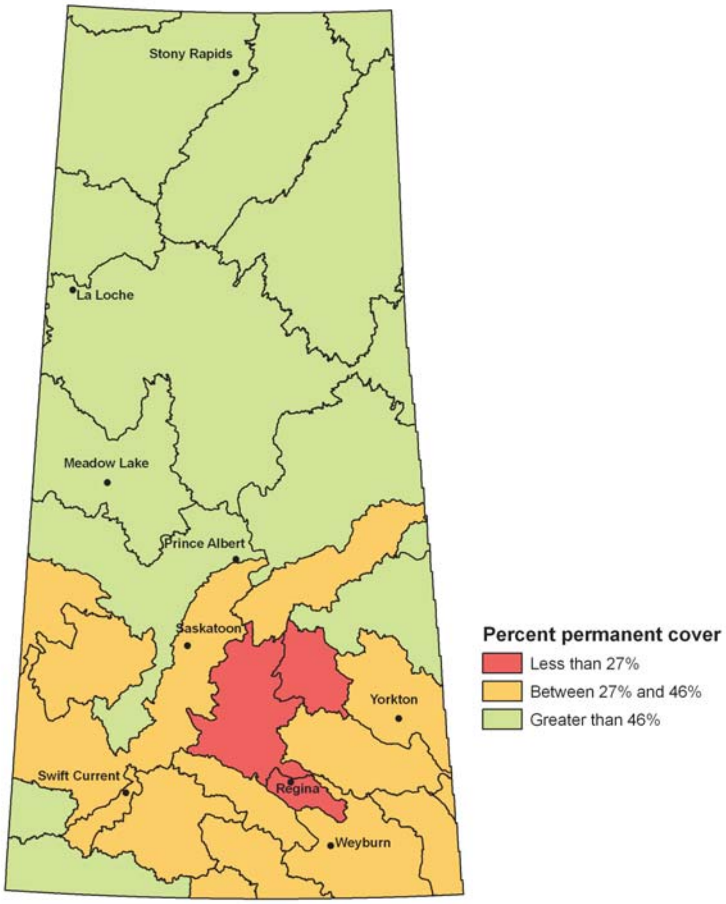

Figure 60. Estimate of percent permanent cover by watershed: 2001.

The three watersheds with the lowest percentage of permanent cover, derived from the 2001 landcover data, were the Upper Qu'Appelle River, Quill Lakes and Wascana Creek Watersheds.

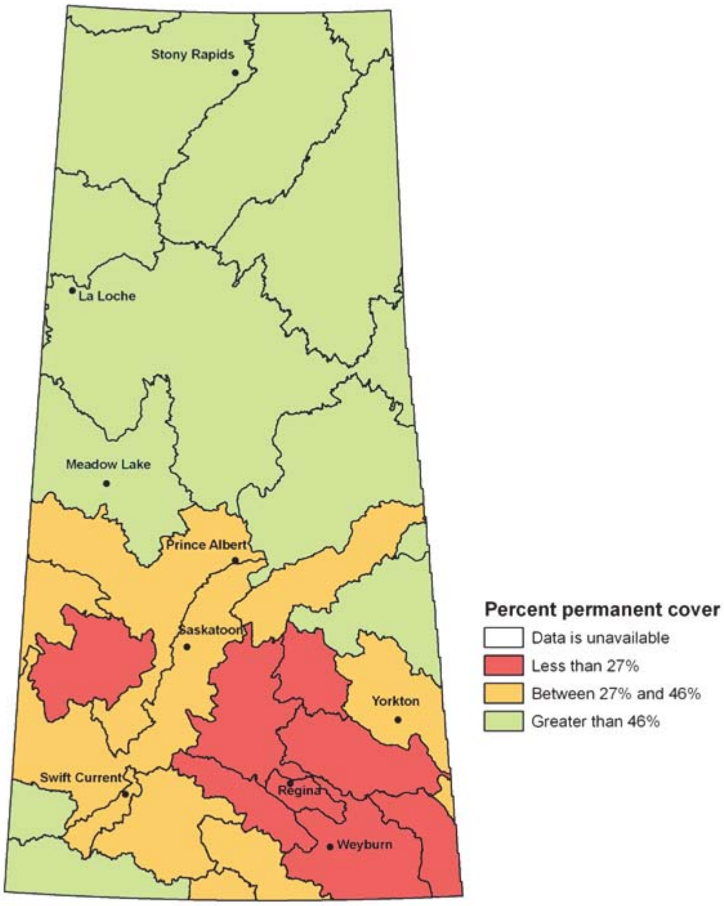

Figure 61. Estimate of percent permanent cover by watershed: 1994.

