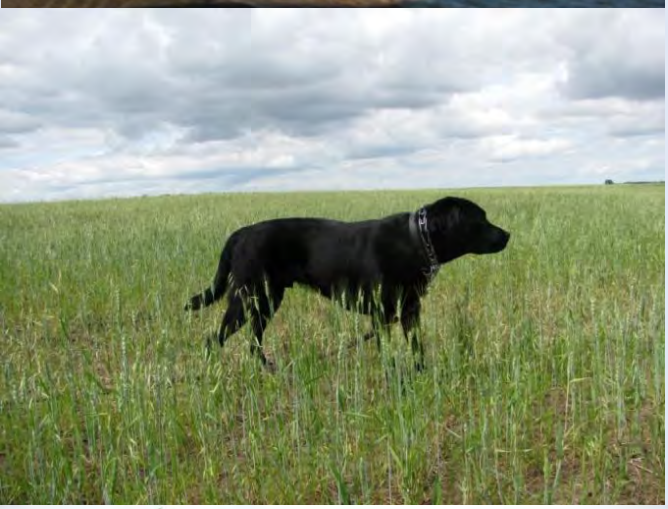

LIMITED

Drought and Excessive Moisture - Saskatchewan's Nemesis: Characterizations for the Swift Current Creek, North Saskatchewan River, Assiniboine River and Upper Souris River Watersheds

Prepared for Saskatchewan Watershed Authority

V. Wittrock[1], E. Wheaton[2] and E. Siemens[1]
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Saskatchewan Research Council
Environment and Forestry Division

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Severe weather event south of Saskatoon June 3, 2010 (Photo: E. Wheaton)

Soil on snow near Alberta/Saskatchewan Border January 16, 2009 (Photo: V. Wittrock)

Excess moisture forming sloughs south of Saskatoon August 13, 2010 (Photo: E. Wheaton)

Wheat crop suffering from drought and cold stress east of Swift Current August 1, 2009 (Photo: V. Wittrock)

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ABSTRACT

Saskatchewan is subject to extreme climatic conditions. In the past 100 years, Saskatchewan has endured numerous droughts and excessive moisture events. These events can occur subtly e.g., droughts start slowly but progress to extreme levels, especially when they are multi-year droughts. Excessive moisture events are usually more dramatic and apparent because they can occur very suddenly. Conditions in Saskatchewan can switch from extreme drought to excessive moisture very quickly. A good example of this occurrence is the 2008-2010 drought which ended dramatically with the 2010 extreme excessive moisture summer. This project characterizes the extreme drought and excessive moisture events over the last 100 years for four watersheds: Swift Current Creek, North Saskatchewan River, Assiniboine River, and Upper Souris River Watersheds. Saskatchewan communities and economic sectors were negatively impacted by these occurrences and as a result, various adaptation measures have been implemented. These impact and adaptation strategies are also examined to help determine advances in adaptation research and solution.

While each watershed had its own extreme drought and excessive moisture years, there were some years in which a commonality occurred. The excessive moisture year of 1954 occurred in all of the watersheds. The extreme drought year of 1961 was a common year for all four watersheds with both the Palmer Drought Severity Index and the 12-month Standardized Precipitation Index. Tracking the occurrence and intensity of drought and excessive moisture is important to allow for understanding the impact these extreme events had on the watersheds and the adaptations resulting because of these impacts.

Many key recommendations were developed including:

- Examination of 2010 excessive moisture patterns in the prairie region and comparison with historic and future projected patterns.
- Relate drought and excessive moisture extremes to water use demand.
- How are similar or different patterns of drought and excessive moisture projected?
- How do the indices compare with the impacts (e.g., reservoir and lake levels etc)?
- Undertake a full assessment of the media coverage of the excessive moisture year of 2010.
- Expand the ranking from being the top 10 most extreme years to rank the entire period of record for each watershed.
- Further develop the top ten indices by undertaking spatial comparisons for all the indices for all the top ten years.
- Assessment of the vulnerability, impacts and adaptation patterns
- How do stages of adaptation (e.g., risk management) compare with drought stages?
- What is the effectiveness of "current" adaptation? What are the residual impacts? How can adaptation be improved?

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BACKGROUND AND INTRODUCTION

Saskatchewan is subject to extreme climatic conditions. Droughts and excessive moisture are not an uncommon occurrence on the Canadian Prairies and both can occur simultaneously in different locations. For example, one portion of the Saskatchewan could be in an extreme drought situation while another part may be enduring excessive moisture conditions. A major threat to water security in Saskatchewan is the hydro-climatic variability and, in particular, the hydro-climatic extremes of drought and excessive moisture.

With a shifting climate, as recently indicated in the 2008-2010 period, the frequency of both severe drought and flood events are expected to increase. The frequency of heavy precipitation events will very likely increase in the future (90-99% probability of occurrence) (IPCC WGI 2007). More specifically, all Global Climate Models project future increased summer continental interior drying and associated risk of droughts (Watson et al., 2001). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC WGI, 2007) concludes that future increases in the area affected by drought are likely (i.e., 66% probability of occurrence). More evidence of changing extremes and their causes has been found with recent work. Min et al. (2011) demonstrated that the observed increase in 1951-1999 in heavy precipitation over the Northern Hemisphere land areas can be attributed to human-induced increases in greenhouse gases in the atmosphere. Natural forcing alone would have caused long-term cooling and drying over this period. The authors also conclude that projected future changes in precipitation extremes may be under-estimated.

As part of the Prairie Regional Adaptation Collaborative (PRAC) project, the Saskatchewan Watershed Authority and the Saskatchewan Research Council are working with local watershed groups to further develop their drought and excessive moisture preparedness plans at the watershed level. The characterization of past drought and excessive moisture events can help understand historic risks associated with extreme events and ways to become better prepared for future extremes with pro-active adaptation strategies. This project also assists the Saskatchewan Watershed Authority's goal of water security by working with communities to identify potential water threats and ensure protection of the province's water resources.

This report includes eight sections ranging from the literature review to determining the drought and excessive moisture patterns of the 10 most extreme years and how the watersheds were impacted and adapted to these extreme years followed by conclusions and recommendations. In addition, there are appendices containing the top 10 extreme year drought and excessive moisture tables, and figures. Presentations targeting each of the watersheds are included as appendices.

PURPOSE AND OBJECTIVES

The purpose of this project is to provide information for improving the planning and preparation process for various watersheds located in Saskatchewan in regards to drought and excessive

moisture (DEM). By focusing on specific watersheds, the project will assist watershed stewards with future watershed planning. The objectives are:

- Develop databases of drought and excessive moisture indices for four selected watersheds (Swift Current Creek, North Saskatchewan, Assiniboine, and Upper Souris).
- Characterize drought and excessive moisture patterns for each watershed, drawing upon methods developed with the Canada Drought Research Initiative (DRI) network, for example
- Contrast and compare drought and excessive moisture patterns of the watersheds and of the province
- Consider the implications for impacts and adaptations
- Coordinate with other related projects for community vulnerability assessment and drought/excessive moisture preparedness planning
- Document the methods and results in a report, and
- Develop and deliver presentations for selected watersheds.

LITERATURE REVIEW

Drought and excessive moisture patterns have been characterized by various Canadian agencies such as Environment Canada and their seasonal trends analysis (2011), Agriculture and Agri-Food Canada and their drought watch website (2011) and the Saskatchewan Ministry of Agriculture and their weekly crop report (2011a). However, these are all very large scale analysis, not completed at a local watershed level and that creates difficulty in planning for extreme drought and excessive moisture events. Therefore, it is important to focus on the smaller scale to assist watersheds with their planning. This section examines information that has been completed.

Research undertaken by previous projects such as the Drought Research Initiative, the Institutional Adaptations to Climate Change plus numerous drought impacts and adaptation projects are utilized here.

Analysis of extreme drought and excessive moisture events requires excellent spatial and temporal coverage of various climatological variables over an extended period of time. Measured climate station data are not uniform in space or time therefore a gridded dataset is more beneficial when examining individual watersheds. In addition, gridded data have become more widely used in the scientific environment (Meinert et al. 2010). The reasons include availability of monthly data over the last century and the procedure of gridding data can remove unnecessary noise which results in smoother data than the station data (Meinert et al. 2010, Zhang et al., 2000). The Meinert et al. work was accomplished through the Drought Research Initiative program.

Meinert et al. (2010) studied the 1999-2005 drought by exploring the different methods for gathering available data and their accuracy. The study region included the agricultural region of the Canadian Prairie Provinces as well as a broader look at the North American Prairie Region. Three gridded data sets were evaluated for accuracy in quantifying drought characteristics, ANUSPLIN, CANGRID and the Climate Research Unit Time Series 2.1 (CRU) (Meinert et al. 2010). The ANUSPLIN dataset consists of historical monthly surface grids of precipitation and maximum and minimum temperature generated using thin plate smoothing splines for the 1901-2005 time period. The resolution is approximately 10 km (Hutchison 2004, McKenney et al. 2006). The CANGRID dataset consists of monthly precipitation and temperature data for the 1895-2007 period with a resolution of approximately 50 km (Zhang et al. 2000). The CRU grid covers the 1901-2002 period with a resolution of 0.5 degrees (Mitchell and Jones 2005). Meinert et al (2010) compared six prairie climate stations' temperature and precipitation values against six corresponding grid locations using the three gridded datasets. The stations were Edmonton, AB; Medicine Hat, AB; Saskatoon, SK; Regina, SK; Winnipeg, MB and The Pas, MB. They found that the ANUSPLIN dataset compared best to observed station data.

Bonsal et al. (2010) focused on the initiation, migration, persistence and termination of the 1999-2005 drought using the ANUSPLIN data. By assessing the Standardized Precipitation Index (SPI) and the Palmer Drought Severity Index (PDSI) the characteristics of this drought were compared to previous droughts in the Prairie region. The SPI and PDSI indices are described in the Database Development section. A stage system was developed to explore the life cycle of the 1999-2005 drought and to compare historic droughts six stages were created including 1) onset, 2) growth, 3) persistence, 4) peak, 5) retreat or decline, and 6) termination. This conceptual stage classification was tested and then applied to the following droughts: 1919, 1929, 1937, 1961, 1988, and 1999-2005. Bonsal et al. (2010) found the six stage system was accurate and useful in describing the life cycle of the droughts. The similarities between drought characteristics are a first step toward understanding surface dynamics of major drought episodes and towards coping with the impacts of droughts.

Wheaton and Nicolichuk (2010) used the ANUSPLIN dataset to examine the severe droughts and excessive moisture conditions in the agricultural portion of the Prairie Provinces for the 1901 to 2005 period. The location, spatial patterns, time frame and severity of these events were explored through the use of drought indices (i.e., PDSI and SPI). The purpose of the study was to improve the understanding of physical characteristics and dynamic space-time processes associated with these extreme events. By ranking the PDSI and Z values, the wettest and driest years were identified. They found that 2002 had the lowest PDSI value, while the mid-1970s had the highest value grids over the study area.

Vulnerabilities, impacts and adaptation strategies to droughts have been examined on the Canadian Prairies (e.g., Wheaton et al. 1992, Wheaton et al. 2008, Wittrock and Wheaton 2007, Wittrock et al. 2011). The reports examine three different drought episodes (1988, 2001-2002 and 2008-2010) of the last 25 years on the Canadian Prairies. Each region and community has

different climate, available resources (both natural and monetary) and vulnerabilities. This resulted in several different adaptation mechanisms being adopted to suit the specific regions' needs.

Most recently, drought impacts, characteristics and adaptations emphasizing the agriculture and water sectors were further examined for the 2008-2010 drought (Wittrock et al. 2010). They found a unique climatic pattern across the Canadian prairies. This included a cold and dry spring in 2009 which was abruptly terminated when a sequence of rainstorms began in mid July and lasted to the latter half of August followed by hot and dry fall lasting to the end of November. The winter of 2009/2010 continued to be extremely dry resulting in minimal runoff in March and early April 2010.

Excessive moisture in the Canadian Prairies also occurs. However, there is very little research targeted at excessive moisture conditions on the Canadian Prairies. This could be due to frequency of occurrence. Extreme excessive moisture conditions are usually localized and occur due to an intense summer precipitation event. They generally do not cover large areas and are generally short lived, unlike drought events. An exception to this is 2010, a very large area across the Canadian Prairies has been affected by extreme excessive moisture conditions resulting in society facing new challenges to deal with the impacts of these extremes.

DATA AND METHODS

Study Area

The study area includes four watersheds (Figure 1) in Saskatchewan including Swift Current Creek, Upper Souris River, Assiniboine River and the North Saskatchewan River. Two of the four watersheds are located in the Palliser triangle (Swift Current Creek and Upper Souris River Watershed). The Palliser Triangle is the driest part of the Canadian Prairie Provinces (Figure 2). The Swift Current Creek is major prairie tributary of the South Saskatchewan River and the Souris River eventually feeds into the Assiniboine River.

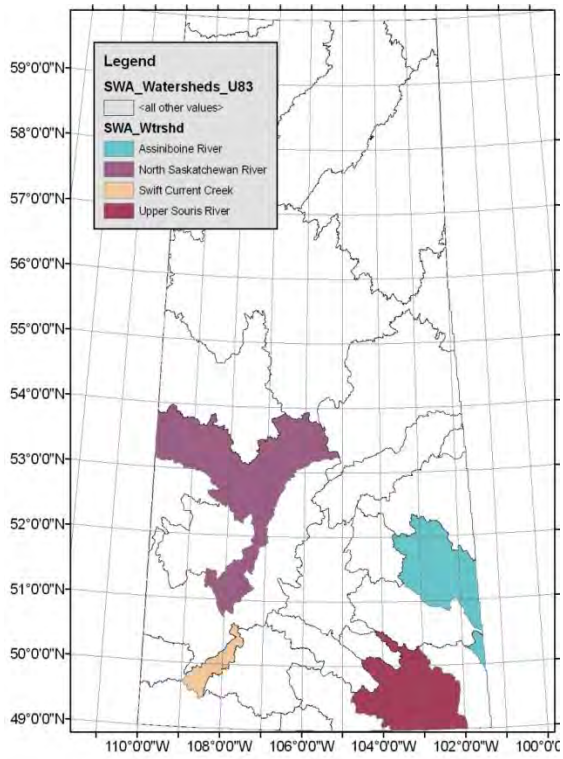

Figure 1 Study area with the four watershed (SWA 2010a)

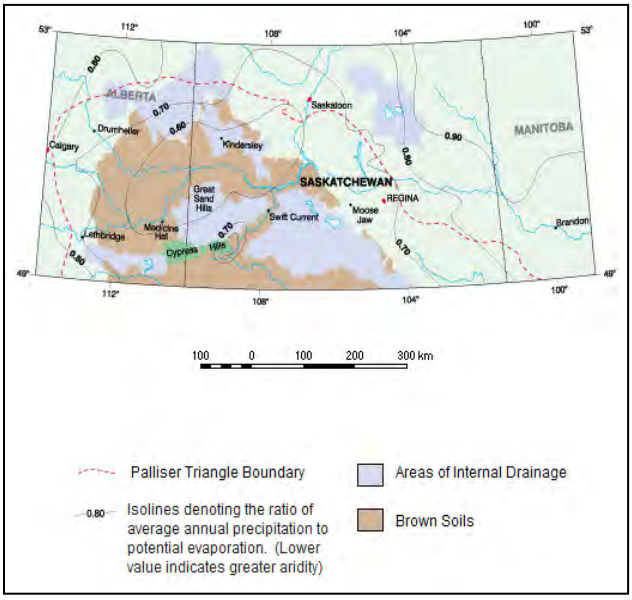

Figure 2 The Palliser Triangle (Lemmen and Dale-Burnett 1999)

The watersheds are unique in terms of their river systems, climate and topography, for example. Each of the watershed planning groups have undertaken an examination of each of their watersheds (Swift Current Creek Advisory Committee and Saskatchewan Watershed Authority (2009), North Saskatchewan River Basin Council and SWA (2007), Assiniboine River

Watershed Advisory Committees and SWA (2006), Upper Souris Advisory Committee and SWA (Draft 2010)) to foster healthy watersheds and protect source water quality and quantity.

Swift Current Creek Watershed

The Swift Current Creek watershed is located in the southwestern corner of Saskatchewan (Figure 3). The creek is formed by spring runoff and flows into the South Saskatchewan River. The watershed's major reservoir, the Duncairn dam, provides its major center, Swift Current, with a reliable water supply (SWA 2009).

The Swift Current Creek watershed is located in the semi-arid portion of the province and is part of what is commonly known as the Palliser Triangle, a drought-prone region of the Canadian Prairies. Swift Current, located in the north east portion of the basin, has an average annual temperature of 3.9°C with the January average temperature of -12.4°C and a July average temperature of 18.1°C with the averaging period of 1971-2000. Its extreme maximum of 38.9°C occurred on August 5th, 1961 and its extreme minimum temperature of -42.0°C occurred on December 23rd, 1983. Swift Current's annual average is 260.8 mm of precipitation with the majority in the May to September period (Data: Environment Canada 2011).

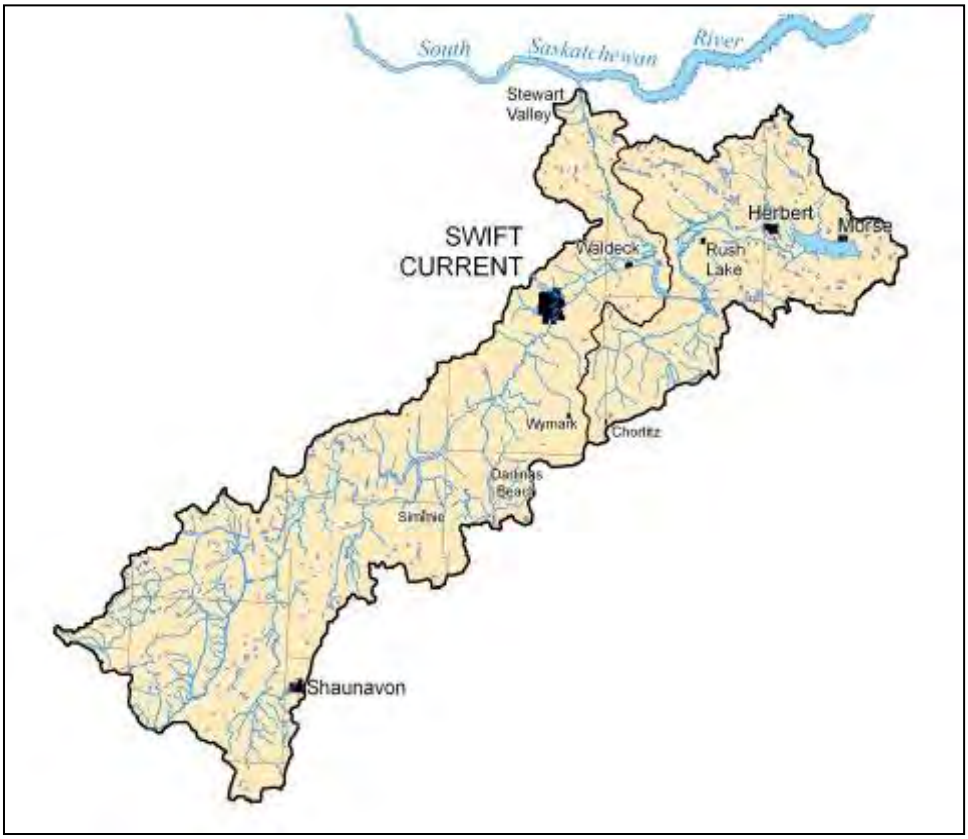

Figure 3 Study Area Map of the Swift Current Creek Watershed (SWA 2010b)

A major background report was completed for the Swift Current Creek Watershed in 2009 (SWA 2009) detailing demographics, general physical characteristics including topographic and soil information as well as surface and ground water availability and water trends such as creek flows and wastewater management.

Upper Souris Watershed

The Upper Souris Watershed is located in southeastern Saskatchewan (Figure 4). This river system flows with spring runoff and high precipitation events. The Souris River flows into North Dakota and then travels into Manitoba to join the Assiniboine River System.

The Upper Souris Watershed is located in a semi-arid climate with extremes in temperature and precipitation common place. The Weyburn region (northwest portion of the watershed) had an average yearly temperature of 3.5°C with an average annual daily minimum of -2.7°C and average annual daily maximum temperature of 9.6°C. The average January temperature is -15.3°C and the average July temperature is 19.1°C based on the 1971-2000 averaging period. Weyburn is subject to temperature extremes with the coldest recorded temperature of -42.2°C in 1969 and the warmest at 41.7 in 1917°C. Based on the 1971-2000 averages, the Weyburn region average annual rainfall is 318 mm and snowfall is 101 cm. Estevan, located on the southern edge of the watershed, is slightly warmer with an average yearly temperature of 3.7°C. This is reflected in the higher annual daily maximum temperature of 9.9°C and minimum temperature of -2.4°C. The July average daily temperature is -14.8°C and the July average daily temperature is 19.5°C based on the 1971-2000 averaging period. The Estevan region receives on average slightly more precipitation than the Weyburn region. The average annual rainfall amount is 333 mm and snowfall is 111 cm. As for Weyburn, Estevan's coldest temperature was -42.2°C in 1954, while the warmest occurred in 1958 when a temperature of 41.1°C was attained (Data: Environment Canada 2011). The highest temperature ever recorded in Canada was 45°C on 5 July 1937 at Midale and Yellowgrass (Wheaton 1998).

A major background report was completed for the Upper Souris Watershed in 2010 (Upper Souris Watershed Association and SWA 2010). That report examined demographic, bio-physical and watershed planning that is currently underway in the watershed. It also makes recommends of future actions required in the watershed.