The percent permanent cover, derived from the 1994 landcover data, was lowest in the Eagle Creek, Moose Jaw River, Lower Souris River, Lower Qu'Appelle River, Upper Souris River, Upper Qu'Appelle River, Quill Lakes, and Wascana Creek Watersheds.

On average, percent permanent cover increased across all watersheds between 1994 (Southern Digital Cover classification of 1993-1994 LANDSAT-TM imagery) and 2001 (AAFC_2001_30m). Using 1994 landcover data there were eight watersheds that had less than 27% permanent cover, while three watersheds had less than 27% permanent cover using 2001 landcover data.

Global, national and provincial agricultural economic forces and conservation/preservation policies are the major determinants of temporal change in the permanent cover indicator. Conservation (e.g. the North American Waterfowl Management Plan) and preservation (e.g. protected area designations) efforts generally result in small contributions to changes in the permanent cover indicator at a provincial scale, but efforts targeted to specific watersheds may produce measurable change over time.

Indicator		
Permanent Cover	=	$\frac{\text{Area of forage (ha) + grassland (ha) + shrub (ha) + tree (ha)}}{\text{Total area of watershed (ha) – Area of water in watershed (ha)}}$

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to find the natural breaks in the data. These natural breaks are currently being used as a preliminary rating scheme. As scientifically defensible thresholds have not yet been developed, the watershed health values for this indicator are considered preliminary and are not used in the report to assess the health of watersheds in Saskatchewan.

Permanent Cover
Greater than 46% of the watershed area is permanent cover.
Between 27% and 46% of the watershed area is permanent cover.
Less than 27% of the watershed area is permanent cover.

Data Source: The Southern Digital Land Cover and Northern Digital Land Cover classification were used to determine the permanent cover for 1993-1994. The AAFC_30m_2000 raster file was used to determine the area of permanent for 2001 for watersheds south of the Churchill River Watershed. The Northern Digital Land Cover classification was used to determine the area of permanent for 2001 for the watersheds north of and including the Churchill River Watershed. The Southern Digital Land Cover classification was derived from 1993-1994 LANDSAT -TM imagery and the Northern Digital Land Cover classification was derived from 2000 LANDSAT -TM imagery at 30 metre resolution. The AAFC_30m_2000 raster file was created by Agriculture and Agri-Food Canada through the National Land and Water Information Service (NLWIS). The AAFC_30m_2000 raster file land cover classes were derived from Landsat 5 TM and/or 7 ETM+ multispectral imagery from circa 2000 (Agriculture and Agri-Food Canada 2008).

Response to the issue
Numerous programs have been initiated to convert marginal annually cropped land to perennial cover (see the **Conservation Stewards Indicator** in Appendix C). Some of these programs include:

- Agriculture and Agri-Food Canada - Agri-Environmental Services Branch's Greencover Canada Program – land conversion component (April 2004 – March 2009);
- Agriculture and Agri-Food Canada - Agri-Environmental Services Branch's Permanent Cover Program I and II (1989-1993);
- the Saskatchewan Watershed Authority's Prairie Stewardship Program;
- Ducks Unlimited Canada's securement programs; and
- Saskatchewan Agriculture's Conservation Cover Program (June 2001 – March 2005).

Species at Risk Indicator (under construction)

This indicator was developed to identify areas in Saskatchewan with high densities of Species at Risk. No rating scheme has been developed to calculate watershed health values for this indicator; therefore this indicator will not be used in this report to assess the health of watersheds in Saskatchewan.

Indicator	
Species at Risk	**Status:** Additional species have been assessed by COSEWIC and listed in the *Species at Risk Act* since the 2007 *State of the Watershed Report*. **Trend:** The increase in the number of Species at Risk between the 2007 *State of the Watershed Report* and this report is mostly due to increased research and more species being assessed, not the actual number of species that have recently become at risk.

The issue
Species at Risk are defined as indigenous organisms (plant, animal, fungus or micro-organism), that have been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and found to be at some risk of declining and/or disappearing from the wild in Canada (Canadian Wildlife Service 2009). COSEWIC categorizes Species at Risk into one of five categories: extinct, extirpated, endangered, threatened, or special concern.