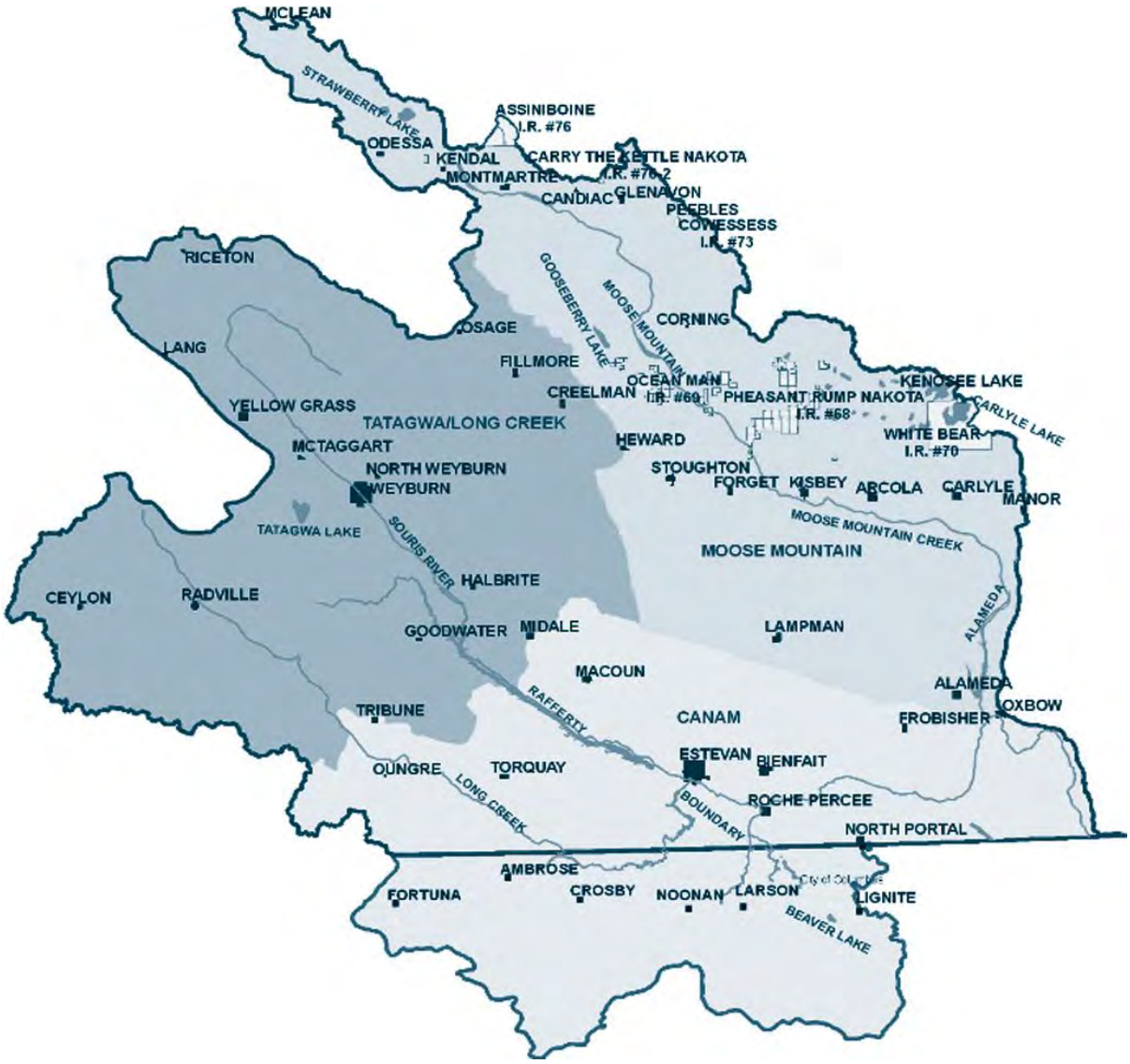

Figure 4 Study Area Map of the Upper Souris Watershed (Upper Souris Watershed Association and SWA 2010).

Assiniboine Watershed

The Assiniboine watershed is located in east central Saskatchewan (Figure 5). As for the Swift Current and Upper Souris watersheds, it's major flows occur with spring runoff and extreme rainfall events.

There is only one climate station in this watershed. Yorkton has an average annual daily temperature of 1.6°C with and average daily maximum of 7.5°C and an average daily minimum of -4.3°C. The January daily average temperature is -17.9°C and the July daily average temperature is 17.8°C based on the 1971-2000 averaging period. This region generally receives

more than 346 mm of rainfall and more than 117 cm of snowfall. The record low temperature is -46.1°C in 1943 and the hottest was 38.9°C in 1941 (Data: Environment Canada 2011).

Figure 5 Assiniboine River Watershed Map (Harrison et al. 2000).

Major reports were completed for the Assiniboine River Watershed in 2000 (Environment Canada, SaskWater and Manitoba Conservation) and 2005 (SWA 2005). The first report examined current and emerging water issues related to both surface and ground water supplies and quality of those supplies. The second report examines demographic, bio-physical and watershed planning that was underway in the watershed. It also makes recommendation of future action items that are required in the watershed. Some of the recommendations include protection water quality upstream of surface water intakes, improve the connectivity of aquatic habitat and prepare a nutrient reduction plan as examples.

North Saskatchewan Watershed

The North Saskatchewan River Watershed is one of the largest watersheds in Saskatchewan (Figure 6). It is located from the west central to central portion of Saskatchewan. This watershed originates in the Columbia ice fields of the Rocky Mountains. In Saskatchewan the watershed covers a total of 41,000 km^2 (North Saskatchewan River Basin Council and SWA 2007).

This basin has three long-term climate stations located at Prince Albert, North Battleford and Lloydminster. Based on the 1971-2000 averages, the Prince Albert area is the coldest and wettest part of the basin (Table 1). This is illustrated by its extreme minimum temperature when Prince Albert's climate station recorded a -50°C temperature in 1943. This is further illustrated with the January daily average temperature at Prince Albert more than 2°C colder than North Battleford and more than 4.5°C colder than Lloyminster. The average daily July temperatures are generally warmer in North Battleford and Prince Albert than Lloydminster by 1°C. Prince Albert has also been the hottest station in the basin with a maximum daily temperature of 38.8°C recorded in 1988.

Table 1 1971-2000 Average yearly climatic conditions (Environment Canada 2011)

	Temperature (°C)								Precipitation	
Station	January Average Daily Maximum	January Average Daily Minimum	January Daily Average	July Average Daily Maximum	July Average Daily Minimum	July Daily Average	Extreme Maximum	Extreme Minimum	Rainfall (mm)	Snowfall (cm)
Prince Albert A	-13.0	-25.2	-19.1	23.9	11.1	17.5	38.8 (1988)	-50 (1943)	323.7	111.3
North Battleford A	-11.8	-22.2	-17.0	24.0	11.2	17.6	37.9 (1991)	-43.1 (1943)	282.4	105.1
Lloydminster A	-9.8	-19.2	-14.5	22.6	10.5	16.6	37.4 (1998)	-42.5 (1994)	311.4	103.5

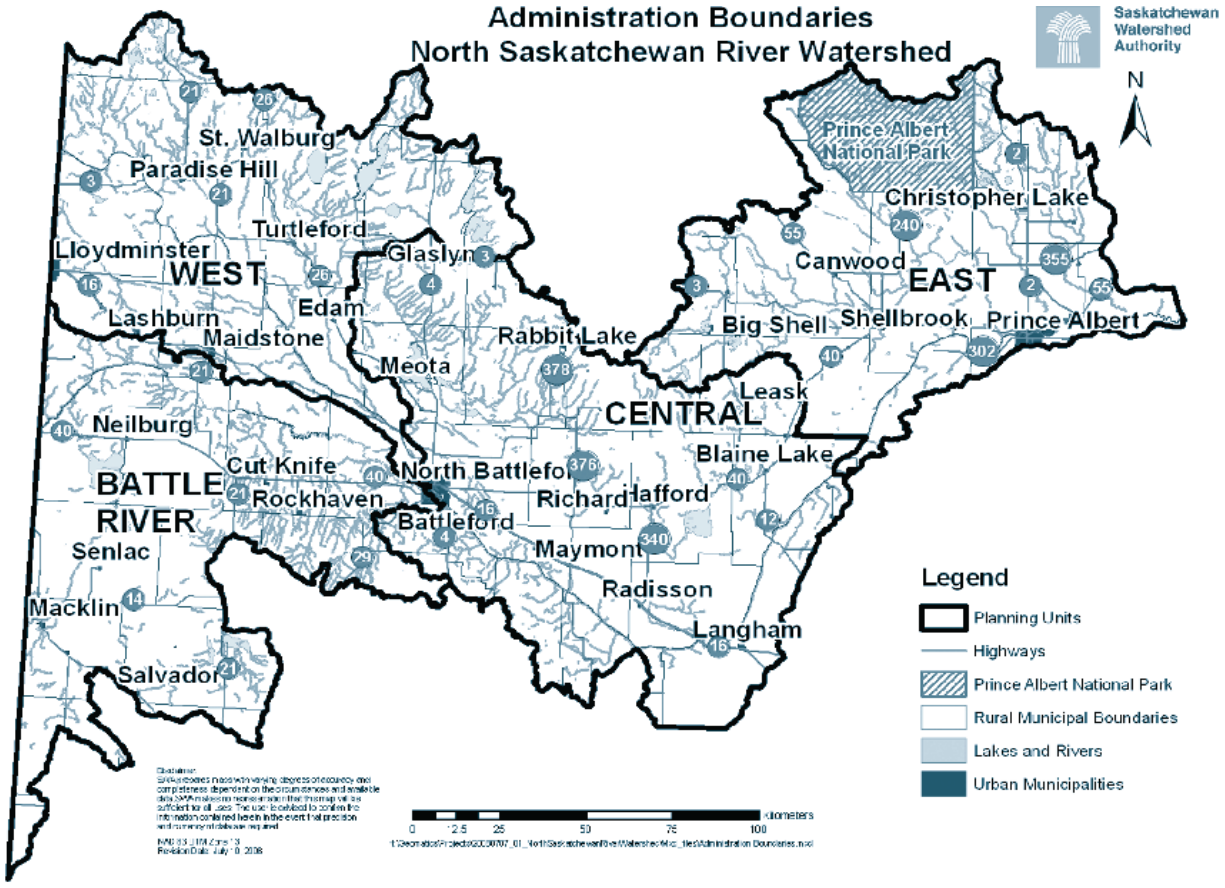

Figure 6 North Saskatchewan River Basin Watershed Map (North Saskatchewan River Basin Council and SWA 2008)

Database Development

As stated previously, the ANUSPLIN data set was chosen over the Canadian gridded climate data (CANGRID) and the Climate Research unit data (CRU TS 2.1) because of its ability to capture several significant precipitation events and its extensive coverage (Meinert et al. 2010, Wheaton and Nicolichuk 2010). Among the numerous meteorological indices available, the Standardized Precipitation Index (SPI) and Palmer Drought Severity Index (PDSI) were selected based on their accuracy and availability of gridded monthly data. These indices were calculated by Meinert et al. (2010) using the ANUSPLIN dataset for monthly temperature and precipitation. The SPI utilizes just one parameter, precipitation (McKee et al. 1993). PDSI is a more complex water balance model that uses precipitation and temperature to derive potential evapo-transpiration, antecedent soil moisture and runoff (Palmer 1965). The 12-month SPI had a strong correlation with the PDSI values (Guttman, 1998). The level of drought and excess moisture described by PSDI and SPI are characterized in Table 2.

Table 2 Classifications based on the PDSI and SPI indices (Palmer 1965, McKee et al. 1993).

Classification		PDSI	SPI
Drought	Exceptional	≤ -5	≤ -2.5
	Extreme	> -5.0 to -4.0	> -2.5 to -2.0
	Severe	> -4.0 to -3.0	> -1.5 to -1.0
	Moderate	> -3.0 to -2.0	> -1.0 to -0.5
	Mild	> -2.0 to -1.0	> -0.5 to 0.5
Near Normal		> -1.0 to 1.0	> -0.5 to 0.5
Wet	Mild	1.0 to < 2.0	0.5 to < 1.0
	Moderate	2.0 to < 3.0	1.0 to < 1.5
	Severe	3.0 to < 4.0	1.5 to < 2.0
	Extreme	4.0 to < 5.0	2.0 to < 2.5
	Exceptional	≥ 5.0	≥ 2.5

The ANUSPLIN gridded data set of monthly temperature and precipitation was used to calculate monthly PDSI, PDSI Z-values and SPI values (Meinert et al. 2010). These values were then extrapolated for each of the selected watersheds. Watershed boundary maps were supplied by the Saskatchewan Watershed Authority. The data include monthly and yearly durations focusing on the agricultural year (September to August). The years with the ten most extreme drought and excessive moisture months were then selected and ranked for each watershed. The extreme value is a point value within the entire watershed. Depending on the size of the watershed, the extreme excessive moisture or drought event could be occurring on one side of the watershed but near normal condition may be happening on the other side.

The extrapolated data are then imported into a GIS package (SURFER (Golden Software 2010)). The watersheds were evaluated based on indices, time period, spatial pattern and spatial extent to explore the characteristics and patterns of the drought and excessive moisture events.

The ANUSPLIN data set covers the 1901 to 2005 period. In order to bring the information to 2010, other sources were required. Agriculture and Agri-Food Canada and Environment Canada information helped extend the analysis to include the drought of 2008-2010 and excessive moisture year of 2010.

The PDSI and SPI values are compared with change in spring wheat yield from average for the individual watersheds. Crop yield information was attained from the Saskatchewan Ministry of Agriculture (2011b). The rural municipal yield data was averaged across each of the watersheds on a yearly basis. The 10 year production average was then calculated based on the years 2000-

2009 inclusive. These values give a very general indication of the impact drought and excessive moisture had on production. However, other factors also influence yield amounts including technological improvements, farm management strategies, insect and disease infestation plus others. Crop yield information is not available pre-1938.

Physical and biological impacts of the drought and excessive moisture situations are documented through analyzing water resource and agriculture information. The impacts and adaptation strategies implemented were documented using a media survey methodology.

Presentations (Appendix 4) were developed for each of the watersheds. The purpose of the presentations was to assist Saskatchewan Watershed Authority and the watershed planning groups with determining when the drought and excessive moisture extremes had occurred in the past, how extrodinary they were, what impacts were incurred by these extremes and how the various watershed adapted the drought and excessive moisture episodes historically. Also included in the presentations, because 2011 may be another excessive moisture year, climate and flood projections were also presented for each of the watershed.

DROUGHT AND EXCESSIVE MOISTURE PATTERNS

The watersheds have different extreme excessive moisture and drought years and different spatial patterns. The top ten most extreme drought and excessive moisture years for each watershed are presented in Appendix 1. The spatial patterns of the most extreme year are presented in Appendix 2. This section is split into two time periods. The first examines the individual watersheds for the top 10 most extreme PDSI and SPI drought and excessive moisture years for the 1901-2005 period using the ANUSPLIN data set. The last section examines the most recent drought and excessive moisture years 2009 and 2010 using PDSI and SPI information supplied from Agriculture and Agri-Food Canada. It is recommended that the whole period of record be classified to determine the trends of wettest to driest. This was beyond the scope of the current project.

Swift Current Creek Watershed

PDSI

As mentioned previously, the Swift Current Creek watershed is located in what is historically considered one of the driest regions of the Canadian Prairies. Six of the 10 most extreme Palmer Drought Severity Index (PDSI) drought values occurred pre-1940 with the most extreme dry PDSI value recorded in 1937 at -6.5. This is unique for the four watersheds examined in this report. The other watersheds were not as continuously dry during the early 20th century. More recent years have also be categorized as being drought years, for example, 1988 is ranked #3 in PDSI drought rating with a value of -6.0 and 1961 is ranked 9th with a value of -5.2.

These extreme dry years contributed to the region having spring wheat crop production dropping to almost 60% below normal in 1988 and more than 75% below normal in 1961 compared to the average 28 bushels/acre for the region (Appendix 1 Table 1). The regional variation of the most severe moisture deficit year indicates that the northern portion and the southern portion of the Swift Current Creek Watershed were in slightly less drought conditions than the rest of the basin (Appendix 2 Figure1).

While this region can be afflicted with drought for extended periods of time, it also has excessive moisture events such as the 1950s when three years are considered excessive moisture years using PDSI (1954 (6.8 – the most extreme), 1951 and 1953 (5.6) (Appendix 1 Table 1)). The most recent extreme excessive moisture year, using the ANUSPLIN 1901-2005 database was 2004 with an excessive moisture level of 5.8 (third wettest).

Unlike below average crop production in drought years, excessive moisture years resulted in half of the top ten excessive moisture years having above average crop production and half below average crop production. This could indicate that the some of the excessive moisture years just allow the region to attain adequate moisture levels for crop production. The regional variation for 1954, the extreme excessive moisture year, indicates the north eastern half of the Swift Current Creek watershed was wetter and the south western portion was less extreme (Appendix 2 Figure 1).

More recently in 2009 and 2010, the region has fluctuated from having PDSI values in the -2 to -3 range (categorized as a moderate drought) in 2009 (Figure 7) to having values in the 3 to 4 (categorized as a severe excessive moisture) range in 2010 (Appendix 2 Figure 8).

PDSI Z-value

The PDSI Z-values indicate how quickly and by how much the area switches from being a dry region to wetter and vice versa. The early 21st century indicates the relative speed the switch from being in drought situation to excessive moisture situation. For example 2001 had the second worst PDSI Z-value for the Swift Current Creek watershed, and 2002 was the second highest extreme year for excessive moisture. 2003 was the fourth worst drought year and 2004 the sixth worst excessive moisture year. The impact on spring wheat crop production in these years shows that all four years had below average yields ranging from except 2004 when yields were over 20% above the 10 year average (Appendix 1 Table 2).

The two most extreme PDSI Z-values were mapped to show the spatial changes (Appendix 2 Figure 2). The greatest change towards drought conditions in 1961 was in the northeastern portion of the watershed with less change to drier conditions occurred in the southwestern portion. The Z-value for greatest moisture increase had similar geographic detailing with the greatest increase in moisture in the northeast, while the southwest had a smaller increase in moisture in the extreme year of 1993.

In 2009 PDSI Z-value indicates a trend to drier than normal conditions (Figure 9), while August 2010 PDSI Z-value indicates a trend towards much wetter conditions in the Swift Current Creek watershed region (Figure 10).

SPI One-month extremes

The one-month Standardized Precipitation Index (SPI) gives a snapshot of an extreme precipitation event or lack of one for a much shorter period than a year. The extreme SPI for a month addresses the question: What is the month with the most extreme value for the 1901 to 2005 period? This analysis provided information about the seasonality of the extreme event. This timing is significant in terms of impacts and preparing to alleviate negative impacts.

In the Swift Current Creek watershed May 1927 had the highest SPI value (3.1) (Appendix 1 Table 3) with the basin being relatively homogeneous in its spatial variation (Appendix 2 Figure 3). The spring timing of this excessive moisture would mean increased risk of flooding with snow-melt occurring at a similar time. Also spring agricultural operations would be more difficult. However, spring moisture may be helpful for summer vegetation growth. June 1967 had the lowest SPI value at -3.9 (Appendix 1 Table 3??). June droughts are more damaging for agriculture and water management than a winter drought.

The spatial variability for lack of moisture is more diverse than excess moisture. The driest region is in the southwest while the moistest region is in the northeast portion. The negative SPI values translated into well below average crops in the watershed with 1961 having the lowest wheat yield at almost 80% below normal. All of the negative SPI values corresponded to below average wheat yields, as did all of the positive SPI values except for 1986. That year had an 18% increase in wheat yields perhaps because the excessive moisture month did not occur until September. While this would not have directly impacted the growth of the crop it may have resulted in poor harvest conditions that year and could have decreased the quality of the grain.

On a seasonal examination of the monthly extremes, the one-month drought episodes occur most often in the winter (December, January, February) and summer (June, July and August). The SPI one-month excessive moisture period is commonly in the winter with five of the 10 extreme months and years occurring in the winter season (Appendix 1 Table 3). This pattern of excessive moisture and drought has implications for spring runoff (too much, too little) and the summer growing season.

SPI 12-month extremes

Similar to the PDSI drought values, half of the SPI 12 month values occurred pre-1940 with the most extreme year also being 1937 with an extreme low value of -2.4 (Appendix 1 Table 4). This low SPI value was very homogonous across the basin with only the extreme southwest side being slightly less dry (Appendix 2 Figure 4). The regional variation for 2004 extreme wet year

was greater than for the moisture deficit variability. The south west corner was the wettest and the northeast corner of the watershed, the driest (Appendix 2 Figure 4).

The years with available wheat yield data showed extremely poor yields. This was especially true for the 1949 drought when the SPI value was -2, the crop yield was more than 90% below normal in the watershed ((Appendix 1 Table 4). The 12 month excessive moisture values do not appear to give a complete picture of yield potential. While three of the years were pre-1930 with no crop yield information available, the other years fluctuated between having above normal yields (2004, 1991, and 1966) to well below normal yields (1965, 1974, 1954 and 1951). Questions that need to be asked are: why this variability in yields, what were the antecedent climatic conditions (e.g., previous wet year/dry year, above/below normal temperatures etc) and what were the other non-climatic conditions (insects/disease infestation, farm management practices, etc)?

Upper Souris Watershed

PDSI

The Upper Souris River Watershed fluctuates from extreme drought to extreme excessive moisture. The driest year, according to the PDSI, was 1961 with an extreme low value of -8.0. This is a much worse drought (three PDSI values lower) than the Swift Current Creek watershed. Not surprising, the decrease in wheat yield was greater (80% below average) in the Upper Souris than Swift Current Creek (77% below average) (Appendix 1 Table 5). The second driest year was 1988 with an extreme low PDSI of -6.8 (Appendix 1 Table 5). The spatial characteristics of the extreme drought year of 1961 indicate that the northern portion of the watershed was hardest hit by the drought while the western edge was less severe, closer to the values recorded in the Swift Current Creek watershed for that period (Appendix 2 Figure 5).

The Upper Souris River watershed had half of its top 10 most extreme PDSI excessive moisture years pre-1930 with 1927 being the most extreme year (6.4) (Appendix 1Table 5??). The spatial variation (Appendix 2 Figure 5) of this extreme year shows the western edge of the watershed having the greatest excessive moisture levels and the northern edge lower excessive moisture values but still considered as severe (Table 1). More recent years, 1991 and 1999 are listed in the top 10 excessive moisture years. However, these years do not show a large decrease in wheat production (-8% and -6% respectively) (Appendix 1 Table 5). This results in questions being asked such as what were the antecedent climatic conditions that may have caused the yields to be less severely impacted. This case was especially true for 1991 which is rated at the third worst in PDSI excessive moisture values.

PDSI Z-value

Six of the top 10 years for changes in extremes to a drought environment have occurred since 1960. The most extreme year was 1961, followed by 1984. Then four years are tied for third

positioning with 2001, and 2003 being two of those four (Appendix 1 Table 6). The spatial variability of 1961 shows the severe drought was relatively uniform throughout the watershed (Appendix 2 Figure 6). Just a small area on the far eastern edge of the watershed was extremely severe and a very small portion on the western edge was only slightly less severe.

The PDSI Z-value excessive moisture also has more years recording extreme changes in excessive moisture since 1960. The most extreme Z-value of excessive moisture occurred in 1968 with a value of 9.6. However, unlike the homogeneousness of the Z-value moisture decrease, the spatial variability of moisture increase was dramatic. The greatest moisture increase occurred on the western side of the Upper Souris River Watershed with levels in the 9 to 10 range, but a strong gradient runs east and northward across the basin with the northeastern edge having values in the 4 to 6 range. However, those northeastern values are still categorized as having extreme to exceptional excessive moisture values (Appendix 1 Table 6 and Appendix 2 Figure 6). The impact of this excessive moisture on the wheat yield was a nearly 50% drop.

SPI One-month extremes

The one-month SPI top 10 extremes show all but one of the one-month drought extremes occurred since 1960 with the greatest extreme drought occurring in August of 1961 with a drop in wheat yield of nearly 80% (Appendix 1 Table 7). The spatial pattern of the August 1961 SPI indicates that the large central portion of the watershed was most extreme with the less extreme SPI values still rated at "extreme" (Table ?). These are located on the far western edge of the watershed (Appendix 2 Figure 7).

Seasonally, the one-month SPI drought events for the Upper Souris River watershed are spaced relatively equally throughout the year for the 10 most extreme years. Winter (November, December and January) had two extreme events, spring (March, April, May) and summer (June, July, August) had three, and autumn (September, October, November) had two. All the drought years had below normal wheat yields except for the fall 1969 when the wheat yield for the watershed was 12% above normal (Appendix 1 Table 7).