Some of the broad-scale human activities that can impact the status of a species include: habitat disturbance, loss and fragmentation; over-harvesting; introduction of invasive alien species; climate change; and the release and deposition of pollutants such as pesticides (Thorpe and Godwin 1999).

Species at Risk Indicator in Saskatchewan

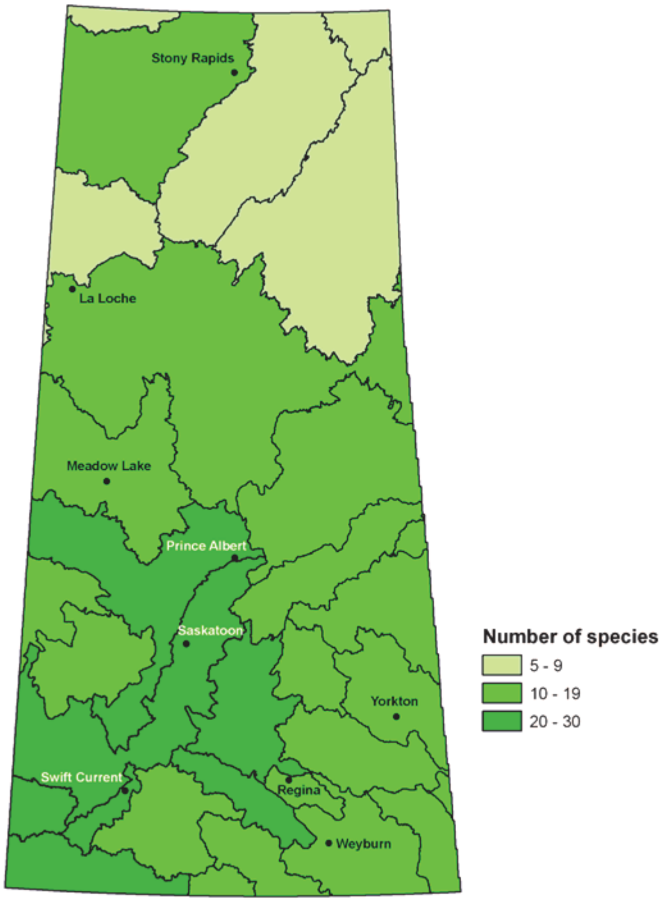

Figure 62. Number of species at risk with breeding ranges that overlap the watershed boundary.

Figure 62 highlights the number of species which have a breeding range within a given watershed that are endangered, threatened or of special concern, as listed in Schedule 1 of the *Species at Risk Act*. There are seven watersheds that have between 20 and 30 species at risk, 16 watersheds that have between 10 and 19 species at risk, and five watersheds that have between five and nine species at risk which breed within their boundaries.

Table 8. Number of extinct, extirpated, endangered, threatened and special concern species in Saskatchewan, as designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC): May 2009.

Taxonomic group	Extinct	Extirpated	Endangered	Threatened	Special concern
Amphibian	0	0	0	0	2
Arthropods	0	0	2	3	2
Reptiles	0	0	1	1	1
Birds	1	1	8	9	6
Fish (Freshwater)	0	0	1	1	2
Mammals (Terrestrial)	0	2	2	2	2
Mosses	0	0	0	1	0
Vascular Plants	0	0	3	5	8
Total	**1**	**3**	**17**	**22**	**23**

Indicator		
Species at Risk	=	Number of Species at Risk with breeding areas that fall within the watershed boundaries

Rating Scheme

No rating scheme has been developed to calculate watershed health values for this indicator, therefore this indicator will not be used in this report to assess the health of watersheds in Saskatchewan. There is currently no rating scheme associated with this indicator due to the complexity of classifying watersheds based on the numbers of Species at Risk present. As the United States Environmental Protection Agency (2006) notes: "The presence of rare or endangered species in a watershed is not necessarily an indication of poor watershed conditions. Indeed, it more likely indicates the opposite: in many instances these species persist only in areas of exceptionally high quality habitat. The presence of species at risk in a watershed indicates, however, that these watersheds are especially vulnerable to future water quality or habitat degradation, which could jeopardize the maintenance or recovery of these organisms".

Data Source: Data summarized in Table 8 were obtained from the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), May 2009. Breeding range data summarized in Figure 62 was obtained from:

- COSEWIC shapefiles;
- Digitizing SARA registry pdf maps; and
- NatureServe.

Data Quality/Caveats: There is currently no rating scheme associated with this indicator, due to the complexity of classifying watersheds based on the numbers of Species at Risk present.