The top 10 SPI one-month excessive moisture extremes show that all of these extremes except for one (1902) have occurred since 1960 with five in the last 20 years (Appendix 1 Table 7). July 1993 had the highest SPI value at 3.5 located on the far western edge of the watershed (Appendix 2 Figure 7). The area of least extreme excessive moisture for July 1993 was in the north eastern arm of the Upper Souris River watershed. Even though July 1993 was the most extreme SPI month, wheat yields were fairly close to average at 2.6% above average (Appendix 1 Table 7). In the top ten years of one-month SPI excessive moisture calculations, three were in winter (February), four were in spring, two in the summer and only one in the fall. While most of these excessive moisture months resulted in below normal wheat yields, all but one (Aug 1968 at 48% below average) had less severe negative impacts compared with the extreme one-month drought SPI (Appendix 1 Table 7).

SPI 12-month extremes

The year of the 12-month SPI drought extreme corresponds to the PDSI drought extreme for the Upper Souris River watershed. 1961 had an extreme low value of -4.2 with a corresponding extreme low wheat yield 80% below average (Appendix 1 Table 8). Spatially, the SPI and PDSI are also similar with the north eastern arm of the watershed being the most extreme and the western edge having the lesser extreme (Appendix 2 Figure 8). All but one of the years (1977 at 4% above average) with available crop information had yields that were well below average – at least 39% or lower (Appendix 1 Table 8).

The 12-month SPI excessive moisture year was 1999 with a value of 2.4 classified as "extreme" (Table 1). Even though it is the most extreme excessive moisture year for the 1901-2005 period the change in wheat yield was only about 5% below average (Appendix 1 Table 8). Spatially, the most extreme region of the watershed was located over a large region in the west central portion of the watershed. The drier region, classified at the moderate level, was in the south eastern portion of the watershed (Appendix 2 Figure 8?).

The top 10 years for excessive moisture ratings were less extreme compared with the top 10 years for SPI drought. Correspondingly, the decrease in wheat yield for excessive moisture was not as extreme as the drought decrease except for 1947. The SPI value for 1947 as 1.6 is classified as severe, but is classified as the least extreme of the top ten years (Appendix 1 Table 8). However, the corresponding decreases in wheat yield are 45% below average. This indicates that more than just excessive precipitation could have occurred in this watershed and should be invested.

Assiniboine Watershed

PDSI

The Assiniboine River watershed is a watershed of extreme high PDSI values (excessive moisture) and extreme low PDSI values (drought). It is the most extreme of the four watershed examined in this project. All of the drought years are classified as being "exceptional" while all but two of the excessive moisture are also classified as "exceptional" (Table 1) (Appendix 1 Table 9). Like the other four watersheds, the PDSI Drought year that was most extreme was 1961 when an unbelievable PDSI value of -8.7 was calculated. The corresponding dramatic drop in wheat yield (80% below average) is not surprising considering that low PDSI value (Appendix 1 Table 9). Spatially, the region that had the lowest PDSI value in the Assiniboine River watershed was in the central portion including the area around Kamsack through to Melville (Appendix 2 Figure 9). Seven of the 10 extreme drought PDSI values occurred prior to 1960 with none occurring between the 1985 to 2005 period. The corresponding drop in wheat yields for years that were available was at least 18% below average (Appendix 1 Table 9).

PDSI excessive moisture time period is opposite to the drought period. All ten excessive moisture extreme years have occurred since the 1940s with five occurring since 1990 had four of the 10 extreme excessive moisture PDSI years (1993, 1994, 1995, 1996 and 2005). The wheat yields all declined for all years except 2005 when yields rose by nearly 10% above average. The reason behind this increase in yield needs further investigation. The decreases in yields were generally not as extreme as the decrease in PDSI top ten drought years. The most extreme excessive moisture year occurred in 1954 with an extreme PDSI value of 8.4. This year had a drop in wheat yield of over 70% (Appendix 1 Table 9). Spatially, this extreme PDSI value was in the northwest section of the watershed decreasing to an excessive moisture level of "severe" in the south east corner (Appendix 2 Figure 9).

PDSI Z-value

Like PDSI most extreme drought year, the PDSI Z-value extreme drought year was 1961 indicating there was a dramatic shift towards a drier situation between 1960 and 1961 with a Z-value of -6.5 (Appendix 1 Table 10). There is not a large spatial variability to the Z-value in 1961 with the entire watershed switching to drier values relatively consistently (Appendix 2 Figure 10). For the ten extreme Z-value drought years, seven occurred between 1960 and 2005 with the two most recent in 2001 and 2003 when Z-values of less than -4.5 were attained. All the years with negative Z-values had below average wheat yields with only 2003 close to average (Appendix 1 Table 10).

The most extreme PDSI Z-value for excessive moisture in the Assiniboine River watershed was in 2002 with a value of 9.9. This year is sandwiched between two extreme Z-value drought years, 2001 and 2003. The wheat yields were below normal for all three of these years with the excessive moisture year having the lowest yield at nearly 17% below average. The spatial variation for 2002 was very marked across the watershed. The northwestern portion of the basin had the highest Z-value while the eastern edge is classified as being "moderate" for excessive moisture (Appendix 2 Figure 10). Similar to the Z-value drought extremes, the Z-value excessive moisture extremes had the majority occurring post 1960 with five in 1985-2005 period. All but two of the years (2005 and 1985) had below average yields (Appendix 1 Table 10).

SPI One-Month Extremes

The most severe SPI one-month extreme drought occurred in May 1971 with a value of -4.5 and had a decrease in crop production of 12% from average (Appendix 1 Table 11). The spatial variability was quite large with the northern edge of the watershed in most severe drought while the southern edge, on the Saskatchewan/Manitoba border was in a "mild" drought situation (Appendix 2 Figure 11). August 1961 is the third worst one-month extreme SPI value but the worst in terms of crop production with production being more than 80% below average for the entire watershed. In the Assiniboine River watershed, winter and spring are the most common

seasons for one-month extreme droughts with fall being the least common. All but two years, of the years with available crop data, had below average yields (Appendix 1 Table 11).

The majority of SPI one-month excessive moisture extremes occur in the summer and fall but all have negative implications on yields. The years when extreme excessive moisture occurred in the traditional harvest months of August, September and October may have had more than an impact on below normal yields, the excessive moisture may have also delayed harvest and resulted in negatively impacting the quality of the crops (Appendix 1 Table 11). The most extreme one-month SPI excessive moisture value occurred in April 1975 with a value of 3.2 with the highest SPI values calculated for the western side of the watershed and the less extreme values categorized at the "severe" level in the northeastern and south eastern portions of the watershed (Appendix 2 Figure 11).

SPI 12-Month Extremes

The Assiniboine River watershed extreme 12-month SPI drought year was 1961 with an exceptionally extreme value of -4.6 and a wheat yield that was more than 80% below normal. This extreme value occurred in the east central portion of the basin with less severe regions in the northwest and south (Appendix 1 Table 12, Appendix 2 Figure 12). Seven of the most extreme 12-month drought SPI years occurred pre-1960 with six 1940 or before. The watershed had below average yields for all of these drought years, where information was available, with 1977 the least drop in yield at 17% below average (Appendix 1 Table 12). None of the extreme SPI 12-month droughts occurred in the 1985 to 2005 period.

As indicated with the PDSI excessive moisture value for the Assiniboine River watershed, the SPI 12-month excessive moisture extreme also occurred in 1954 with a value of 2.4 categorized as "extreme" (Appendix 1 Table 12). This region lands in the northwestern portion of the watershed with less severe or categorized as the "moderate" region, in the eastern half of the watershed (Appendix 2 Figure 12). Five of the top ten SPI 12-month excessive moisture years occurred pre-1960. The 1985-2005 period had four of the top ten years with the most extreme year in 1995 with a value of 2 or "extreme". The years of 2004 and 2005 rounded out the top ten with values of 1.7, classified as "severe" excessive moisture years (Appendix 1 Table 12). All of the excessive moisture years had below average wheat yields except for 2005 which was 10% above average.

North Saskatchewan River Watershed

PDSI

The North Saskatchewan River watershed is the largest watershed of the four examined in this project. As the result there is large variability within the watershed where one region could be in a drought situation while another portion of the watershed could be in an excessive moisture situation. This is the exact situation of what occurred in 1915 with the PDSI. The north eastern

portion of the watershed was having PDSI values less than -7.0 while the south western portion had values in the one to two range classified as a mild excessive moisture situation (Appendix 1 Table 13, Appendix 2 Figure 13). Four of the driest years occurred pre-1940, two were in the early 1970s and one in 1988. Most recently the early 21st century had three of the driest years with 2002 ranking 4th with wheat yields below normal by more than 70% (Appendix 1 Table 13).

The North Saskatchewan River watershed has the most extreme PDSI excessive moisture value at 10.1 in 1974, a dramatic change from 1973 when an extreme minimum PDSI value of -5.6 was calculated (Appendix 1 Table 13). The spatial variability across the river basin in 1974 shows the extreme high excessive moisture PDSI values were in the north eastern portion of the watershed while the values closest to normal PDSI were in the south western corner of the watershed (Appendix 2 Figure 13). The 1973 to 1975 inclusive period all had high PDSI values of at least 7.0, all with below average wheat yields. The lowest wheat yield year was 1954 with nearly 73% below normal wheat crops and a PDSI value of 7.1 (Appendix 1 Table 13).

PDSI Z-value

Like the other watersheds, 1961 was the year for trending toward a drying scenario. The trend towards dryness was more evident in the southern two/thirds of the watershed with a rating of "exceptional" while the rest of the watershed having a rating of -3 or lower (severe to extreme) (Appendix 1 Table 14, Appendix 2 Figure 14). Six of the 10 extreme Z-value PDSI years occurred post-1960 with three between the 1985 to 2005 period. All of the years had below average wheat yields with the lowest record in 1961 and 1958 (58 and 51% below average respectively) (Appendix 1 Table 14).

The highest excessive moisture year Z-value of the four watersheds occurred in 1954 with a value of 11.9 and a decrease in wheat yield for the entire basin of nearly 73% below average (Appendix 1 Table 14). The spatial variability of the excessive moisture PDSI Z-value is greater than for the moisture decrease. The highest Z-value is in the southeast-central region with the lowest Z-value in the southern portion of the watershed. However, all of the values are well above the "exceptional" classification (Appendix 2 Figure 14). Seven of the ten Z-value excessive moisture PDSI years had below average wheat yields. The three that had above average yields were 1982, 2005 and 1993. 1982 and 2005 were years when the watershed was recovering from drought events in previous years. Six of the 10 extreme excessive moisture PDSI Z-values have occurred since 1960 with the most recent occurring in 2005 for the 2001 to 2005 period (Appendix 1 Table 14).

SPI One-Month Extremes

The North Saskatchewan River watershed SPI one-month droughts occur predominantly in the spring period with four occurrences in 1967, 1980, 2002 and 1988. The other seasons are split equally for monthly extreme one-month occurrences of droughts. In addition eight of the 10 most extreme one-month SPI values occurred since 1960 with three in the 1985-2005 period. The

most extreme year, like many of the other watersheds was August 1961 when a SPI value of -3.7 was attained (Appendix 1 Table 15). The spatial variability of this month is large with the southern peninsula of the watershed being most extreme while the far northern edge of the watershed classified in the "moderate drought" range (Appendix 2 Figure 15). While this watershed did not have as extreme of SPI levels as some of the other watersheds, the wheat yields were still nearly 60% below the average amount (Appendix 1 Table 15).

The SPI one-month excessive moisture period is predominantly in the spring and summer period with four occurrences in each of the months and two occurred in the winter season. This is the only watershed with no extreme one-month excessive moisture period did not occur in the autumn. Six of the 10 most extreme years occurred post 1960 with four taking place between the 1985-2005 period. The wheat yield fluctuated between being near normal for four of the years to being nearly 73% below average in 1954. The most extreme one-month SPI event was May 1977 with a value of 3.4 (Appendix 1 Table 15). The highest SPI values were in the centre of the North Saskatchewan River watershed decreasing towards the edges of the watershed (Appendix 2 Figure 15). The change in wheat yield for this extreme year was only 14 % below average for the entire watershed.

SPI 12-Month Extremes

The 12-month SPI values for the North Saskatchewan River watershed indicate that the early part of the 20th century has several below average precipitation years with five of the 10 extreme SPI years occurring pre-1940 and only two happening in the 1985-2005 period (2001 and 2002). All of the extreme SPI drought years, where information is available had below normal yields with 2002 the lowest at 70% below average. The most extreme SPI drought year was 1929 with -3.2 (Appendix 1 Table 16). This extreme area is located at the far western edge of the basin with the less extreme SPI values on the eastern and south central portions of the watershed (Appendix 2 Figure 16).

The majority (seven) of the 12 month excessive moisture SPI values have occurred in 1960 and later with three documented in the 1985-2005 period. The wheat yields for all of the extreme SPI years fluctuated from being 26% above average in 2005 to 73% below average in 1954 but the majority had below average crop yields for the excessive moisture 12-month SPI years (Appendix 1 Table 16). The most extreme was 1974 with a SPI value of 3.0 and a decrease in crop yields by nearly 24%). The SPI values ranged from this high level in the northeastern quarter of the watershed to being consider a "mild" excessive moisture period in the south central region (Appendix 2 Figure 16).

The Prairies in 2009-2010

As stated in the methods section of this paper, the ANUSPLIN drought indices dataset is only for the period 1901 to 2005. The result is the most recent drought and excessive moisture events could not be examined using it. Therefore, another data source, using the same indices, is utilized

(AAFC 2010) but the methodology in calculating the indices is slightly different. For example, the AAFC information does not include the extremes, the classification stops at +/-5 for PDSI and +3.5/-2.75 for PDSI Z-value, +/- 2 for SPI.

Parts of Alberta and Saskatchewan were in severe drought during the autumn 2008 to early 2010 (Wittrock et al. 2010). In Saskatchewan, the driest regions were on the western and southern portions of the province. This is illustrated in the August 2009 PDSI map (Figure 7) with the Swift Current Creek watershed PDSI values in the moderate drought category, while the North Saskatchewan River watershed ranged from normal/mild drought to near normal. The Assiniboine River and Upper Souris River watersheds were categorized normal to mild excessive moisture category. The August 2010 PDSI map shows a much wetter situation with the Swift Current Creek, and North Saskatchewan River watershed in the beyond exceptional category (+5) while the Assiniboine River and the Upper Souris River were rated moderate to beyond exceptional category (Figure 8).

The PDSI Z-values for August 2009 show that the western edge of the province was near normal while the eastern side of the province was getting wetter (Figure 9). The August 2010 PDSI Z-value maps shows all four watersheds had a large increase in moisture levels (Figure 10).

The 12-month SPI map for 2009 further illustrates that the western half of the province was under a drought situation while the Upper Souris River watershed was in a moderate excessive moisture event but the Assiniboine River watershed was near normal (Figure 13). The 2010 12-month SPI map shows that much of the North Saskatchewan River watershed, the Assiniboine River watershed and the Upper Souris watershed were in an extreme excessive moisture event. The Swift Current River watershed was in a moderate excessive moisture event (Figure 14).

There was a dramatic shift in 2010 from a drought situation to excessive moisture. This is illustrated in Figures 11 and 12. The March 2010 Standardized Precipitation Index shows most of the Canadian Prairies in diminished precipitation levels with large portions of agricultural Saskatchewan in the beyond exceptional drought situation. Two short months later the SPI values shifted to the other side of the scale showing much of agriculture Saskatchewan and Manitoba in extreme excessive moisture situation. The annual temperature for 2010 ranged from being near normal in the southern portion of the province to being 1.5°C above normal in the Assiniboine River and North Saskatchewan River watersheds (Figure 15) but the precipitation amounts were extraordinary. The precipitation amounts for 2010 in Saskatchewan were above normal by at least 70% (Figure 16), in some localities such as in the Saskatoon region, the annual precipitation was nearly double the normal amounts at 707.5 mm (Figure 17). It was not just rainfall occurring, it was also severe hail events (Figure 18) and tornadoes with the town of . North Battleford was impacted by a severe hailstorm event on July 22, 2010 with enough hailstones on the ground to resemble a winter situation (CBC News 2010). The severe weather continued with tornadoes for example, on July 2 with one touching down near Raymore and the same storm system went on to destroy many homes in the Kawacatoose First Nation with the

tornado being rated as an F3 (Stockton July 6, 2010, CBC News July 3, 2010, CBC News July 4, 2010).

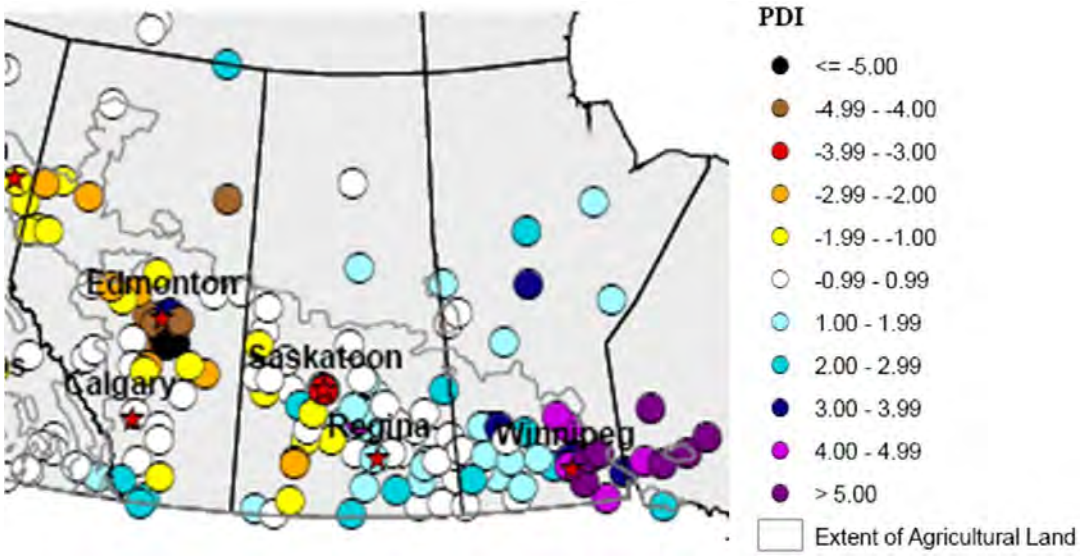

Figure 7 Palmer Drought Index August 2009 (AAFC 2010)

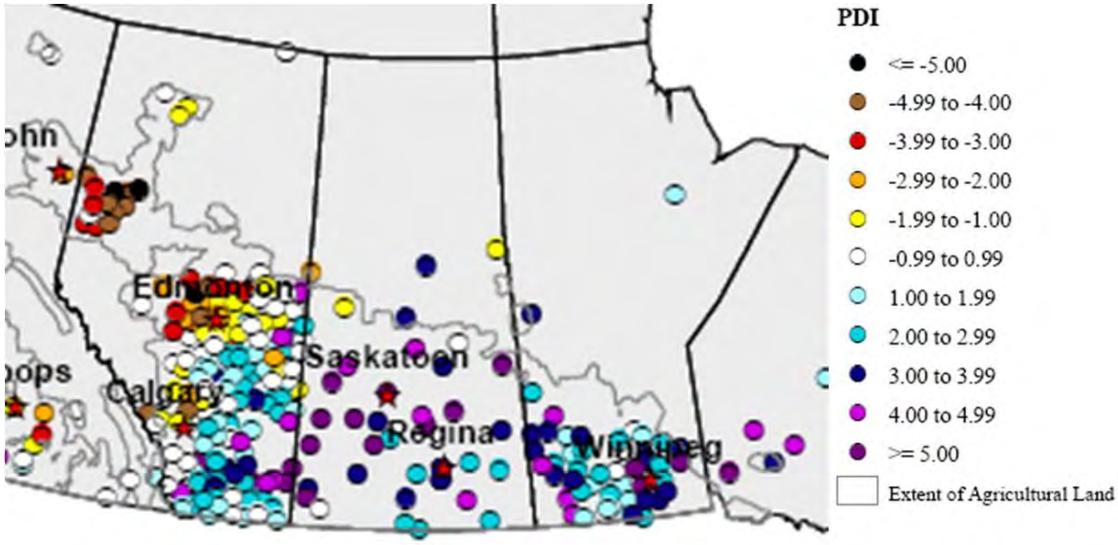

Figure 8 Palmer Drought Index August 2010 (AAFC 2010)

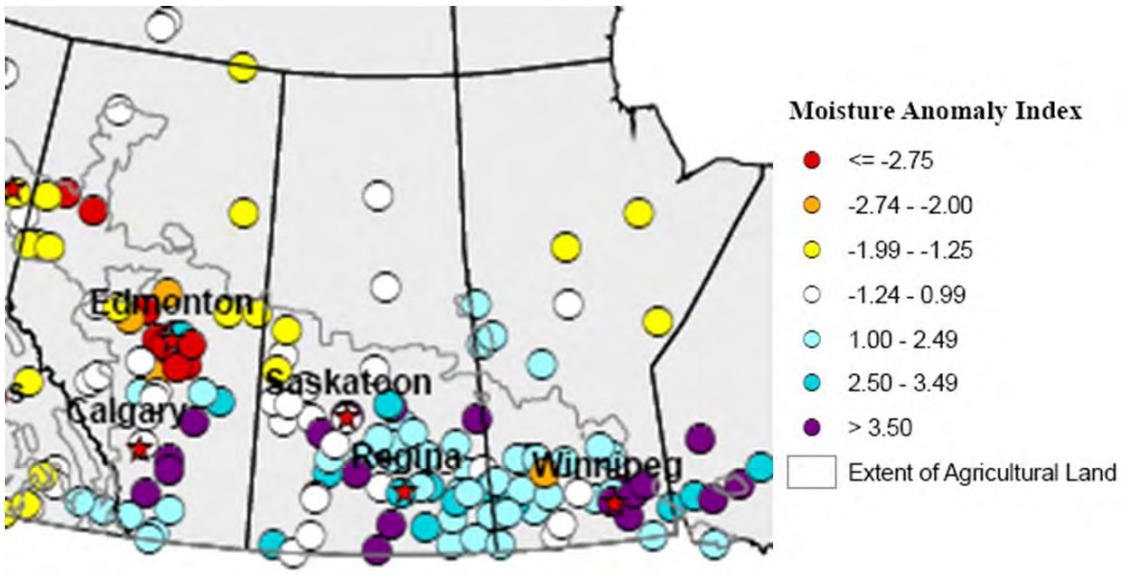

Figure 9 Palmer Drought Index (Z-value) August 2009 (AAFC 2010)

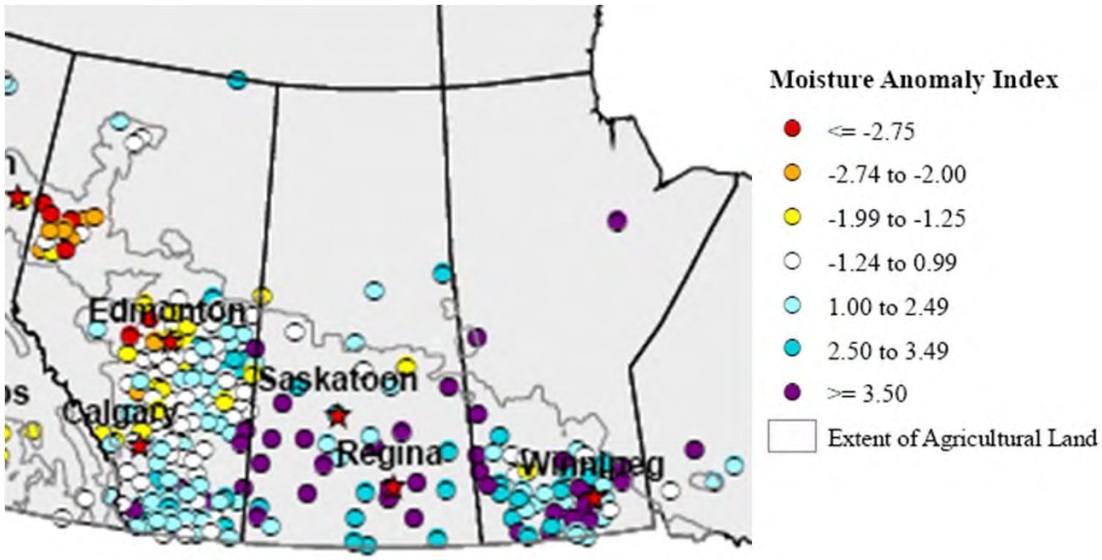

Figure 10 Palmer Drought Index (Z-value) August 2010 (AAFC 2010)

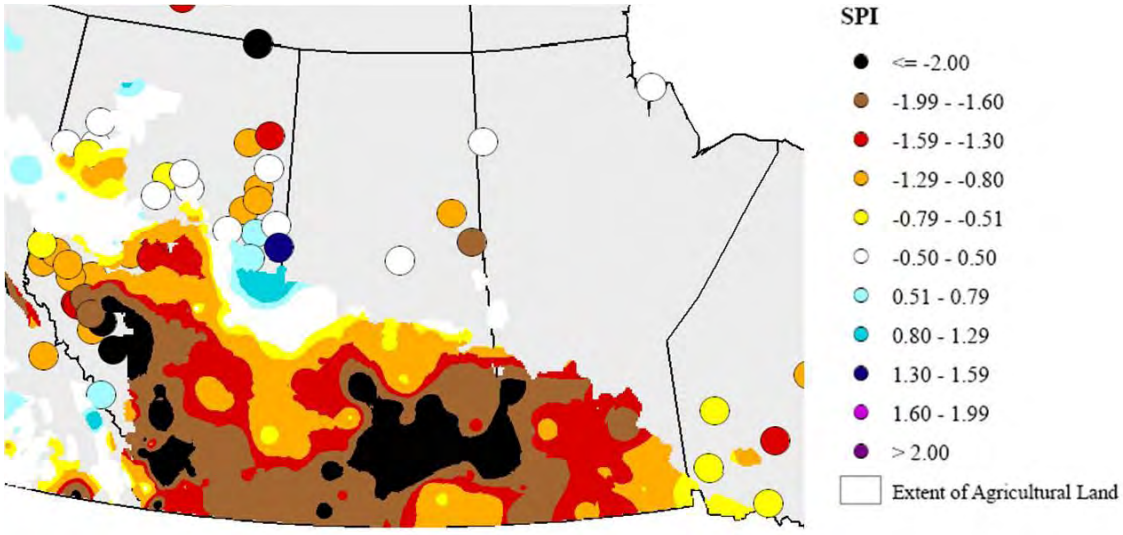

Figure 11 Standardized Precipitation Index (1 month) March 2010 (AAFC 2010)

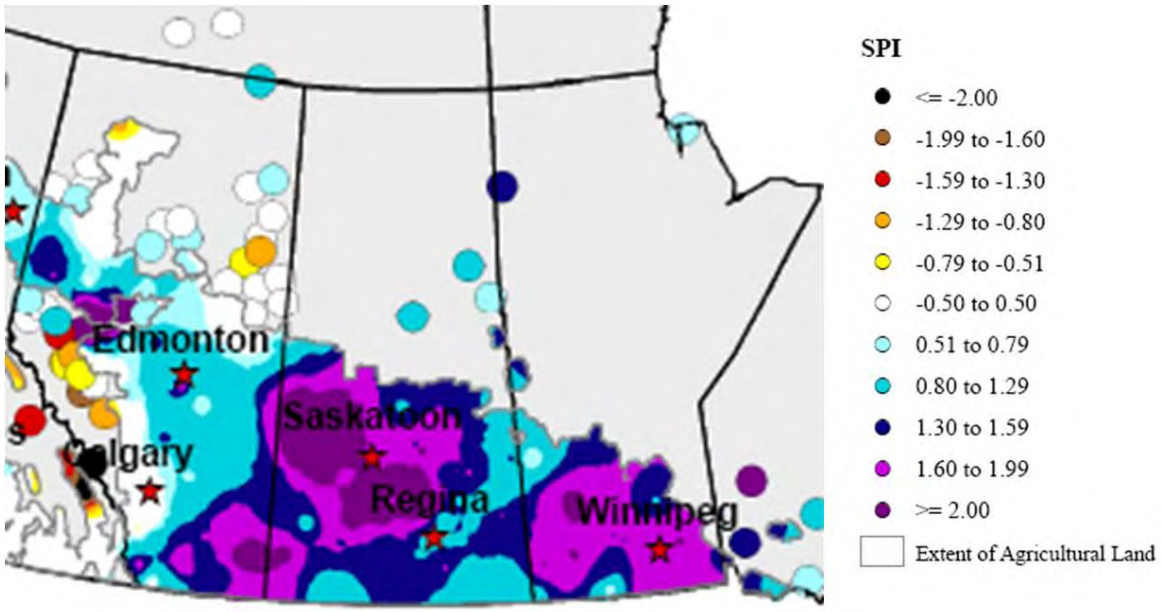

Figure 12 Standardized Precipitation Index (1 month) May 2010 (AAFC 2010)

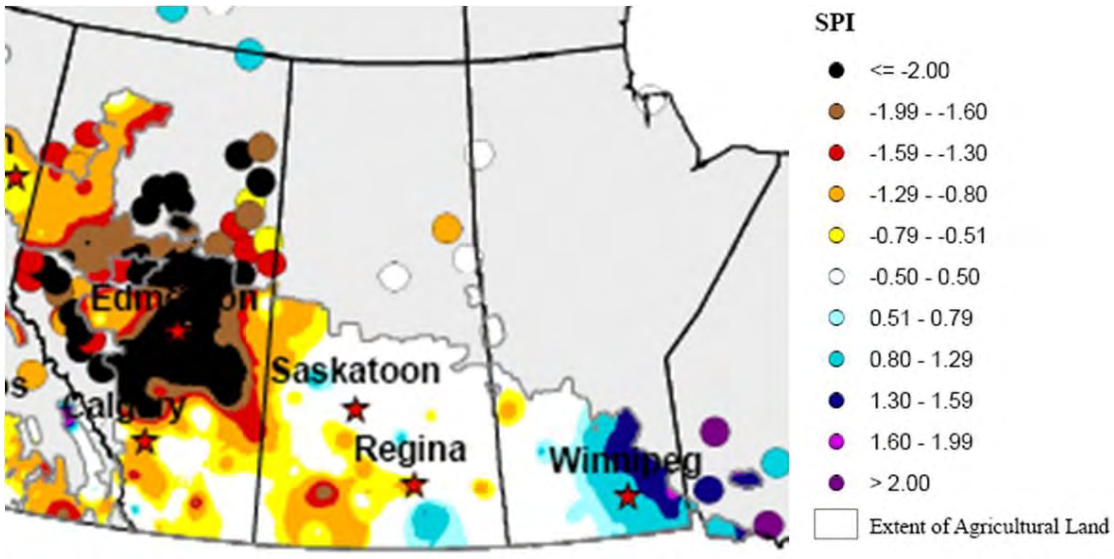

Figure 13 Standardized Precipitation Index (12 month) August 2009 (AAFC)

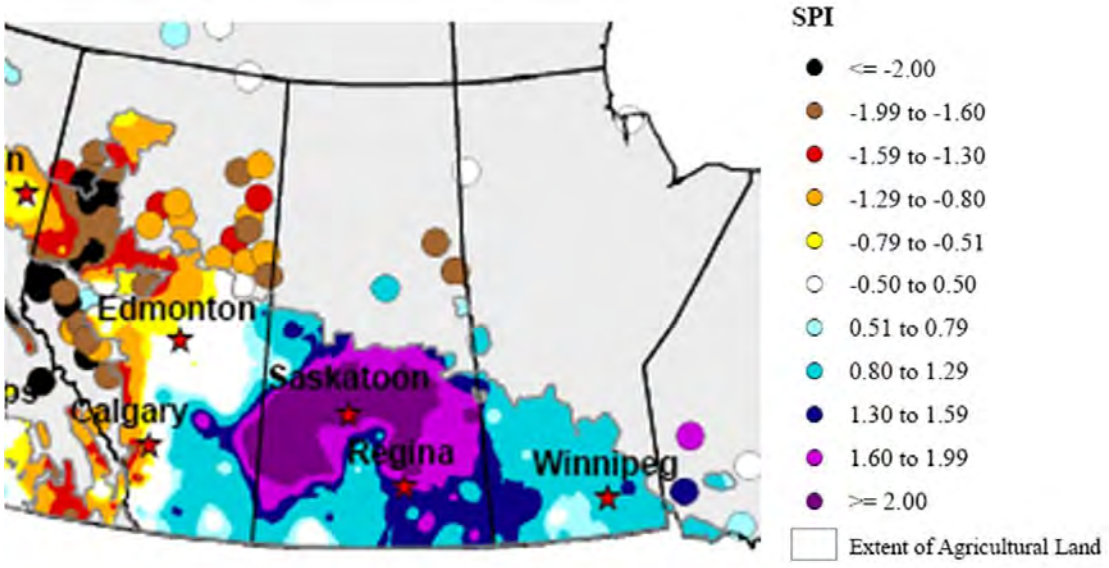

Figure 14 Standardized Precipitation Index (12 month) August 2010 (AAFC)

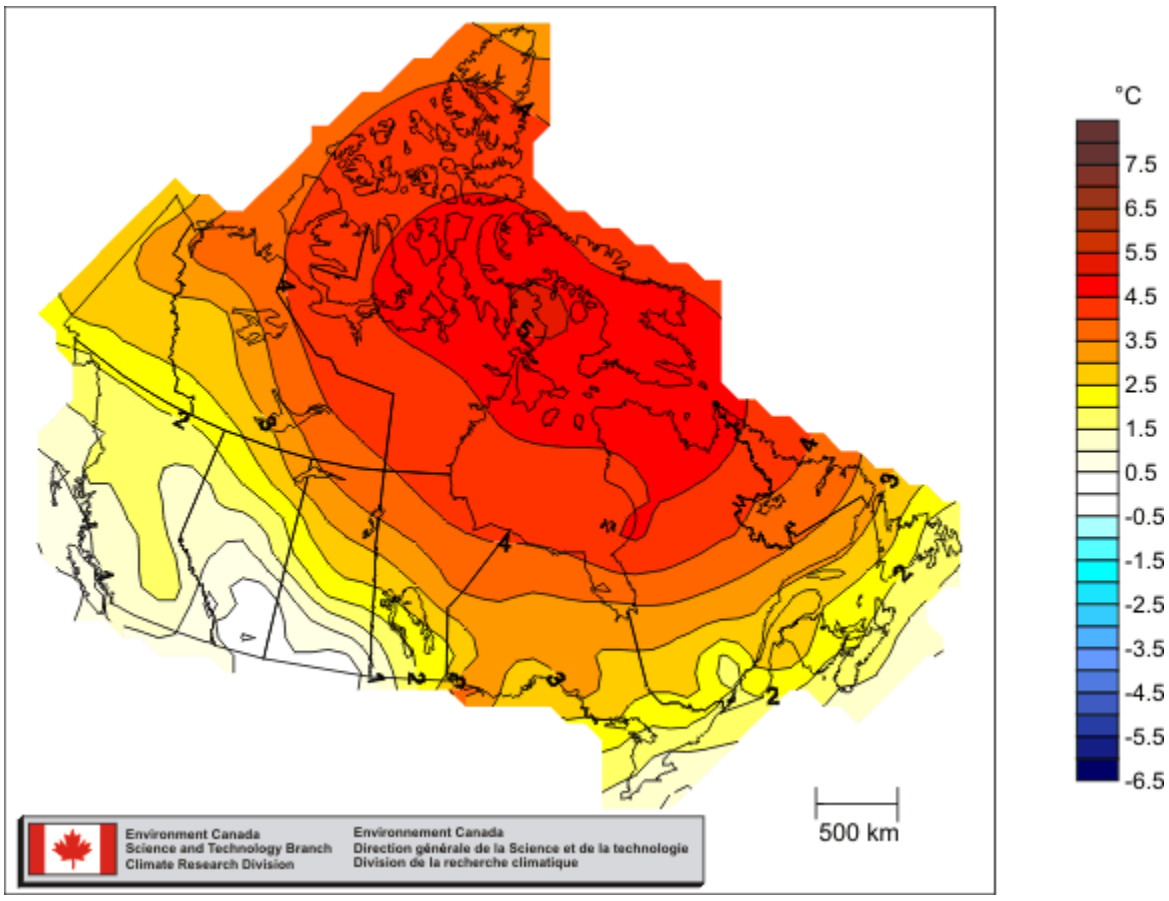

Figure 15 National temperatures for 2010, departure from normal (Environment Canada 2011)

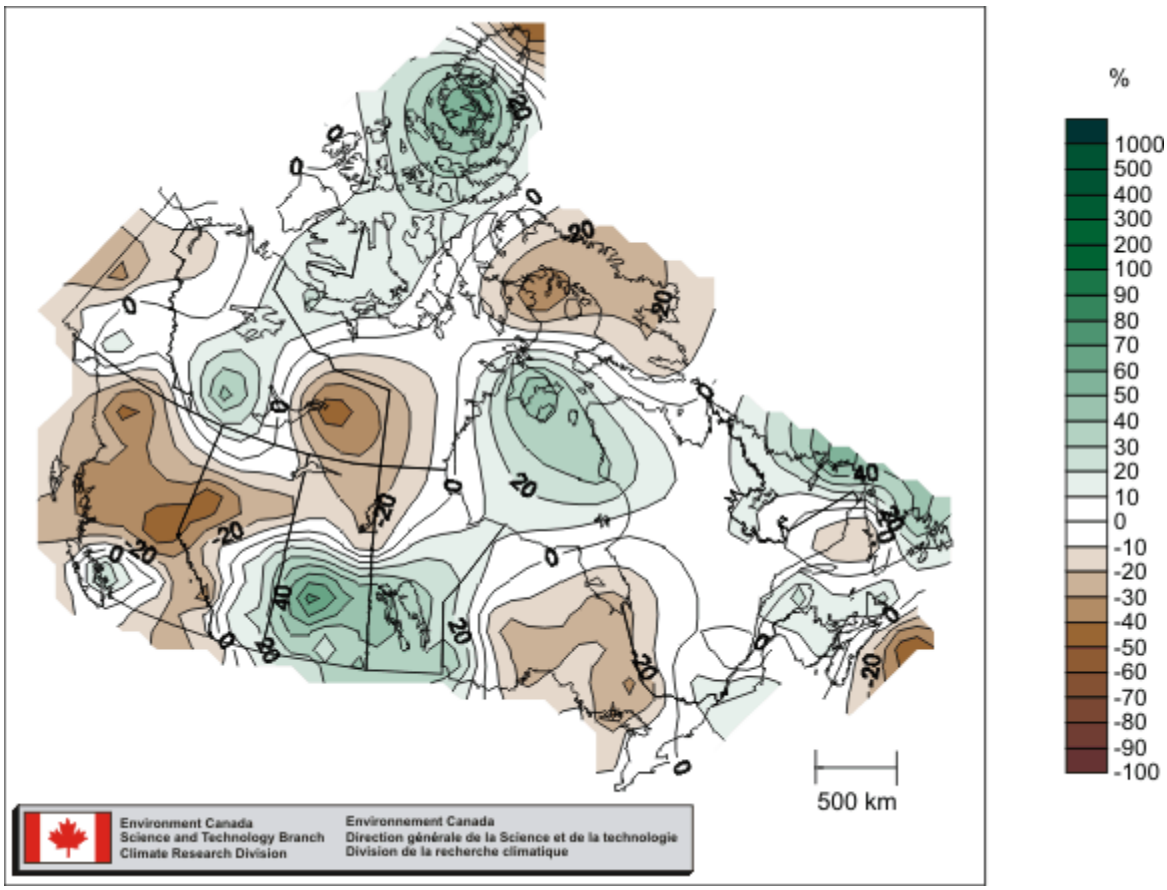

Figure 16 National precipitation for 2010, departure from normal (Environment Canada 2011)

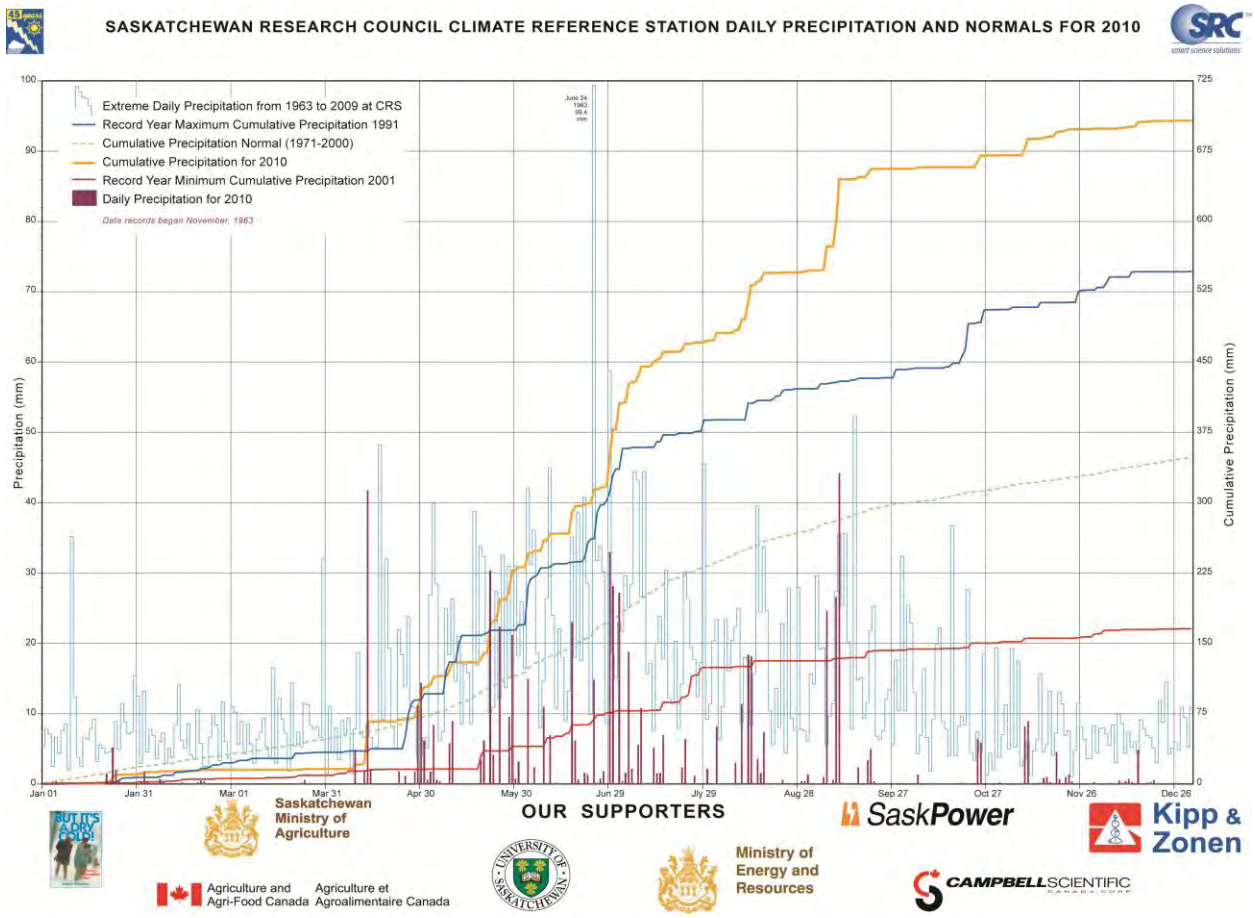

Figure 17 Record setting precipitation levels at Saskatoon in 2010 (Beaulieu and Wittrock 2011).

Figure 18 Severe Hail Storm south of Saskatoon August 13, 2010 (Photo: E. Wheaton)

Drought and Excessive Moisture Pattern Comparison

Several years were extreme years in all four watersheds. For example, PDSI values indicate 1954 was the most extreme excessive moisture year in the Assiniboine River Watershed (8.4) and the Swift Current Creek Watershed (6.8) while it was rated in the top ten extreme excessive moisture years in the other two (Upper Souris River Watershed (5.5) and North Saskatchewan River Watershed (7.1)). Other years were extreme in multiple watersheds as well. Upper Souris River and Swift Current Creek Watersheds had excessive moisture years in 1991 while the Assiniboine River Watershed and the North Saskatchewan River Watershed had excessive moisture years in 2005 (Appendix 1 Tables 1, 5, 9, and 13).

While 1954 was categorized as one of the wettest PDSI years, this was also the case for PDSI Z-value indicating there was a strong switch from moisture deficit conditions in 1953 to excessive moisture conditions in all four watersheds (Appendix 1 Table 2, 6, 10, and 14).

PDSI drought also had several years in common in several of the four selected watersheds. One of the worst drought years in three out of the four watersheds was 1961. The Assiniboine River Watershed has the most extreme PDSI drought level occurring in 1961 (-8.7) followed closely by the Upper Souris River Watershed with an extreme drought value of -8.0. The North Saskatchewan River Watershed had the extreme PDSI excessive moisture value of 10.1 in 1974 followed by the Assiniboine River Watershed with a value of 8.4. It is interesting that the extreme PDSI drought values are not located in the Palliser triangle i.e. Swift Current Creek watershed. This requires more investigation to determine why this is occurring. The extreme PDSI excessive moisture values occur in the more northerly watersheds, which is what is expected due to generally higher amounts of precipitation and lower temperatures, in general. The 1961 August one-month and the 12-month SPI drought extreme values occurred in all of the watersheds (Appendix 1 Tables 3, 4, 7, 8, 11, 12, and15, 16).

The four watersheds had several years in common PDSI Z-value as it related to drought onset. All four watersheds categorized 1961 as the worse followed closely by 2001 (classified as either 2nd highest or 3rd) followed by 1984 and 2003. These four years indicate that much of agricultural Saskatchewan was tending toward a drought situation in those years for the four selected watersheds (Appendix 1 Tables 2, 6, 10, and 14).