The method used by COSEWIC to assess the number of species that are at risk in Canada should be used with caution:

1) Temporal trends cannot be determined based on the increasing number of species that are added to COSEWIC's Species at Risk categories. The increase in the number of species added to the at-risk categories (special concern, threatened, and endangered) is typically a reflection of the pace that species are investigated and designated, and not the speed at which their at-risk status is changing.
2) The inflation in the numbers of designated Species at Risk can occur due to COSEWIC's assessment process.
    a) COSEWIC first assesses the entire population of a species, and if necessary will assess a subpopulation of that species. Occasionally, two subpopulations of the same species may both be listed as at-risk.
    b) There are a number of species that are listed as at-risk in Canada; however, Canada represents the northernmost extent of their range.

Response to the issue
Within Saskatchewan, Species at Risk are regulated by the *Species at Risk Act*, administered by Environment Canada, *The Wildlife Act, 1998* and *The Wildlife Habitat Protection Act*, administered by the Saskatchewan Ministry of Environment, and the *Accord for the Protection of Species at Risk*.

In 1996 Canada's federal, provincial and territorial governments agreed to the national *Accord for the Protection of Species at Risk*. The accord outlines a national commitment to designate species at risk, protect their habitats and develop recovery plans (Environment Canada 2002a).

The federal *Species at Risk Act* (SARA) was passed in June 2003. The act is one component of Canada's three-part Strategy for the Protection of Species at Risk that also includes the *Habitat Stewardship Program for Species at Risk* and the *Accord for the Protection of Species at Risk*.

Numerous assessments have been conducted and documents compiled outlining the status of Species at Risk in Canada (Canadian Endangered Species Conservation Council 2001 and Cannings et al. 2005). In Saskatchewan there are 65 species of wildlife that are at-risk and are designated as extirpated (3 species), endangered (14 species), threatened (24 species), and special concern (24 species) as designated by COSEWIC.

Once a species is listed as extirpated, endangered or threatened under SARA, recovery strategies and action plans must be developed. Recovery strategies have been developed and finalized for 11 Species at Risk; recovery strategies have been developed, but the finalization has been delayed, for one Species at Risk; and recovery strategies are currently being developed for 12 Species at Risk in Saskatchewan that are listed in Schedule 1 of SARA (Species at Risk Public Registry 2009).

In Saskatchewan, Species at Risk are assessed and tracked by both COSEWIC and the Saskatchewan Conservation Data Centre. The Saskatchewan Conservation Data Centre was established in 1992 as a cooperative initiative between the Government of Saskatchewan, The Nature Conservancy (U.S.A), and The Nature Conservancy of Canada. The purpose of the Saskatchewan Conservation Data Centre is to ensure scientific information on plants, animals, and ecological communities in Saskatchewan is reliable, accessible, and current.

Biodiversity monitoring programs that are operating or collecting information on Species at Risk in Saskatchewan include:

- The Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Created in 1977, the mandate of COSEWIC is to use the best available scientific and Aboriginal traditional knowledge to assess and classify the status of wildlife species in Canada. Once assessed, species are placed into one of seven status categories: extinct, extirpated, endangered, threatened, special concern, not at risk, and data deficient.
- The Habitat Stewardship Program for Species at Risk. The program was initiated in 2000 by the Government of Canada to develop partnerships and stewardship programs to promote and maintain habitat for Species at Risk.
- The Saskatchewan Ministry of Environment's Representative Areas Network. In 1997, the Saskatchewan Ministry of Environment initiated the Representative Areas Network Program. The purpose of the program is to conserve areas of land and water within Saskatchewan that are representative of a unique part of the province's 11 ecoregions.
- Operation Burrowing Owl. Initiated by Nature Saskatchewan in 1987, Operation Burrowing Owl is a stewardship program that promotes the protection of burrowing owl habitat through:
    - monitoring population trends;
    - educating the public; and
    - land stewardship activities to conserve habitat.
- The Rare Plant Rescue Program. Launched by Nature Saskatchewan in 2002, the purpose of the program is to conserve rare plant habitat by working with landowners and providing them with the information they need to make informed stewardship decisions.
- The Piping Plover Guardian Program. The program was created by Nature Saskatchewan in 2002 to increase the productivity of Piping Plovers in Saskatchewan.
- The Shrubs for Shrikes Program. Established by Nature Saskatchewan in 2003, the Shrubs for Shrikes Program promotes the protection of Loggerhead Shrike habitat through monitoring, education and habitat conservation.