The PDSI Z-value for excessive moisture does not give as clear of picture with only 1954 indicating a trend toward moisture conditions throughout the four watersheds. The only year for SPI 12-month excessive moisture with commonality between watersheds was 1974 which appeared in the top 10 excessive moisture years for Swift Current Creek, Upper Souris River and North Saskatchewan River watersheds (Appendix 1 Tables 4, 8 and 16).

Besides the 1961 12-month SPI drought values occurring in all the watersheds, 1929 did as well but was not as second in extremeness in all the watersheds except the Upper Souris River watershed when it rated at fifth (Appendix 1 Tables 4, 8, 12, and 16).

COMMUNITY VULNERABILITY ASSESSMENT (IMPACTS AND ADAPTATION)

There has recently been research into the impacts and adaptations strategies implemented in Saskatchewan and the rest of Canada in relation to the droughts of 1988, 2001/2002 and more recently the 2008-2010 drought (, Wheaton et al. 2005, Wittrock et al. 2007 Wheaton et al. 2008, Wittrock et al. 2010, Drought Research Initiative, Institutional Adaptations to Climate Change). This portion draws upon the findings discovered in these projects.

Droughts and excessive moisture events regardless of their intensity, have impacts on the environment, and society. Often adaptation strategies are put in place either as a reaction or proactive processes. The drought events of the early 20th century occurred when the Canadian prairies were still new to the European settlers. They did not know how extreme the climate would be and as a result, some of the agricultural practices brought over from Europe only partially suited the "new" world and adaptation measures were quickly adopted throughout the prairies. One of the first impacts of a drought that was noticed was the lack of adequate potable water. This resulted in wells being dug, and small dams being built. But when the extended droughts of the 1930s occurred, government had to assist the agriculture communities of the Canadian prairies.

One of the largest governmental adaptation strategies to help producers and communities deal with the droughts of the 1930s was the implementation of Agriculture Canada's Prairie Farm Rehabilitation Administration. This organization provided the farming community with advice on how to deal with drought events plus it was involved in designing water retention facilities from the relatively small such as dugouts to the larger projects including the Duncairn dam in the Swift Current Creek region. Other water retention projects were engineered throughout Saskatchewan to allow for access to water in drought years. Besides lack of available high quality water, crops types had to be improved to deal with less available water than generally available in Europe therefore crops such as Marquis Wheat was developed. New drought tolerant varieties continue to be developed.

Other impacts from droughts include soil degradation, insects and diseases, decreased yields, feed shortages, decreased income (income instability). Some of the impacts can be positive including higher quality grains, decreased mosquitoes, and cities and town gaining revenue due to increased usage of water, as long as no shortage results.

Adaptation strategies have occurred in response to these drought situations. Some are quick response adaptation strategies, while others are longer term adaptation strategies. Wittrock and Wheaton (2007) and Wheaton and Wittrock (2005) undertook an in-depth examination of the adaptation strategies utilized to offset the negative impacts of the 2001-2002 drought. Some of these adaptation strategies include off-farm income with one or both spouses, increased water storage, and changing farm management strategies to be able to cope with extreme events. These include options such as increased feed storage, changing herd size to match environmental

conditions, increased area of minimum tillage, reducing amount of fallow, installing water pipelines from a more sustainable supply, and increased use of irrigation, where suitable.

Excessive moisture impacts can be just as dramatic as droughts but unlike droughts, excessive moisture events especially extreme events such as flood due to a convective storm event are visible very quickly. 2010 is a prime example of the impacts with an extreme excessive moisture event. All of the four watersheds had extreme precipitation events and cumulative rainfall amounts during the spring to fall of 2010 which resulted in severe impacts. Much of the information provided here has been gleaned from various media sources (Appendix ??). Impacts included damage to infrastructure (building, roads, dams, waterways, sewage systems, etc), crop and forage quantity and quality as well as damage from insects and disease brought on by the dampness. A positive impact was that water quantity was not generally a problem but the quality of the water may be a concern. Secondary impacts include loss of income for cities and towns due to less water being used to irrigate lawns and gardens. The Bank of Montreal estimates that the damage from all the excessive moisture events in 2010 costs the Canadian Prairie farmers approximately $1.5 Billion (Cunliffe et al. Dec 1, 2010).

The impacts from the excessive moisture year of 2010 are still being determined and felt but many adaptation strategies have been implemented to help offset the impacts. For example, Saskatchewan crop insurance was changed to allow for coverage of unseeded acres due to flooded fields and in 2011 the allowable coverage was increased. The Government of Canada allowed Saskatchewan until the fall of 2011 to complete many large infrastructure projects due to the record weather conditions of 2010. These projects were originally to be completed by March 31, 2011. In addition, many farmers, communities and rural municipalities in partnership with provincial and federal government agencies are preparing for the potential excessive moisture spring of 2011. The government of Saskatchewan has pledge $22 million to assist with minimizing the impacts of the potential high waters resulting from spring run-off (SWA 2011).

CONCLUSION AND RECOMMENDATIONS

Droughts and excessive moisture events are not an uncommon occurrence in Saskatchewan. The most extreme drought year for the study area watersheds appears to be 1961, according to PDSI values. Historically, the most extreme excessive moisture year varied among the watersheds, but 1954 was the common excessive moisture year. 2010 will likely overtake 1954 in its exceptionality.

The spatial variability within and between the watersheds indicates that while one portion of a watershed could be in an excessive moisture event, other parts could be near normal or even in a slightly dry period.

It is important to understand the uniqueness of each extreme event to further develop adaptation strategies to cope with the next event. Under a changing climate, it is projected that the frequency, intensity and area of these events, both droughts and excessive moisture, will increase

(e.g., IPCC WGI 2007). Therefore undertaking proactive useful adaptation strategies is a necessity because it will decrease the cost and necessity of reactive adaptation strategies. Improved information about extremes, their patterns and impacts is required to design and implement effective adaptation strategies.

Key recommendations include:

- Examination of 2010 excessive moisture patterns in the prairie region and comparison with historic and future projected patterns.
- Relate drought and excessive moisture extremes to water use demand.
- How similar or different patterns of drought and excessive moisture are projected. This information is the basis for improving adaptation through enhanced climate adaptation information services.
- How do the indices compare with the impacts (e.g., reservoir and lake levels etc)?
- Undertake a full assessment of the media coverage of the excessive moisture year of 2010.
- Expand the ranking from being the top 10 most extreme years to rank the entire period of record for each watershed. Further develop the top ten indices by undertaking spatial comparisons for all the indices for all the top ten years.
- Assessment of Vulnerability, Impacts and Adaptation patterns. This can be accomplished through answering this question - How do biophysical and socio-economic impacts change with different stages of drought evolution through time and space?
- How do stages of adaptation (e.g., risk management) compare with drought stages?
- What is the effectiveness of "current" adaptation? What are the residual impacts? How can adaptation be improved?

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ACRONYMS:

CRU – Climate Research Unit
AB – Alberta
SK – Saskatchewan
MB – Manitoba
PDSI – Palmer Drought Severity Index
SPI – Standardized Precipitation Index
DEM – drought and excessive moisture
DRI – Drought Research Initiative
SWA – Saskatchewan Watershed Authority
GIS – geographic information system

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APPENDIX 1

Top 10 Extreme Drought and Excessive Moisture Tables:

Table 1 PDSI for the Swift Current Creek Watershed. The 10 year average (2000-2009) wheat yield is 28 bushels/acre.

PDSI Excessive Moisture (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1954	6.8	-41.0
1966	6.7	5.4
2004	5.8	21.6
1951	5.6	-44.6
1953	5.6	-17.6
1916	5.5	Not Available
1965	5.4	-16.5
1991	5.1	18.7
1907	5.1	Not Available
1975	5.0	-16.9

PDSI Drought (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1937	-6.5	Not Available
1931	-6.0	Not Available
1988	-5.9	-58.3
1919	-5.9	Not Available
1946	-5.8	-73.4
1936	-5.6	Not Available
1949	-5.4	-91.0
1905	-5.3	Not Available
1961	-5.2	-77.3
1914	-4.6	Not Available

Table 2 PDSI Z-value for the Swift Current Creek Watershed. The 10 year average (2000-2009) wheat yield is 28 bushels/acre.

PDSI Z-value Excessive Moisture (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1993	9.2	14.0
2002	8.1	-13.7
1954	7.4	-41.0
1951	7.2	-44.6
1974	6.8	-28.4
2004	6.6	21.6
1965	5.7	-16.5
1995	5.7	10.4
1907	5.7	Not Available
1989	4.7	5.4

PDSI Z-value Drought (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1961	-5.2	-77.3
2001	-4.8	-36.7
1971	-4.0	-25.5
2003	-3.9	-16.5
1967	-3.7	-52.2
1984	-3.3	-38.1
1940	-3.3	-55.8
1988	-3.2	-58.3
1930	-3.2	Not Available
1901	-3.1	Not Available

Table 3 SPI One-Month for the Swift Current Creek Watershed. The 10 year average (2000-2009) wheat yield is 28 bushels/acre.

SPI One-Month Excessive Moisture			
Year	Month	Value	% Change in Wheat Yield
1927	May	3.1	Not Available
1971	January	2.9	-25.5
1986	September	2.8	17.6
1967	January	2.7	-52.2
1955	July	2.7	-20.5
1993	August	2.7	14.0
1977	December	2.6	-1.8
1904	March	2.6	Not Available
1938	February	2.6	-66.9
1964	December	2.5	-42.1

SPI One-Month Drought			
Year	Month	Value	% Change in Wheat Yield
1967	June	-3.9	-52.2
1959	December	-3.5	-45.7
1973	January	-3.5	-38.5
1985	June	-3.3	-66.5
1952	December	-3.1	-8.6
1917	November	-3.1	Not Available
1961	August	-2.9	-77.3
1903	December	-2.9	Not Available
2001	August	-2.9	-36.7
1952	May	-2.8	-8.6

Table 4 SPI 12 Month for the Swift Current Creek Watershed. The 10 year average (2000-2009) wheat yield is 28 bushels/acre.

SPI August Excessive Moisture (12 Month)		
Year	Value	% Change in Wheat Yield
2004	2.1	17.4
1965	2.0	-16.5
1927	1.9	Not Available
1974	1.8	-28.4
1991	1.8	18.7
1916	1.8	Not Available
1966	1.7	5.4
1954	1.7	-41.0
1907	1.6	Not Available
1951	1.6	-44.6

SPI August Drought (12 Month)		
Year	Value	% Change in Wheat Yield
1937	-2.4	Not Available
1929	-2.4	Not Available
1961	-2.3	-77.3
1984	-2.2	-38.1
1988	-2.1	-58.3
1936	-2.1	Not Available
1949	-2.0	-90.6
1919	-2.0	Not Available
1914	-1.8	Not Available
1945	-1.8	-79.5

Table 5 PDSI for the Upper Souris River Watershed. The 10 year average (2000-2009) wheat yield 28 bushels/acre.

PDSI Excessive Moisture (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1927	6.4	Not Available
1902	6.3	Not Available
1991	6.0	-7.6
1909	5.8	Not Available
1928	5.6	Not Available
1923	5.5	Not Available
1954	5.5	-73.1
1955	5.5	-25.7
1999	5.3	-5.6
1947	5.2	-44.6

PDSI Drought (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1961	-8.0	-79.9
1988	-6.8	-54.8
1958	-6.7	-64.9
1959	-6.6	-53.6
1984	-6.5	-39.3
1977	-6.1	4.2
1989	-6.0	-42.7
1937	-5.9	Not Available
1931	-5.2	Not Available
1915	-5.0	Not Available

Table 6 PDSI Z-value for the Upper Souris River Watershed. The 10 year average (2000-2009) wheat yield 28 bushels/acre.

PDSI Z-value Excessive Moisture (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1968	9.6	-47.8
1985	8.3	-33.8
1942	7.8	-16.0
1903	7.3	Not Available
1974	6.7	-27.3
2002	6.3	-6.6
1975	5.9	-19.0
1954	5.8	-73.1
1963	5.6	-5.6
1980	5.6	-31.7

PDSI Z-value Drought (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1961	-6.0	-79.9
1984	-5.2	-39.3
2001	-4.7	-8.9
1929	-4.7	Not Available
1971	-4.7	-0.8
2003	-4.7	-23.2
1958	-4.3	-64.9
1936	-3.9	Not Available
1967	-3.9	-43.1
1937	-3.8	Not Available

Table 7 SPI One-Month for the Upper Souris River Watershed. The 10 year average (2000-2009) wheat yield 28 bushels/acre.

SPI One-Month Excessive Moisture			
Year	Month	Value	% Change in Wheat Yield
1993	July	3.5	2.6
1998	February	3.4	-10.8
2000	November	3.3	-0.4
1975	April	3.1	-19.0
1968	August	3.0	-47.8
1970	April	3.0	-17.0
1902	February	2.9	Not Available
1999	February	2.9	-5.6
1965	May	2.9	-11.5
2003	April	2.7	-23.2

SPI One-Month Drought			
Year	Month	Value	% Change in Wheat Yield
1961	August	-3.7	-79.9
1997	December	-3.5	-25.5
1980	May	-3.5	-31.7
1973	January	-3.4	-10.2
1968	April	-3.4	-47.8
1985	July	-3.4	-33.8
2001	August	-3.3	-8.9
1934	April	-3.1	Not Available
1969	October	-3.1	11.9
1965	October	-3.1	-11.5

Table 8 SPI 12 Month for the Upper Souris River Watershed. The 10 year average (2000-2009) wheat yield 28 bushels/acre.

SPI August Excessive Moisture (12 Month)		
Year	Value	% Change in Wheat Yield
1999	2.4	-5.6
1927	2.1	Not Available
1902	2.1	Not Available
1974	2.0	-27.3
1972	2.0	-17.9
1991	1.9	-7.6
1963	1.8	-5.6
1923	1.7	Not Available
1976	1.7	0.2
1947	1.6	-44.6

SPI August Drought (12 Month)		
Year	Value	% Change in Wheat Yield
1961	-4.2	-79.9
1958	-3.1	-64.9
1967	-2.7	-43.1
1977	-2.7	4.2
1929	-2.7	Not Available
1936	-2.3	Not Available
1937	-2.3	Not Available
1984	-2.2	-39.3
1959	-1.9	-53.6
1989	-1.8	-42.7

Table 9 PDSI for the Assiniboine River Watershed. The 10 year average wheat yield is 34 bushels/acre.

PDSI Excessive Moisture (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1954	8.4	-71.3
1995	6.1	-15.8
1996	5.9	-6.1
1993	5.6	-29.2
2005	5.5	9.9
1953	5.3	-24.3
1950	5.3	-38.6
1994	5.1	-19.0
1942	5.0	-20.8
1966	4.8	-11.7

PDSI Drought (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1961	-8.7	-80.1
1941	-7.0	-55.0
1958	-5.8	-41.8
1984	-5.8	-18.1
1915	-5.7	Not Available
1959	-5.6	-30.1
1937	-5.5	Not Available
1931	-5.4	Not Available
1944	-5.3	-33.3
1934	-5.2	Not Available

Table 10 PDSI Z-value for the Assiniboine River Watershed. The 10 year average wheat yield is 34 bushels/acre.

PDSI Z-value Excessive Moisture (Agriculture Year)		
Year	Value	% Change in Wheat Yield
2002	9.9	-16.7
1995	9.1	-15.8
1942	8.5	-20.8
1985	8.5	1.8
2005	7.8	9.9
1993	6.6	-29.2
1975	6.3	-28.4
1954	6.0	-71.3
1968	5.7	-34.2
1966	5.6	-11.7

PDSI Z-value Drought (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1961	-6.5	-80.1
1984	-4.9	-18.1
2001	-4.8	-12.6
2003	-4.6	-5.8
1929	-4.5	Not Available
1936	-4.3	Not Available
1967	-4.0	-49.1
1972	-3.9	-26.0
1930	-3.8	Not Available
1960	-3.8	-31.9

Table 11 SPI One-Month for the Assiniboine River Watershed. The 10 year average wheat yield is 34 bushels/acre.

SPI One-Month Excessive Moisture			
Year	Month	Value	% Change in Wheat Yield
1975	April	3.2	-28.4
1996	July	3.2	-6.1
1983	July	2.9	-23.1
1995	August	2.9	-15.8
2002	August	2.9	-16.7
1969	September	2.9	-10.2
1965	September	2.9	-25.1
1909	July	2.8	Not Available
1926	October	2.8	Not Available
1970	October	2.7	-22.5

SPI One-Month Drought			
Year	Month	Value	% Change in Wheat Yield
1971	May	-4.5	-12.3
1980	April	-4.0	-32.5
1961	August	-4.0	-80.1
1924	May	-3.9	Not Available
1913	December	-3.9	Not Available
1973	January	-3.9	-20.8
1992	March	-3.5	-24.9
1981	November	-3.4	1.5
1925	December	-3.4	Not Available
1985	July	-3.2	1.8

Table 12 SPI 12 Month for the Assiniboine River Watershed. The 10 year average wheat yield is 34 bushels/acre.

SPI August Excessive Moisture (12 Month)		
Year	Value	% Change in Wheat Yield
1954	2.4	-71.3
1953	2.2	-24.3
1942	2.0	-20.8
1995	2.0	-15.8
1993	2.0	-29.2
1927	1.8	Not Available
1921	1.8	Not Available
1970	1.7	-22.5
2005	1.7	9.9
2004	1.7	-14.3

SPI August Drought (12 Month)		
Year	Value	% Change in Wheat Yield
1961	-4.6	-80.1
1929	-2.8	Not Available
1967	-2.5	-49.1
1958	-2.4	-41.8
1914	-2.3	Not Available
1924	-2.3	Not Available
1940	-2.3	-58.5
1936	-2.2	Not Available
1977	-2.1	-17.3
1934	-2.1	Not Available

Table 13 PDSI for the North Saskatchewan River Watershed. The 10 year average (2000-2009) wheat yield 31 bushels/acre.

PDSI Excessive Moisture (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1974	10.1	-23.7
1916	7.3	Not Available
1973	7.3	-19.0
1954	7.1	-72.6
1975	7.0	-14.1
1965	6.5	-31.7
1907	6.4	Not Available
1927	6.3	Not Available
1960	6.2	-35.4
2005	5.9	26.1

PDSI Drought (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1915	-7.5	Not Available
1919	-7.3	Not Available
1929	-6.8	Not Available
2002	-6.3	-70.3
1972	-6.0	-28.9
2003	-5.7	-23.6
1973	-5.6	-19.0
1937	-5.5	Not Available
1988	-5.5	-38.5
2001	-5.5	-17.5

Table 14 PDSI Z-value for the North Saskatchewan River Watershed. The 10 year average (2000-2009) wheat yield 31 bushels/acre.

PDSI Z-value Excessive Moisture (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1954	11.9	-72.6
1988	8.7	-38.5
1982	8.3	4.5
1951	8.3	-27.5
1974	7.4	-23.7
2005	7.3	26.1
1959	6.7	-58.1
1907	6.6	Not Available
1995	6.3	-21.6
1993	6.2	7.7

PDSI Z-value Drought (Agriculture Year)		
Year	Value	% Change in Wheat Yield
1961	-5.7	-58.4
1915	-5.5	Not Available
2001	-5.4	-17.5
1929	-4.7	Not Available
1981	-4.5	-12.1
1939	-4.3	-47.0
1958	-4.2	-50.6
2003	-4.1	-23.6
1984	-4.0	-16.0
1998	-4.0	-7.6

Table 15 SPI One-Month for the North Saskatchewan River Watershed. The 10 year average (2000-2009) wheat yield 31 bushels/acre.

SPI One-Month Excessive Moisture			
Year	Month	Value	% Change in Wheat Yield
1977	May	3.4	-14.3
1965	February	3.2	-31.7
1942	January	3.1	-21.0
1955	April	3.1	-27.7
2000	July	3.1	5.5
1991	April	3.1	4.4
1986	July	3.1	0.6
1985	April	3.0	-7.2
1954	August	3.0	-72.6
1916	July	3.0	Not Available

SPI One-Month Drought			
Year	Month	Value	% Change in Wheat Yield
1961	August	-3.7	-58.4
1967	May	-3.7	-21.9
1952	Dec	-3.7	-10.9
1995	Sept	-3.4	-21.6
1964	June	-3.3	-57.7
1974	Nov	-3.2	-23.7
1980	April	-3.2	-13.4
2002	May	-3.2	-70.3
1988	April	-3.2	-38.5
1928	January	-3.2	Not Available

Table 16 SPI 12 Month for the North Saskatchewan River Watershed. The 10 year average (2000-2009) wheat yield 31 bushels/acre.

SPI August Excessive Moisture (12 Month)		
Year	Value	% Change in Wheat Yield
1974	3.0	-23.7
1973	2.6	-19.0
1965	2.5	-31.7
1916	2.5	Not Available
1954	2.3	-72.6
1932	2.3	Not Available
1993	2.2	7.7
1960	2.2	-35.4
2005	2.0	26.1
1985	2.0	-7.2

SPI August Drought (12 Month)		
Year	Value	% Change in Wheat Yield
1929	-3.2	Not Available
1917	-2.8	Not Available
1961	-2.8	-58.4
2001	-2.6	-17.5
1924	-2.6	Not Available
1972	-2.4	-28.9
1918	-2.3	Not Available
2002	-2.3	-70.3
1936	-2.3	Not Available
1973	-2.1	-19.0

APPENDIX 2

Maps of the most extreme drought and excessive moisture years:

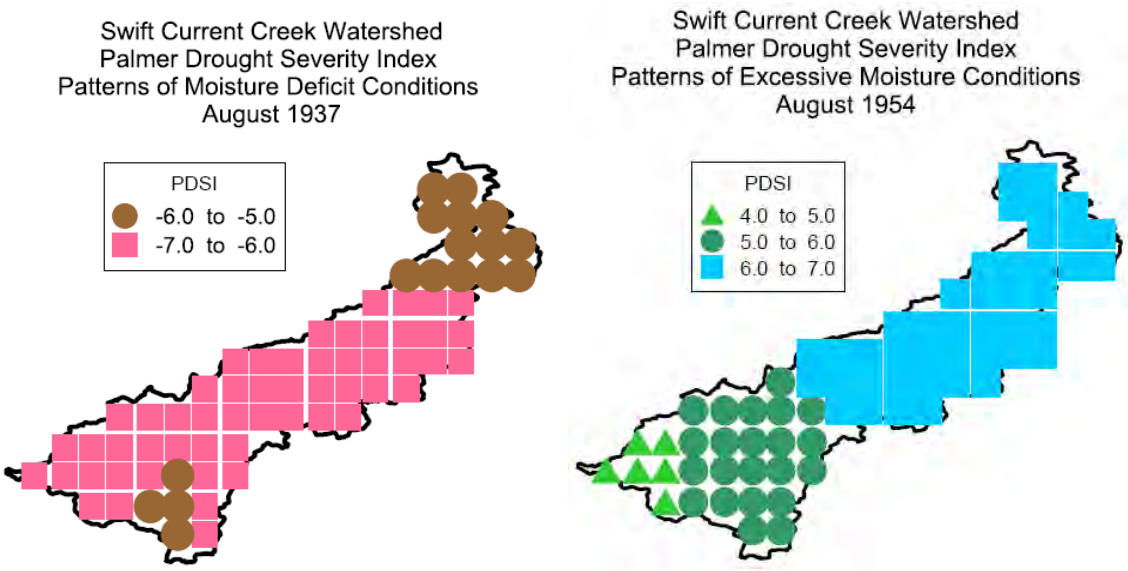

Figure 1 PDSI Swift Current Creek Watershed Maps for the drought year of 1937 and excessive moisture year of 1954

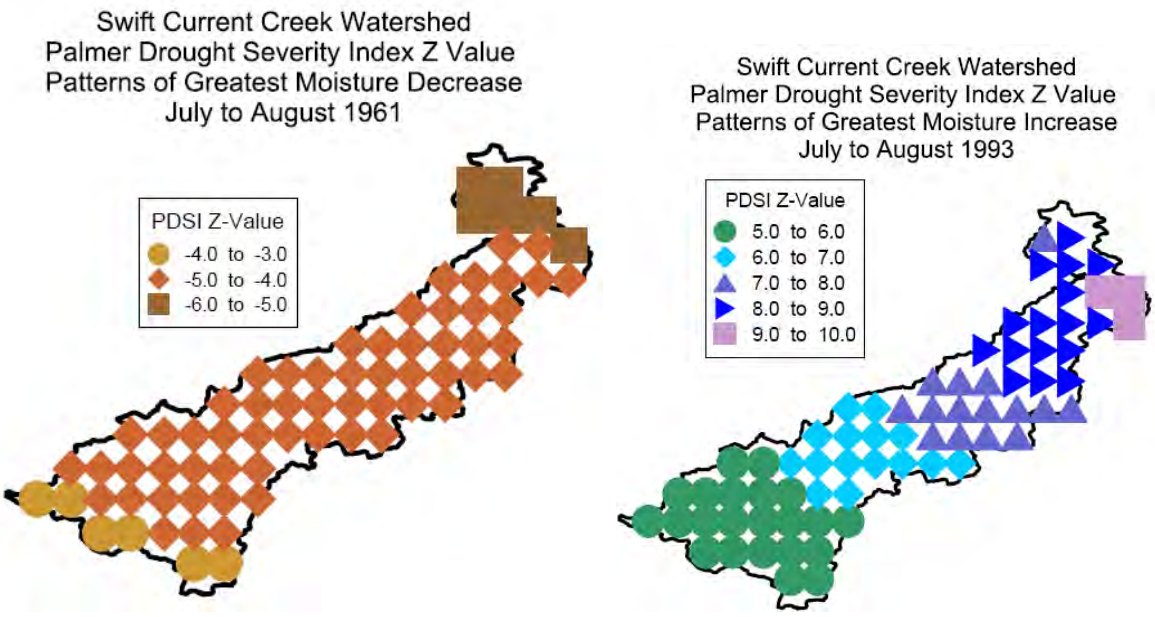

Figure 2 PDSI Z-Value Swift Current Creek Watershed Maps for the drought of 1961 and excessive moisture of 1993

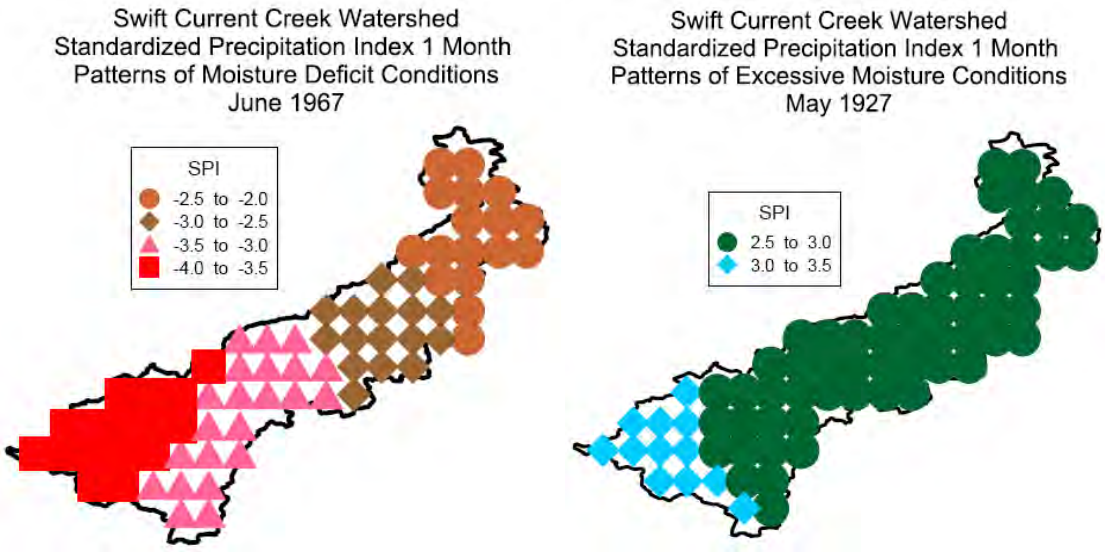

Figure 3 SPI 1-Month Swift Current Creek Watershed Maps for the drought month of June 1967 and excessive moisture month of May 1927

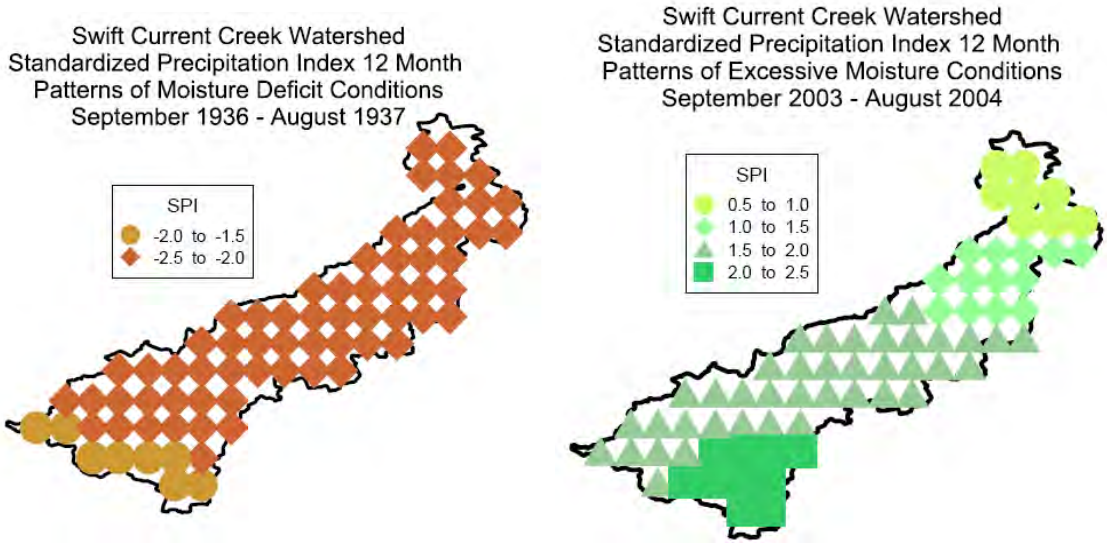

Figure 4 SPI 12-Month Swift Current Creek Watershed Maps for the drought year of 1937 and excessive moisture year of 2004

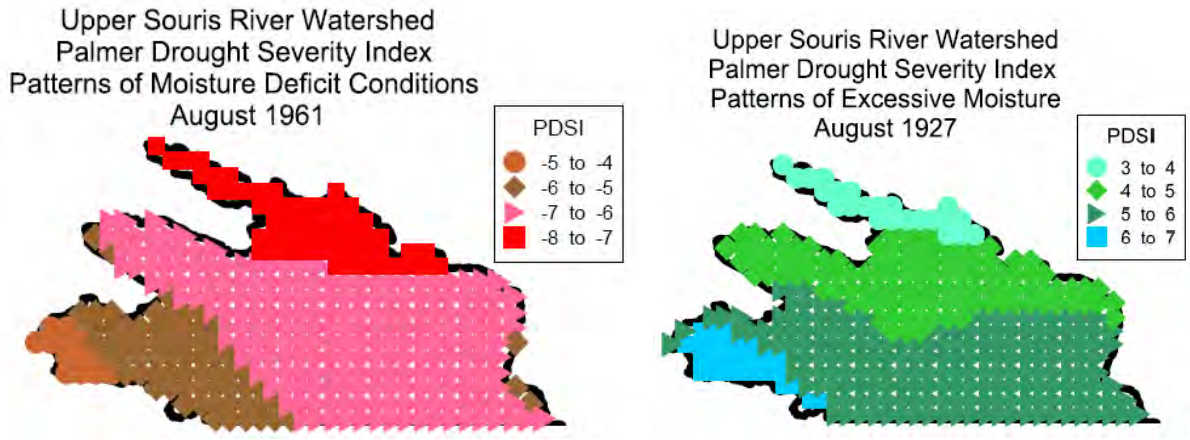

Figure 5 PDSI Upper Souris River Watershed Maps for the drought year of 1961 and excessive moisture year of 1927

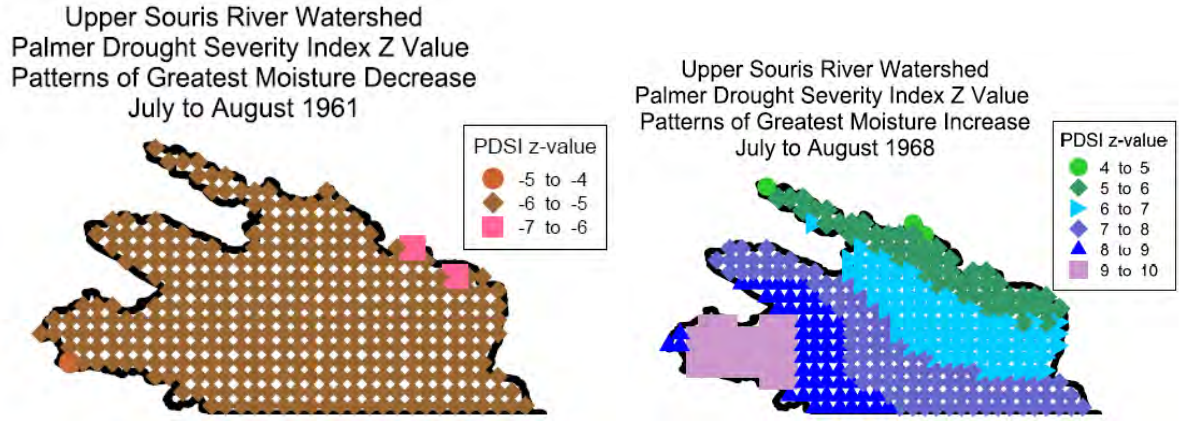

Figure 6 PDSI Z-Value Upper Souris River Watershed Maps for the drought year of 1961 and excessive moisture year of 1968

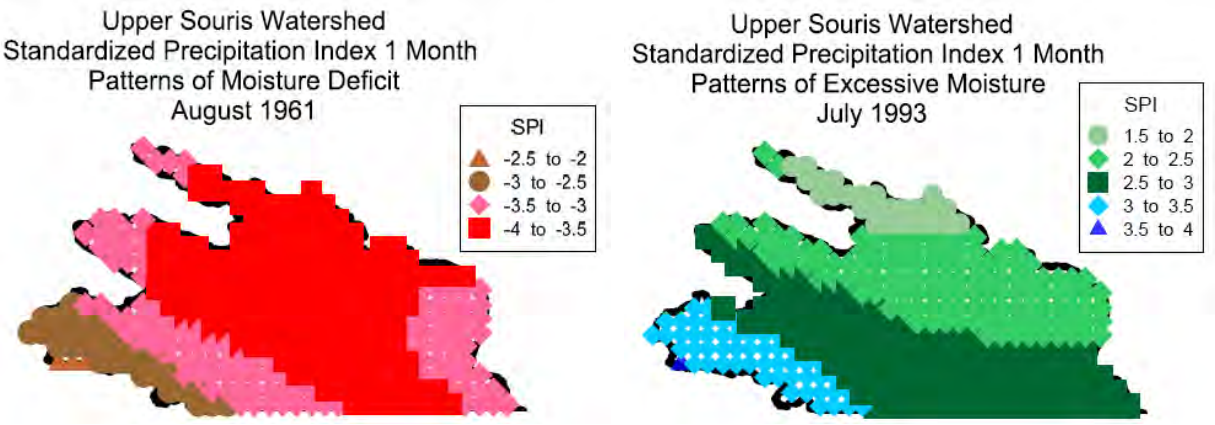

Figure 7 SPI One-Month Upper Souris River Watershed Maps for the drought month of August 1961 and excessive moisture month of July 1993

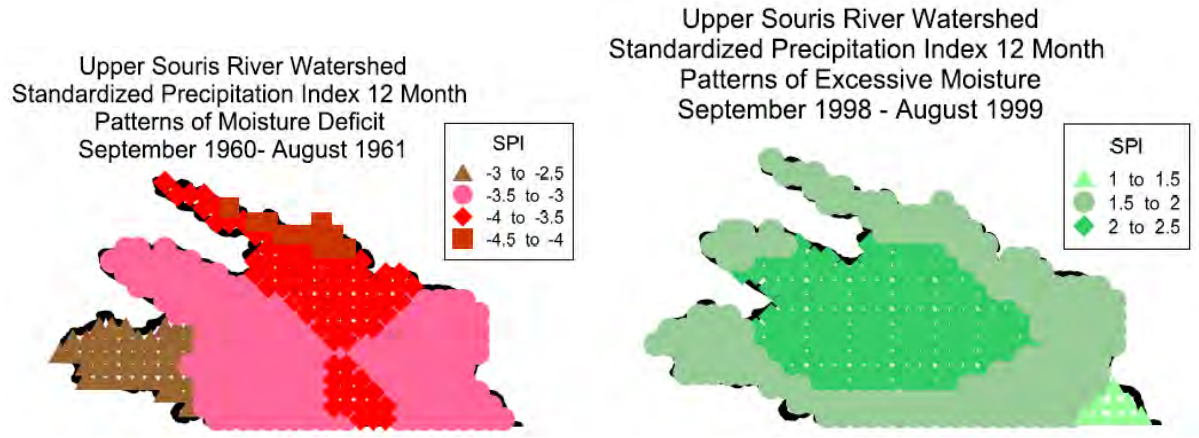

Figure 8 SPI 12-Month Upper Souris River Watershed Maps for the drought year of 1961 and excessive moisture year of 1999

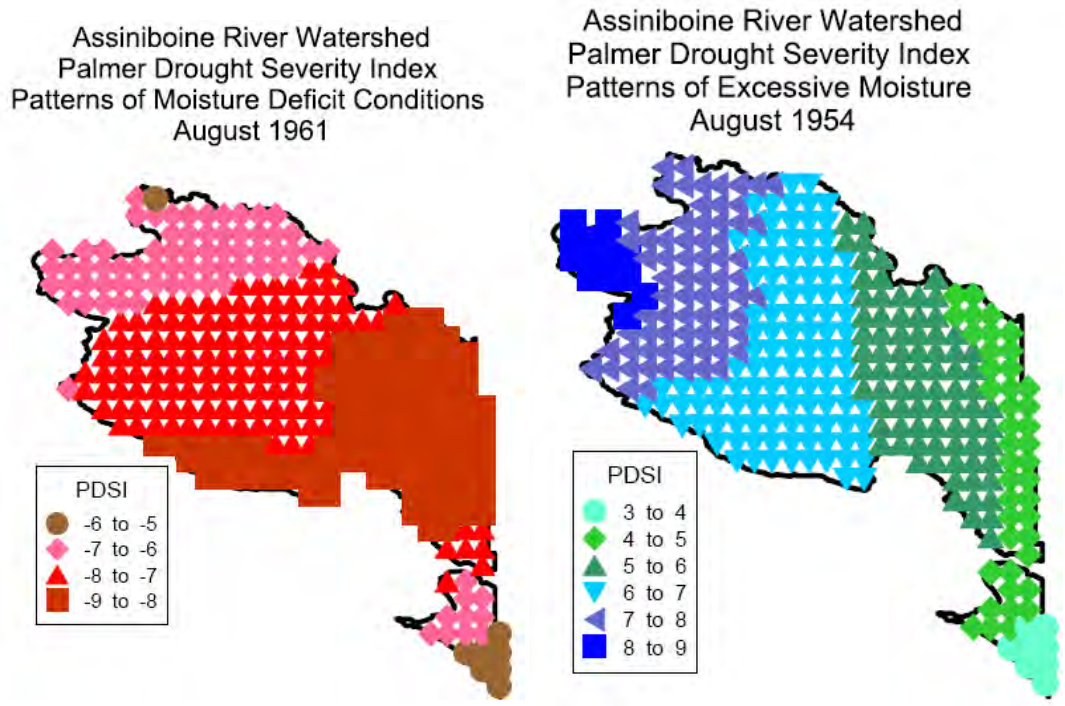

Figure 9 PDSI Assiniboine River Watershed Maps for the drought year of 1961 and excessive moisture year of 1954

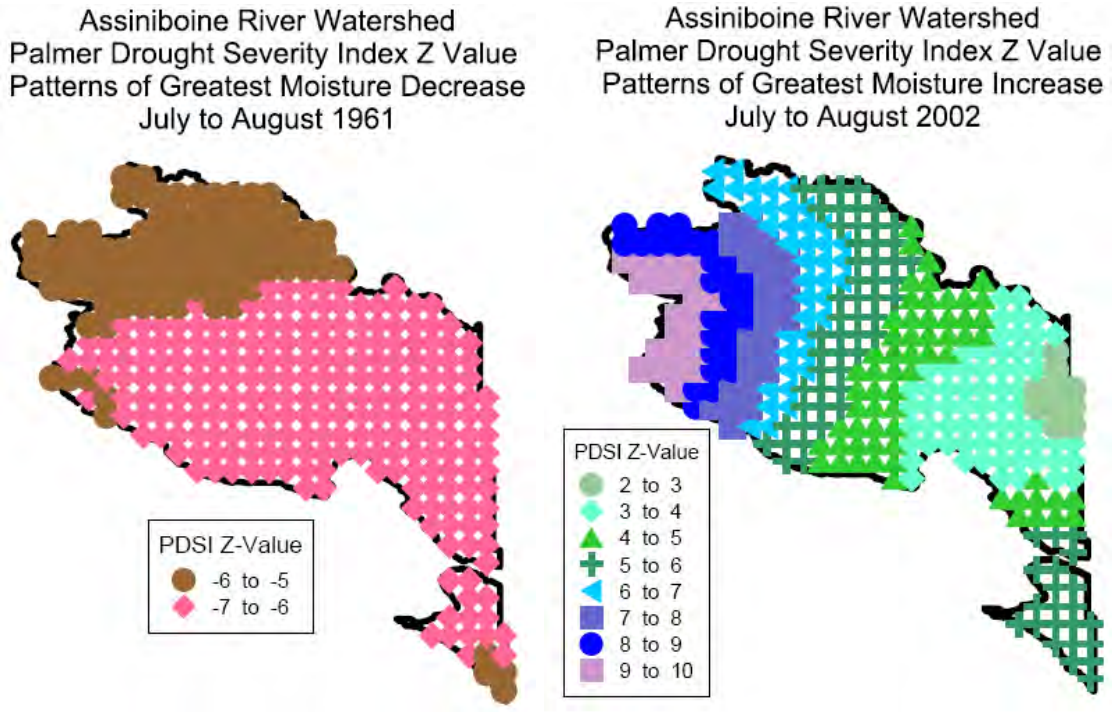

Figure 10 PDSI Z-Value Assiniboine River Watershed Maps for the drought year of 1961 and excessive moisture year of 2002

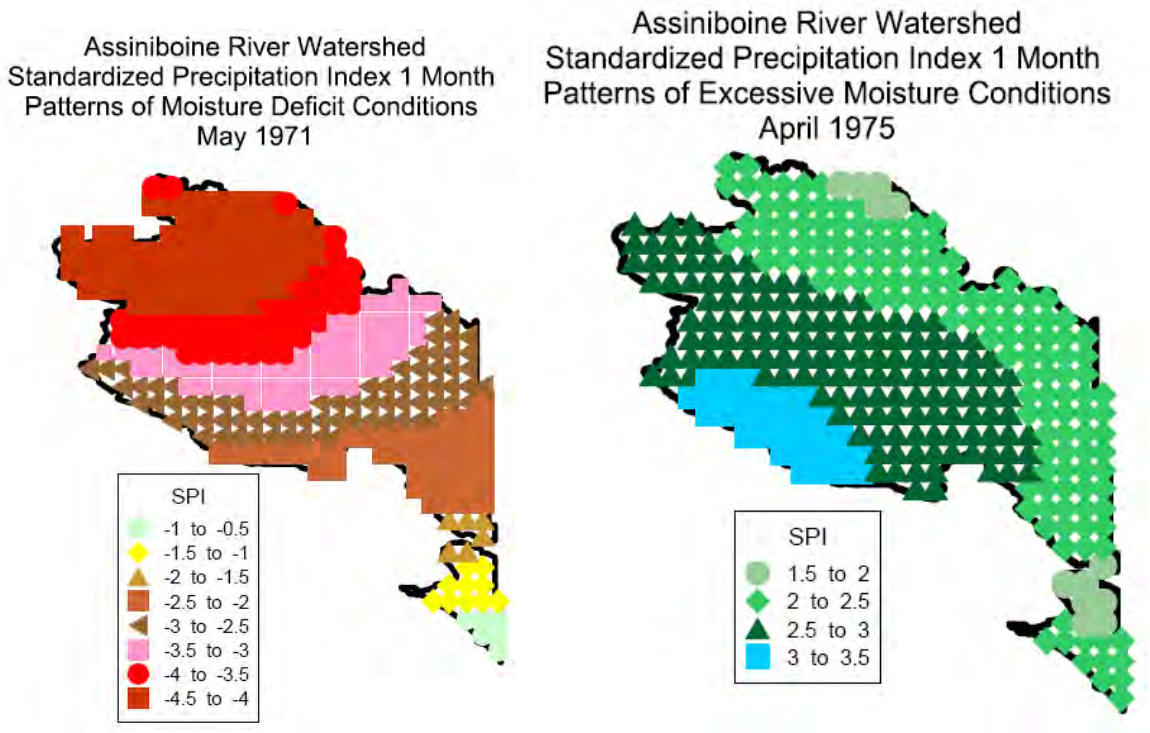

Figure 11 SPI One-Month Upper Souris River Watershed Maps for the drought month of May 1971 and excessive moisture month of April 1975