In addition to long-term province-wide Species at Risk programs listed above, there are other biodiversity projects that have a narrower geographic scope or time-frame, including:

- The Frenchman River Biodiversity Project. This was a multidisciplinary research project involving a number of agencies that was initiated in 2003 and concluded in 2008. The project was initiated to assess the health of the Frenchman River and the sustainability of local activities such as agriculture and ranching (Frenchman River Biodiversity Project 2009).
- The South Saskatchewan River Piping Plover Project. This project is the responsibility of the Saskatchewan Watershed Authority. The project monitors and surveys Piping Plovers nesting along the South Saskatchewan River between Saskatchewan Landing and Gardiner Dam.
- Northern Leopard Frog Abundance, Distribution and Over-winter Survival along the Upper Qu'Appelle River Conveyance Channel. In the spring of 2008, the Saskatchewan Watershed Authority initiated a mark/recapture study to evaluate the abundance and distribution of Northern Leopard frogs along the Upper Qu'Appelle River Conveyance Channel.
- The use of risk assessment analysis to identify quality and at-risk habitat for the Saskatchewan Rivers Lake Sturgeon (*Acipenser fulvescens*) population. To better understand the challenges faced by the Lake Sturgeon, in the summer of 2008 the Saskatchewan Watershed Authority initiated a survey of 15 locations along the North, South and Saskatchewan Rivers considered to be valuable foraging habitat for Lake Sturgeon and associated fish species (Pollock et al. 2009).

Other documents and activities that have been initiated to address biodiversity in Saskatchewan include:

- In 2007, The Nature Conservancy of Canada released a document entitled *Saskatchewan Biodiversity Report: Conservation Blueprint for Canada's Prairies and Parklands*. The purpose of the report was to assemble, classify, map and analyze the available biological diversity information for the prairie and parkland biome of Saskatchewan.
- In 2004, Saskatchewan's Biodiversity Interagency Steering Committee released *Caring for Natural Environments: A Biodiversity Action Plan for Saskatchewan's Future 2004-2009* (Government of Saskatchewan 2004). The focus of the action plan was to encourage all sectors of government to conserve biodiversity and promote the sustainable use of natural resources through an ecosystem-based management approach.
- In 2003, the Saskatchewan Ministry of Environment developed a document entitled *Activity Restriction Guidelines for Sensitive Species in Natural Habitats* (Saskatchewan Conservation Data Centre 2003). The guidelines were developed to assist proponents during the planning of proposed projects. The guide informs the proponent of the appropriate setback distance that a project must be from habitat known to be utilized by Species at Risk. The Saskatchewan Conservation Data Centre distributes the guidelines when a data request is submitted and Species at Risk are known to occur in the area of the project (http://www.biodiversity.sk.ca/Docs/SKactivityrestrictions-background.pdf).
- In 2003, a Saskatchewan Agri-Environmental Scan was conducted to provide a preliminary assessment of the agricultural impacts on soil, air, water and biodiversity. The scan was a joint initiative of federal and provincial departments and agencies, lead by Agriculture and Agri-Food Canada and the Saskatchewan Ministry of Agriculture (Agriculture and Agri-Food Canada and Saskatchewan Agriculture and Food 2003).

- In 1998, in response to the Canadian Biodiversity Strategy, the Saskatchewan Biodiversity Interagency Steering Committee was established. The purpose of Saskatchewan's Biodiversity Interagency Steering Committee was to oversee the development of a biodiversity action plan for Saskatchewan.
- In 2002, Saskatchewan's Biodiversity Interagency Steering Committee released a document entitled *Conserving Saskatchewan's Natural Environment: A Proposed Saskatchewan Biodiversity Action Plan* (Government of Saskatchewan 2002).
- In 2000, Saskatchewan's Biodiversity Interagency Steering Committee released a discussion paper entitled *Conserving Saskatchewan's Natural Environment: Framework for a Saskatchewan Biodiversity Action Plan* (Government of Saskatchewan 2000).
- In 1999, *Threats to Biodiversity in Saskatchewan* was released by the Saskatchewan Research Council. The document identified, categorized, and ranked the potential threats to biodiversity in Saskatchewan (Thorpe and Godwin 1999).
- In 1999, the Government of Saskatchewan released a progress report entitled *Conserving Saskatchewan's Biodiversity* (Government of Saskatchewan 1999).