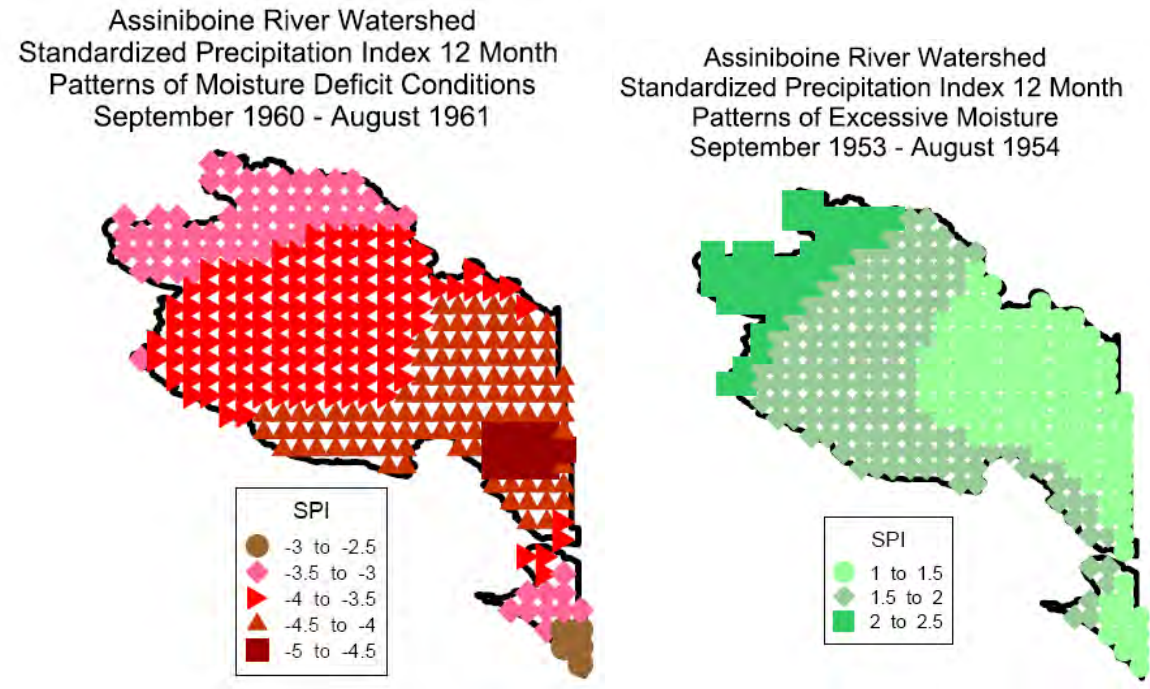

Figure 12 SPI 12-Month Upper Souris River Watershed Maps for the drought year of 1961 and excessive moisture year of 1954

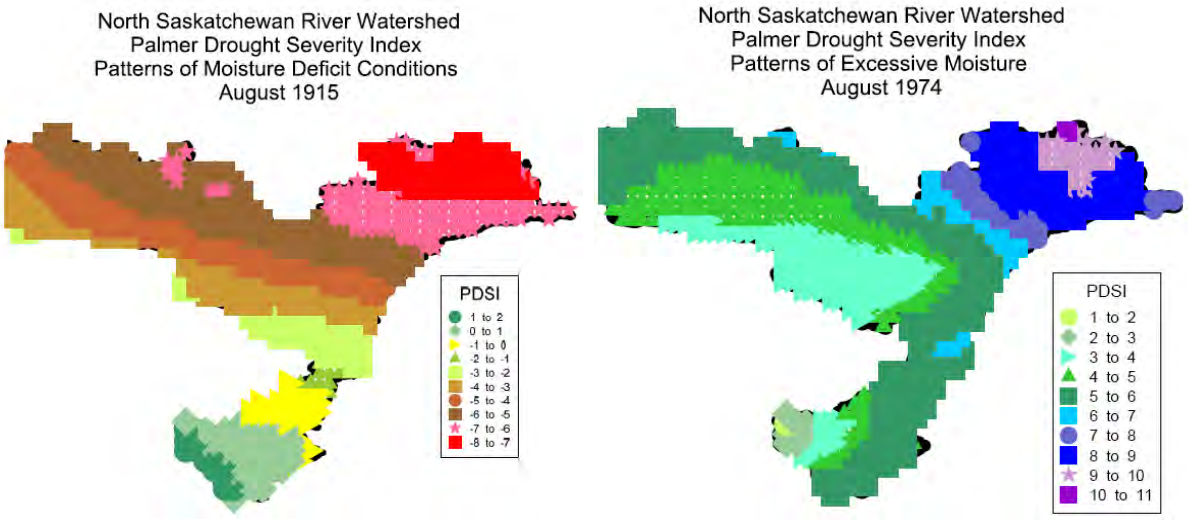

Figure 13 PDSI North Saskatchewan River Watershed Maps for the drought year of 1915 and excessive moisture year of 1974

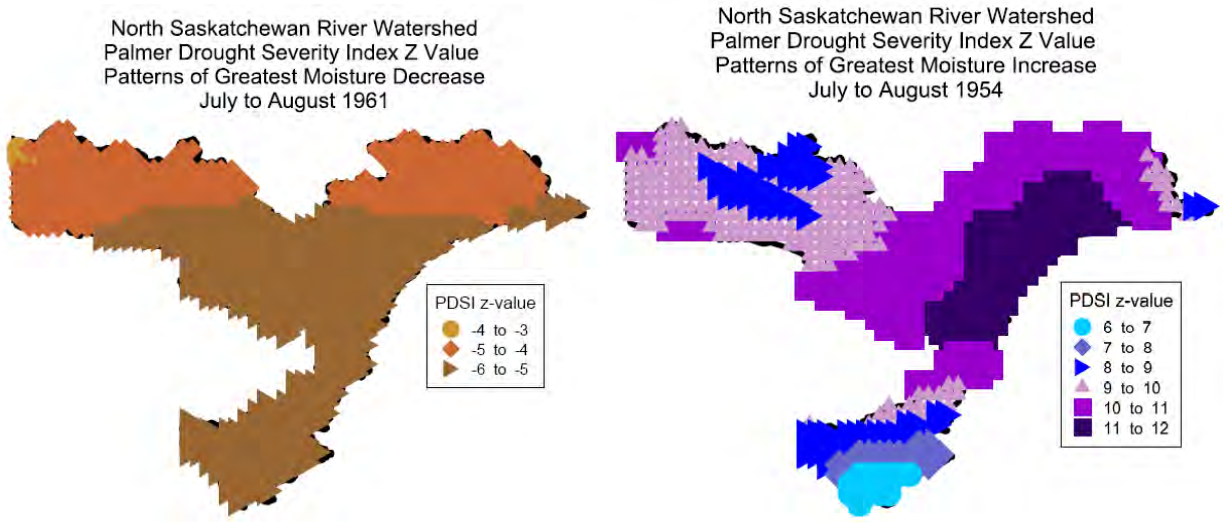

Figure 14 PDSI Z-Value North Saskatchewan River Watershed Maps for the drought year of 1961 and excessive moisture year of 1954

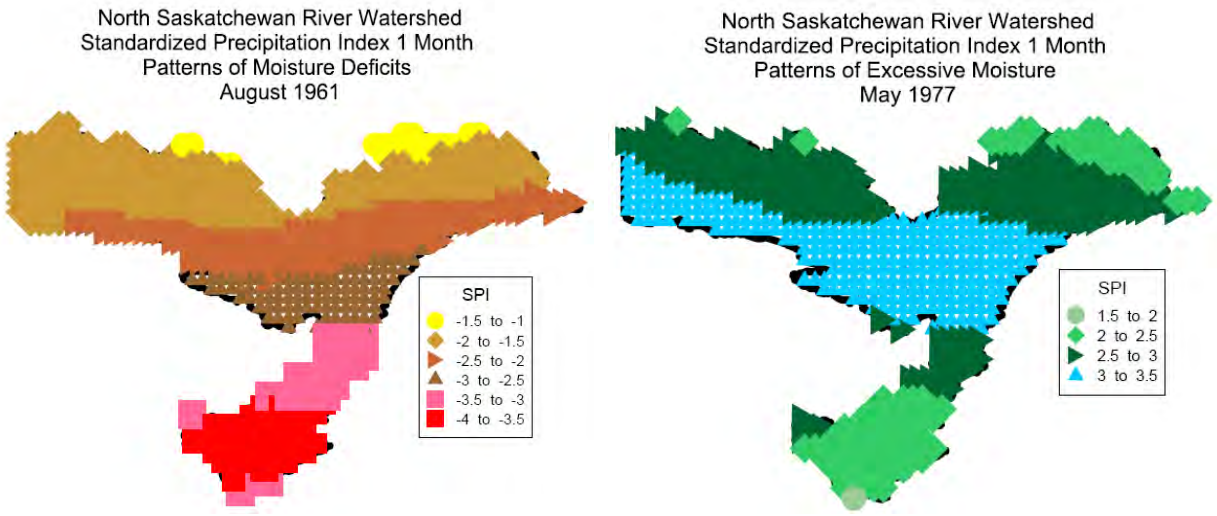

Figure 15 SPI One-Month North Saskatchewan River Watershed Maps for the drought month of August 1961 and excessive moisture month of May 1977

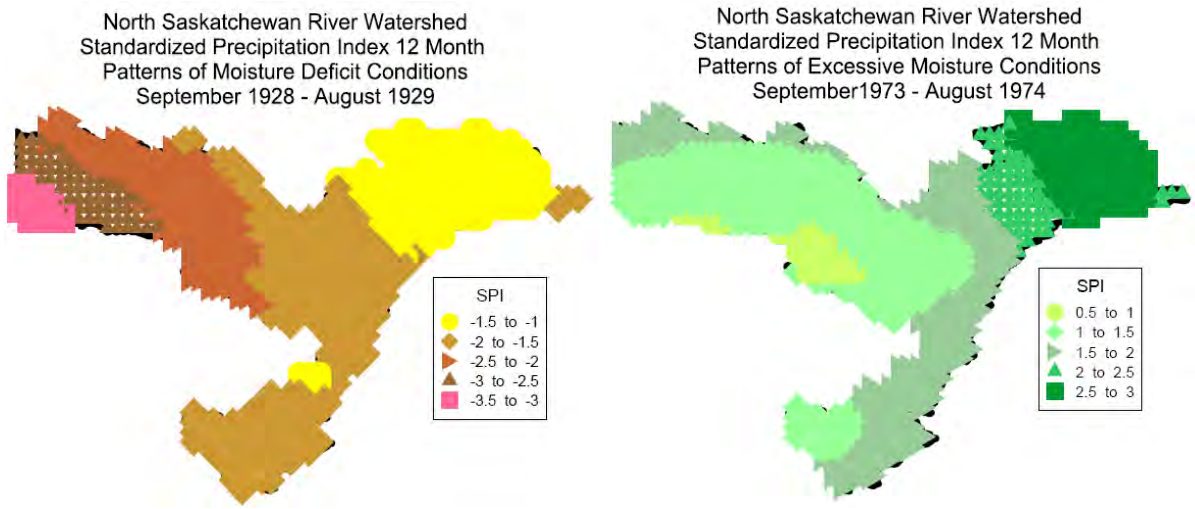

Figure 16 SPI 12-Month North Saskatchewan River Watershed Maps for the drought year of 1929 and excessive moisture year of 1974

APPENDIX 3

Media Table for Impacts and Adaptations of the 2010 Excessive Moisture Event

Legend for Media Table:
N = Negative
P = Positive
1 = Flood
2 = Drought

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
Briere, Karen	June 24 2010	Western Producer	Sask	Maple Creek	N	N				N			Evacuated due to flooding	N	1				
Pratt, Sean	June 24 2010	Western Producer	United States	Rural	N	N		Stripe rust		N					1				
White, Ed	June 24 2010	Western Producer	Prairies	Rural	N					N					1				
White, Ed	June 24 2010	Western Producer	Prairies	Rural						N					1				
Pratt, Sean	June 24 2010	Western Producer													1				
Briere, Karen	Jan 28 2010	Western Producer	Prairies	Rural											Storm (blizzard)				
McMillan, D'Arce	Jan 28 2010	Western Producer	Prairies	Rural	P					P									
Arnason, Robert	Feb 4 2010	Western Producer	Manitoba	Red River Valley	N					N					1				
Ewins, Adrian	Feb 4 2010	Western Producer	Prairies	Rural	N	N	Grasshopper	Wheat Midge, Ergot		N									
	Feb 11 2010	Western Producer																	
Arnason, Robert	Feb 18 2010	Western Producer	Manitoba	Rural	N	N	Grasshopper			N					2				
Rueters	Feb 18 2011	Western Producer	Alberta	Rural							N	N		N	2				
Rueters	Feb 18 2012	Western Producer	Global		N					N									
Hursh, Kevin	Feb 23 2010	StarPhoenix	Prairies	Rural						P				P					
	Feb 24 2010	Government of Sask	Sask	Rural						P				P	1,2				
Briere, Karen	Mar 4 2010	Western Producer	Sask	Rural						P									
Rueters	Mar 4 2010	Western Producer	Manitoba	Red River Valley											1				
Cross, Brian	Mar 4 2010	Western Producer	Sask	Rural	P	P				P									
Duckworth, Barbara	Mar 4 2010	Western Producer	Prairies	Rural															
Rueters	Mar 4 2010	Western Producer	Global												1				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
Rueters	Mar 4 2010	Western Producer	Canada	Arctic															
Briere, Karen	Mar 4 2010	Western Producer	Sask	Rural	N	N	Grasshopper (all listed)			N									
Briere, Karen	Mar 4 2010	Western Producer	Sask	Rural	P	P				P					1				
Hartley, Scott	Mar 2010	Agriview	Sask	Rural	N	N	Wheat midge			N									
Duckworth, Barbara	Mar 11 2010	Western Producer	Alberta	Rural	N	N				N									
Duckworth, Barbara	Mar 11 2010	Western Producer	Alberta	Rural															
Macarthur, Mary	Mar 11 2010	Western Producer	Alberta	Rural	N	N	Grasshoppers			N									
Arnason, Robert	Mar 18 2010	Western Producer	Manitoba	Red River Valley	P	P				P					1				
Briere, Karen	Mar 18 2010	Western Producer	Prairies	Rural	N	N				N									
Briere, Karen	Apr 1 2010	Western Producer	Prairies	Rural	N	N				N					2				
Arnason, Robert	Apr 1 2010	Western Producer	Manitoba	Interlake	P	P				P									
Arnason, Robert	Apr 1 2010	Western Producer	Manitoba	Interlake											1				
Barteski, Lloyd	Apr 2010	Agriview	Sask	Rural															
Raine, Micheal	Apr 8 2010	Western Producer	Prairies	Rural															
Kossowan, Brenda	Apr 8 2010	Western Producer	Alberta	Rural										P					
Cross, Brian	Apr 8 2010	Western Producer	Alberta	Rural							N			N	2				
Wingrove, Josh/Walton, Dawn	Apr 13 2010	Globe and Mail	Alberta	Rural	N	N				N	N	N		N	2				
Briere, Karen	Apr 15 2010	Western Producer	Prairies	Rural	N	N				N	N	N		N	2				
Cross, Brian	Apr 22 2010	Western Producer	Prairies	Rural	P	P				P					1				
Cross, Brian	Apr 22 2010	Western Producer	Prairies	Rural	P	P				P									
Kossowan, Brenda	Apr 22 2010	Western Producer	Alberta	Rural								N		N					
Cross, Brian	Apr 29 2010	Western	Alberta	Rural	P	P				P					1				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
		Producer																	
	May 1 2010	Canadian Press	Alberta	Rural	N	N				N	N			N	1				
Macarthur, Mary	May 6 2010	Western Producer	Alberta	Rural	P	P				P	P	P		P	1				
Arnason, Robert	May 6 2010	Western Producer	Prairies	Rural	P	P				P									
Briere, Karen	May 6 2010	Western Producer	Sask	Rural	P	P				P									
	May 6 2010	Sask Ministry of Ag	Sask	Rural											1,2				
Hall, Angela	May 11 2010	Regina Leader-Post	Sask	Rural	N					N				N	1				
Schmidt, Lisa	May 11 2010	Calgary Herald	Alberta	Rural	P	P				P	P	P		P	1				
	May 11 2010	CBC news	Prairies	Rural	N	N				N					1				
Cross, Brian	May 20 2010	Western Producer	Sask	UofS															
Macarthur, Mary	May 20 2010	Western Producer	Alberta	Rural	P	P				P					1				
Lyseng, Ron	May 20 2010	Western Producer	Prairies	Rural	P	P				P	P	P		P					
Cross, Brian	May 20 2010	Western Producer	Praires	Rural							N	N		N	1,2				
Swihart, Ric	May 20 2010	Western Producer	Alberta	Rural				Scour, Pneumonia			N	N		N	1				
Wilson, Barry	May 20 2010	Western Producer	Prairies	Rural	N	N				N	N	N		N					
Pratt, Sean	May 27 2010	Western Producer	Prairies	Rural	N	N				N									
	May 31 2010	CBC News	Manitoba	Winnipeg											1				
	June1 2010	CBC News	Alberta	Rural	N	N				N					1				
Briere, Karen	June3 2010	Western Producer	Prairies	Lloydminster							P	P		P	2				
Macarthur, Marcy	June3 2010	Western Producer	Alberta	Rural	N	N				N					1				
Briere, Karen	June3 2010	Western Producer	Sask	Last Mountain	N	N				N									
McMillan, D'Arce	June3 2010	Western Producer	Prairies	Rural	N	N				N					1				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
Rueters	June 3 2010	Western Producer	Prairies	Rural	N	N				N	N	N		N	2				
	June 8 2010	CBC News	Prairies	Rural	N	N				N					1				
	June 10 2010	CBC News	Sask	Rural	N	N				N					1				
White, Ed	June 10 2010	Western Producer	Manitoba	Red River Valley	N	N				N				N	1				
Briere, Karen	June 10 2010	Western Producer	Sask	Rural							N	N		N	2				
Briere, Karen	June 10 2010	Western Producer	Sask	Rural	N	N				N					1				
???	June 10 2010	Western Producer																	
	June 15 2010	CBC News	Sask	Rural	P					P				P	1				
Wood, James	June 16 2010	StarPhoenix	Prairies	Rural						P				P	1				
Adamko, Alanna	June 16 2010	StarPhoenix	Sask	Rural	N	N				N					1				
Wood, James	June 16 2010	StarPhoenix	Sask	Rural						P				P	1				
Wood, James	June 17 2010	StarPhoenix	Sask	Rural						P				P	1				
Wood, James	June 17 2010	StarPhoenix	Sask	Rural						P				P	1				
Hutton, David	June 17 2010	StarPhoenix	Sask	Saskatoon											1				
	June 17 2010	CBC News	Sask	Rural											1				
Cross, Brian	June 17 2010	Western Producer	Sask	Rural	N	N				N					1				
Pratt, Sean	June 17 2010	Western Producer	Sask	Rural	N	N				N					1				
Arnason, Robert	June 17 2010	Western Producer	Prairies	Rural	N	N				N					1				
Pratt, Sean	June 17 2010	Western Producer	Prairies	Rural	N	N				N					1				
Pratt, Sean	June 17 2010	Western Producer	Prairies	Rural	N	N				N					1				
Briere, Karen	June 17 2010	Western Producer	Prairies	Rural	N	N				N					1				
Adamko, Alanna	June 17 2010	Western Producer	Sask	Saskatoon	N	N				N					1				
Cowan, Pamela	June 17 2010	Regina Leader-Post	Sask	Rural	N	N				N					1				
	June 17 2010	Sask Watershed Authority	Sask	Rural											1				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
	June 17 2010	Sask Watershed Authority	Sask	Rural											1				
	June 18 2010	CBC News	Alberta	Rural	N	N				N	N			N	1				
Government of Sask	June 18 2010	Road Conditions	Sask	Rural	N	N				N	N			N	1				
	June 18 2010	CBC News	Prairies	Rural							N			N	1				
	June 18 2010	Southwest TV News	Sask	Maple Creek											1				
	June 18 2010	Southwest TV news	Sask	Swift Current											1				
	June 20 2010	CBC News	Alberta	Rural	N	N				N					1				
	June 20 2010	CBC News	Prairies	Rural											1				
Fries, Joe	June 20 2010	Calgary Herald	Alberta	Rural	N	N				N	N			N	1				
Gerson, Jen	June 20 2010	Calgary Herald	Alberta	Rural											1				
Gerson, Jen	June 21 2010	Calgary Herald	Alberta	Rural							N			N	1				
Gerson, Jen	June 21 2010	Calgary Herald	Prairies	Rural											1				
Gerson, Jen	June 21 2010	Calgary Herald	Alberta	Rural											1				
Gerson, Jen/Couture, Joe	June 21 2010	Canwest News Service	Alberta	Medicine Hat						N				N	1				
	June 21 2010	CBC News	Prairies	Rural						N				N	1				
	June 21 2010	CBC News	Alberta	Medecine Hat						N				N	1				
Couture, Joe	June 21 2010	Sask News Network	Sask	Maple Creek						P				P	1				
Switzer, Tim	June 21 2010	Leader Post	Sask	Maple Creek											1				
	June 21 2010	Macleans.ca	Prairies	Rural						N					1				
Switzer, Tim	June 22 2010	Regina Leader-Post	Sask	Maple Creek						P				P	1				
Johnstone,	June 22 2010	Sask News	Sask	Rural	N					N					1				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
Bruce		Network																	
	June 22 2010	CBC News	Sask	Maple Creek						N				N	1				
Adamko, Alanna	June 22 2010	StarPhoenix	Sask	Rural	N	N				N					1				
	June 22 2010	CBC News	Sask	Rural	N	N				N	N			N	1				
	June 22 2010	Sask News Network	Sask	Rural											1				
Kyle, Cassandra	June 23 2010	StarPhoenix	Sask	Rural							P			P	1				
Briere, Karen	June 24 2010	Western Producer	Sask	Maple Creek	N	N				N			Evacuated due to flooding	N	1				
Pratt, Sean	June 24 2010	Western Producer	United States	Rural	N	N		Stripe rust		N					1				
White, Ed	June 24 2010	Western Producer	Prairies	Rural	N					N					1				
White, Ed	June 24 2010	Western Producer	World	Rural	N	N		Stripe rust		N					1				
Pratt, Sean	June 24 2010	Western Producer	Prairies	Rural															
Editorial	June 24 2010	Western Producer	Prairies	Rural	N	N				N					1				
Harder, Cam	June 24 2010	Western Producer	Global	Rural											1				
Arnason, Robert	June 24 2010	Western Producer	Manitoba	Rural	N	N				N					1				
Wilson, Barry	June 24 2010	Western Producer	Prairies	Rural	N	N				N					1				
	June 28 2010	Leader Post	Sask	Maple Creek											1				
Kyle, Cassandra	July 7 2010	Sask News Network	Sask	Rural	N	N				N					1				
Kyle, Cassandra	July 8 2010	StarPhoenix	Prairies	Rural						P				P	1				
	July 8 2010	CBC News	Sask	Yorkton						P				P	1				
	July 8 2010	CBC news	Prairies	Rural						P				P	1				
Massinon, Steph/Down, John	July 13 2010	Postmedia News	Alberta	Rural										N	1				
Hall, Angela	July 13 2010	Regina Leader-Post	Sask	Rural											1				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
	July 14 2010	CBC News	Alberta	Rural	P					P				P	1				
Switzer, Tim	July 14 2010	Regina Leader-Post	Sask	Radville	N	N				N					1				
Wilson, Bary	July 15 2010	Westen Producer	Canada	Rural											1				
Wilson, Barry	July 15 2010	Western Producer	Prairies	Rural	N	N				N									
Cross, Brian	July 15 2010	Western Producer	Sask	Yorkton	N	N				N					1				
Editorial	July 15 2010	Western Producer	Prairies	Rural	P	P				P					1				
Briere, Karen	July 15 2010	Western Producer	Sask	Yorkton	P	P				P					1				
Briere, Karen	July 15 2010	Western Producer	Sask	Rural											1				
Briere, Karen	July 15 2010	Western Producer	Sask	Rural											1				
Duckworth, Barbara	July 15 2010	Western Producer	Alberta	Rural	N	N		sclerotinia blackleg		N					1				
Ewins, Adrian	July 15 2010	Western Producer	Global	Rural	P	P				P					1				
	July 19 2010	CBC News	Prairies	Rural	N	N				N					1				
Johnstone, Bruce	July 19 2010	Regina Leader-Post	Sask	Rural						N				N	1				
	July 21 2010	CBC News	Sask	Yorkton	N	N				N	N			N	1				
	July 21 2010	CBC News	Prairies	Rural						N				N	1				
	July 21 2010	CBC News	Sask	Yorkton						N					1				
Briere, Karen	July 22 2010	Western Producer	Sask	Maple Creek	N	N				N					1				
Arnason, Robert	July 22 2010	Western Producer	Manitoba	Rural	N	N				N	N			N	1				
MacArthur, Mary	July 22 2010	Western Producer	Alberta	Rural	N	N				N					2				
(Crop Report)	July 22 2010	Western Producer	Alberta	Rural	N	N			hail	N					1				
(Crop Report)	July 22 2010	Western Producer	Manitoba	Rural	N	N		root rot		N					1				
(Crop Report)	July 22 2010	Western Producer	Sask	Rural	N	N		ascochyta blight		N					1				
Duckworth, Barbara	July 22 2010	Western Producer	Alberta	Rural											2				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
	July 23 2010	Postmedia News	Sask	North Battleford											1				
Cowan, Pamela	July 24 2010	Sask News Network	Sask	Rural											1				
	July 26 2010	Sask News Network	Sask	Lanigan	N	N			tornado	N	N			N					
Hall, Angela	July 26 2010	Regina Leader-Post	Sask	Rural	N	N				N	N			N	1				
	July 27 2010	StarPhoenix	Prairies	Rural	P	P				P	P			P	1				
	July 27 2010	CBC News	Sask	Rural						N				N	1				
Ewins, Adrian	July 29 2010	Western Producer	Prairies	Rural	N	N				N					1				
Pratt, Sean	July 29 2010	Western Producer	Prairies	Rural	N	N				N					1				
Arnason, Robert	July 29 2010	Western Producer	Manitoba	Arborg	N	N				N					1				
MacArthur, Mary	July 29 2010	Western Producer	Prairies	Rural	P	P			hail	P					1				
(Crop Report)	July 29 2010	Western Producer	Alberta	Rural	N	N				N				N	1,2				
(Crop Report)	July 29 2010	Western Producer	Manitoba	Rural	P	P				P					1				
(Crop Report)	July 29 2010	Western Producer	Sask	Rural	N	N				N					1				
Briere, Karen	July 29 2010	Western Producer	Sask	Rural	N	N				N					1				
Macarthur, Mary	July 29 2010	Western Producer	Alberta	Edberg	P	P				P					1				
Arnason, Robert	July 29 2010	Western Producer	Manitoba	Brookdale	P	P				P									
Lyseng, Rob	July 29 2010	Western Producer	Prairies	Rural	P	P				P					1				
Lyseng, Rob	July 29 2010	Western Producer	Prairies	Rural	P	P				P					1				
Wilson, Barry	July 29 2010	Western Producer	Canada		P	P				P	P			P					
White, Ed	Aug 5 2010	Western Producer	Canada		N	N				N					1				
Pratt, Sean	Aug 5 2010	Western Producer	Prairies	Rural	N	N				N					1				
White, Ed	Aug 5 2010	Western Producer	Prairies	Rural	N	N				N					1				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
Rueters	Aug 5 2010	Western Producer	United States	Kansas							N			N	2				
Briere, Karen	Aug 5 2010	Western Producer	Sask	Rural	N	N				N									
Raine, Micheael	Aug 5 2010	Western Producer	Alberta	Rural						P									
Arnason, Robert	Aug 12 2010	Western Producer	Manitoba	Rural							N			N	1				
Arnason, Robert	Aug 12 2010	Western Producer	Prairies	Rural	N					N					1				
(Crop Report)	Aug 12 2010	Western Producer	Alberta	Rural	N	N				N	N			N	1,2				
(Crop Report)	Aug 12 2010	Western Producer	Manitoba	Rural	P					P					1				
(Crop Report)	Aug 12 2010	Western Producer	Sask	Rural	P					P					1				
Duckworth, Barbara	Aug 12 2010	Western Producer	Alberta	Rural						N									
Pratt, Sean	Aug 12 2010	Western Producer	Prairies	Rural	N	P				N									
Hamilton, Charles	Aug 12 2010	Western Producer	Prairies	Rural							P			P	1				
Ewins, Adrian	Aug 12 2010	Western Producer	Sask	Rural						P					1				
MacArthur, Mary	Aug 12 2010	Western Producer	Sask	Rural	N	N				N					1				
Macarthur, Mary	Aug 19 2010	Western Producer	Prairies	Rural	N	N				N					1				
(Crop Report)	Aug 19 2010	Western Producer	Alberta	Rural	N	N				N					1				
(Crop Report)	Aug 19 2010	Western Producer	Manitoba	Rural	N	N				N					1				
(Crop Report)	Aug 19 2010	Western Producer	Sask	Rural	N	N		foot rot		N					1				
McMillan, D'Arce	Aug 19 2010	Western Producer	Prairies	Rural	N	N				N					1				
Macbean, Sylvia	Aug 19 2010	Western Producer	Prairies	Rural	N	N		late blight		N									
	Aug 20 2010	CBC News	Sask	Rural						N				N	1				
Pratt, Sean	Aug 26 2010	Western Producer	Sask	Rural	N	N		sclerotinia, botrytis, mould		N									
Ewins, Adrian	Aug 26 2010	Western	Global	Rural	N	N				N					1,2				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
		Producer																	
Wilson, Barry	Aug 26 2010	Western Producer	Canada		N	N				N	N			N					
Macarthur, Mary	Aug 26 2010	Western Producer	Prairies	Rural															
(Crop Report)	Aug 26 2010	Western Producer	Alberta	Rural															
(Crop Report)	Aug 26 2010	Western Producer	Manitoba	Rural															
(Crop Report)	Aug 26 2010	Western Producer	Sask	Rural															
Pratt, Sean	Aug 26 2010	Western Producer	Prairies	Rural	N	N				N					1				
Pratt, Sean	Aug 26 2010	Western Producer	Prairies	Rural	N	N				N									
Arnason, Robert	Aug 26 2010	Western Producer	Manitoba	Rural							P			P	1				
Lyseng, Ron	Aug 26 2010	Western Producer	Prairies	Rural											1				
Briere, Karen	Aug 26 2010	Western Producer	Sask	Rural	N	N				N	N			N	1				
Cross, Brian	Sept 2 2010	Western Producer	Alberta	Rural	P	P				P									
MacArthur, Mary	Sept 2 2010	Western Producer	Prairies	Rural	N	N				N					1				
(Crop Report)	Sept 2 2010	Western Producer	Alberta	Rural	N	N				N	N			N	1				
(Crop Report)	Sept 2 2010	Western Producer	Manitoba	Rural											1				
(Crop Report)	Sept 2 2010	Western Producer	Sask	Rural											1				
Pratt, Sean	Sept 2 2010	Western Producer	Prairies	Rural	N	N				N					1				
Arnason, Robert	Sept 9 2010	Western Producer	Manitoba	Rural	N	N				N	N			N	1				
(Crop Report)	Sept 9 2010	Western Producer	Alberta	Rural	N	N				N				N	1				
(Crop Report)	Sept 9 2010	Western Producer	Manitoba	Rural	N					N					1				
(Crop Report)	Sept 9 2010	Western Producer	Sask	Rural	N	N		disease		N					1				
White, Ed	Sept 9 2010	Western Producer	Prairies	Rural	N	N				N					1				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
Pratt, Sean	Sept 9 2010	Western Producer	Sask	Rural	N	P				P					1				
Guenter, Henry	Sept 9 2010	Western Producer	Prairies	Rural	N	N				N					1				
Dekay, William	Sept 9 2010	Western Producer	Prairies	Rural											1				
	Sept 13 2010	CBC News	Sask	Rural						P				P	1				
Macarthur, Mary	Sept 16 2010	Western Producer	Prairies	Rural	N	N				N					1				
Arnason, Robert	Sept 16 2010	Western Producer	Manitoba	Rural	P	P				P									
Macarthur, Mary	Sept 16 2010	Western Producer	Prairies	Rural	N	N				N	N			N	1				
(Crop Report)	Sept 16 2010	Western Producer	Alberta	Rural	N	N									1				
(Crop Report)	Sept 16 2010	Western Producer	Manitoba	Rural	N										1				
(Crop Report)	Sept 16 2010	Western Producer	Sask	Rural	N										1				
Briere, Karen	Sept 16 2010	Western Producer	Prairies	Rural							N			N					
Wilson, Barry	Sept 16 2010	Western Producer	Canada		N	N				N	N			N	1				
Raine, Micheal	Sept 16 2010	Western Producer	Prairies	Rural	N	N				N					1				
Briere, Karen	Sept 16 2010	Western Producer	Prairies	Rural						N					1				
Hall, Angela	Sept 22 2010	Sask News Network	Sask	Rural	N	N				N					1				
Briere/Ewins	Sept 23 2010	Western Producer	Prairies	Rural	N	N				N	N			N	1				
Macarthur, Mary	Sept 23 2010	Western Producer	Canada		N	N				N					1				
Wilson, Barry	Sept 23 2010	Western Producer	Prairies	Rural	N	N				N					2				
Arnason, Robert	Sept 23 2010	Western Producer	Praires	Rural	N	N				N					1				
White, Ed	Sept 23 2010	Western Producer	Prairies	Rural											1				
Scott, Neil	Sept 24 2010	Regina Leader-Post	Sask	Rural	N	N				N					1				
Roth, Pam/Couture,	Sept 27 2010	Regina Leader-Post	Sask	Maple Creek											1				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
Joe																			
Arnason, Robert	Sept 30 2010	Western Producer	Canada		N	N				N	N			N	1				
MacArthur, Mary	Sept 30 2010	Western Producer	Alberta	Rural											1				
(Crop Report)	Sept 30 2010	Western Producer	Alberta	Rural	P	P				P					1				
(Crop Report)	Sept 30 2010	Western Producer	Manitoba	Rural	N					N					1				
(Crop Report)	Sept 30 2010	Western Producer	Sask	Rural	P	P				P	N				1				
White, Ed	Sept 30 2010	Western Producer	Prairies	Rural	N	N				N					1				
McMillan, D'Arce	Sept 30 2010	Western Producer	Prairies	Rural						P					1				
Duckworth, Barbara	Sept 30 2010	Western Producer	Alberta	Rural						P				P	1				
Recksiedler, Blaine	Sept 2010	Agriview	Prairies	Rural	P					P					1				
Babcock, John	Sept 2010	Agriview	Sask	South Sask	P	P				P									
AgriStability	Sept 2010	Agriview	Prairies	Rural						P					1				
Ministry of Ag	Sept 2010	Agriview	Prairies	Rural						P				P	1				
Pratt, Sean	Oct 7 2010	Western Producer	Prairies	Rural	N	N				N					1				
Briere, Karen	Oct 7 2010	Western Producer	Sask	Rural	P	P				P	P			P	1				
Cross, Brian	Oct 7 2010	Western Producer	Prairies	Rural	N					N	N			N	1				
Wilson, Barry	Oct 7 2010	Western Producer	Canada							P				P	1				
Arnason, Robert	Oct 7 2010	Western Producer	Prairies	Rural	N	N		fungus		N					1				
White, Ed	Oct 7 2010	Western Producer	Global							P				P					
White, Ed	Oct 7 2010	Western Producer	Prairies	Rural	P	P				P	P			P	1				
Glen, Barb (editorial)	Oct 7 2010	Western Producer	Prairies	Rural	N	N				N				N	1				
Glen, Barb (editorial)	Oct 7 2010	Western Producer	Prairies	Rural	N	N				N	N	N		N	2				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
Ewins, Adrian	Oct 7 2010	Western Producer	Prairies	Rural						N				N	1				
Pratt, Sean	Oct 7 2010	Western Producer	Prairies	Rural		P				P									
Macarthur, Mary	Oct 7 2010	Western Producer	Sask	Rural	P	N				N					1				
Arnason, Robert	Oct 7 2010	Western Producer	Manitoba	Rural	N	N		Sclerotinia		N					1				
Lyseng, Ron	Oct 7 2010	Western Producer	Manitoba	Rural						P					1				
Arnason, Robert	Oct 7 2010	Western Producer	Prairies	Rural											1				
Briere, Karen	Oct 7 2010	Western Producer	Prairies	Rural		N				N	N			N	1				
Duckworth, Barbara	Oct 7 2010	Western Producer	Prairies	Rural							N			N	1				
Grognet, Jeff	Oct 7 2010	Western Producer	Prairies	Rural				Sweet clover poisoning						N	1				
Andrews, Jacklin	Oct 7 2010	Western Producer	Prairies	Rural											1				
Briere, Karen	Oct 14 2010	Western Producer	Prairies	Rural	P	P				P					1				
Briere, Karen	Oct 14 2010	Western Producer	Canada							P				P	1				
Ewins, Adrian	Oct 14 2010	Western Producer	Prairies	Rural						P				P	1				
Arnason, Robert	Oct 14 2010	Western Producer	Manitoba	Rural	P	P				P					1				
Glen, Barb (editorial)	Oct 14 2010	Western Producer	Prairies	Rural	N	N				N				N	1,2				
Guenter, Henry	Oct 14 2010	Western Producer	Prairies	Rural						N					1				
Ewins, Adrian	Oct 14 2010	Western Producer	Praiires	Rural						N				N	1,2				
Swihart, Ric	Oct 21 2010	Western Producer	Alberta	Taber	P	P				P					1				
Dekay, William	Oct 21 2010	Western Producer	Sask	Rural	N	N				N					1				
Byers, Shirley	Oct 21 2010	Western Producer	Sask	Rural							N			N	1				
Wilson, Barry	Oct 21 2010	Western Producer	Prairies	Rural															
Arnason, Robert	Oct 21 2010	Western Producer	Prairies	Rural	N	N		Sclerotinia		N	N			N	1				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
Rueters	Oct 21 2010	Western Producer	United States	Rural						P				P	1,2				
Briere, Karen	Oct 21 2010	Western Producer	Prairies	Rural							N			N	1				
Levy, Bryn	Oct 21 2010	Western Producer	Prairies	Rural				Fusarium head blight			N			N	1				
	Oct 25 2010	CBC News	Prairies	Rural	N	N				N					1				
Arnason, Robert	Oct 28 2010	Western Producer	Prairies	Rural	N	N				N					1				
Briere, Karen	Oct 28 2010	Western Producer	Sask	Rural						N					1,2				
Briere, Karen	Oct 28 2010	Western Producer	Prairies	Rural							N			N	1				
Arnason, Robert	Nov 4 2010	Western Producer	Prairies	Rural	N	N				N					1,2				
Glen, Barb (editorial)	Nov 4 2010	Western Producer	Prairies	Rural							N			N	1				
Moneo, Shannon	Nov 4 2010	Western Producer	North America	Rural	N	N				N					1				
Pratt, Sean	Nov 4 2010	Western Producer	Sask	Rural	P	P				P					2				
Levy, Bryn	Nov 4 2010	Western Producer	Sask	Rural						N					2				
Glen, Barb (editorial)	Nov 11 2010	Western Producer	Canada	Rural															
Cross, Brian	Nov 11 2010	Western Producer	Sask	Rural	P	N				P					1				
Levy, Bryn	Nov 11 2010	Western Producer	Sask	Rural							N			N	1				
Levy, Bryn	Nov 11 2010	Western Producer	Prairies	Rural							P			P	1				
Swihart, Ric	Nov 11 2010	Western Producer	Alberta	Rural	P	N				N					1				
Pratt, Sean	Nov 18 2010	Western Producer	Prairies	Rural	N	N				N					1				
Levy, Bryn	Nov 18 2010	Western Producer	Prairies	Rural							P			P	1				
	Nov 22 2010	CBC News	Manitoba	Rural															
Wilson, Barry	Nov 25 2010	Western Producer	Manitoba	Rural							P			P	1				
Swihart, Ric	Nov 25 2010	Western Producer	Prairies	Rural	N	P				P					1				
McMillan,	Nov 25 2010	Western	Prairies	Rural	P	P				P	P			P	1,2				

Author	Date	Newspaper	Location of Article		Agriculture											Communities / Towns		Municipalities	
					crops						livestock				type of impact	water		water	
					yield	quality	pests	diseases	storm	economic	feed	water	transport	economic		quantity	quality	quantity	quality
D'Arce		Producer																	
	Dec 3 2010	Western Producer	Prairies	Rural	P	P				P	P			P	1				
Pratt, Sean	Dec 9 2010	Western Producer	Prairies	Rural	P	P				P					1				
Pratt, Sean	Dec 9 2010	Western Producer	Prairies	Rural	N	N				N					1				
Briere, Karen	Dec 9 2010	Western Producer	Sask	Rural							N			N	1				
Rogers, Diane	Dec 9 2010	Western Producer	Sask	Rural	N	N				N					1				
Raine, Michael	Dec 9 2010	Western Producer	Alberta	Rural	N	N		Fusarium head blight		N	N			N	1				
Wilson, Barry	Dec 9 2010	Western Producer	Canada											N	1				
	Dec 17 2010	CBC News	Prairies	Rural	N	N				N	N			N	1				
Kusch, Larry	Jan 1 2011	Winnipeg Free Press	Manitoba	Rural	N	N				N					1				

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
Briere, Karen	June 24 2010	Western Producer	Sask	Maple Creek					Provincial Disaster Assistance Program	
Pratt, Sean	June 24 2010	Western Producer	United States	Rural	Checking crops for early signs of disease to apply fungicide					
White, Ed	June 24 2010	Western Producer	Prairies	Rural						
White, Ed	June 24 2010	Western Producer	Prairies	Rural						
Pratt, Sean	June 24 2010	Western Producer								
Briere, Karen	Jan 28 2010	Western Producer	Prairies	Rural						
McMillan, D'Arce	Jan 28 2010	Western Producer	Prairies	Rural						
Arnason, Robert	Feb 4 2010	Western Producer	Manitoba	Red River Valley	Monitoring to water levels from U.S. to prepare for flooding					
Ewins, Adrian	Feb 4 2010	Western Producer	Prairies	Rural	Monitoring for early signs of disease and using appropriate pesticides					
?	Feb 11 2010	Western Producer								
Arnason, Robert	Feb 18 2010	Western Producer	Manitoba	Rural	Monitoring the number of hatchings early on					
Rueters	Feb 18 2011	Western Producer	Alberta	Rural						
Rueters	Feb 18 2012	Western Producer	Global							
Hursh, Kevin	Feb 23 2010	StarPhoenix	Prairies	Rural					AgriStability	
	Feb 24 2010	Government of Sask	Sask	Rural						
Briere, Karen	Mar 4 2010	Western Producer	Sask	Rural						
Rueters	Mar 4 2010	Western Producer	Manitoba	Red River Valley						
Cross, Brian	Mar 4 2010	Western Producer	Sask	Rural						
Duckworth, Barbara	Mar 4 2010	Western Producer	Prairies	Rural						
Rueters	Mar 4 2010	Western Producer	Global							
Rueters	Mar 4 2010	Western Producer	Canada	Arctic						
Briere, Karen	Mar 4 2010	Western Producer	Sask	Rural						
Briere, Karen	Mar 4 2010	Western Producer	Sask	Rural	Honey producers now offered yield loss coverage				Provincial Crop Insurance Corp. Program	
Hartley, Scott	Mar 2010	Agriview	Sask	Rural						
Duckworth, Barbara	Mar 11 2010	Western Producer	Alberta	Rural						
Duckworth, Barbara	Mar 11 2010	Western Producer	Alberta	Rural						
Macarthur, Mary	Mar 11 2010	Western Producer	Alberta	Rural						

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
Arnason, Robert	Mar 18 2010	Western Producer	Manitoba	Red River Valley						
Briere, Karen	Mar 18 2010	Western Producer	Prairies	Rural	Increased monitoring of crops put into bins					
Briere, Karen	Apr 1 2010	Western Producer	Prairies	Rural						
Arnason, Robert	Apr 1 2010	Western Producer	Manitoba	Interlake					AgriStability	
Arnason, Robert	Apr 1 2010	Western Producer	Manitoba	Interlake						
Barteski, Lloyd	Apr 2010	Agriview	Sask	Rural						
Raine, Micheal	Apr 8 2010	Western Producer	Prairies	Rural	Burning off session ahead of seeder					
Kossowan, Brenda	Apr 8 2010	Western Producer	Alberta	Rural	Hog price insurance				Agriculture Financial Services Corp.	
Cross, Brian	Apr 8 2010	Western Producer	Alberta	Rural						
Wingrove, Josh/Walton, Dawn	Apr 13 2010	Globe and Mail	Alberta	Rural						
Briere, Karen	Apr 15 2010	Western Producer	Prairies	Rural						
Cross, Brian	Apr 22 2010	Western Producer	Prairies	Rural						
Cross, Brian	Apr 22 2010	Western Producer	Prairies	Rural						
Kossowan, Brenda	Apr 22 2010	Western Producer	Alberta	Rural						
Cross, Brian	Apr 29 2010	Western Producer	Alberta	Rural					Alberta crop insurance program	
	May 1 2010	Canadian Press	Alberta	Rural						
Macarthur, Mary	May 6 2010	Western Producer	Alberta	Rural						
Arnason, Robert	May 6 2010	Western Producer	Prairies	Rural						
Briere, Karen	May 6 2010	Western Producer	Sask	Rural						
	May 6 2010	Sask Ministry of Ag	Sask	Rural						
Hall, Angela	May 11 2010	Regina Leader-Post	Sask	Rural						
Schmidt, Lisa	May 11 2010	Calgary Herald	Alberta	Rural						
	May 11 2010	CBC news	Prairies	Rural						
Cross, Brian	May 20 2010	Western Producer	Sask	UofS					CERC Program	
Macarthur, Mary	May 20 2010	Western Producer	Alberta	Rural						
Lyseng, Ron	May 20 2010	Western Producer	Prairies	Rural					WeatherFarm	
Cross, Brian	May 20 2010	Western Producer	Praires	Rural						
Swihart, Ric	May 20 2010	Western Producer	Alberta	Rural						
Wilson, Barry	May 20 2010	Western Producer	Prairies	Rural						
Pratt, Sean	May 27 2010	Western Producer	Prairies	Rural						

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
	May 31 2010	CBC News	Manitoba	Winnipeg						
	June 1 2010	CBC News	Alberta	Rural						
Briere, Karen	June 3 2010	Western Producer	Prairies	Lloydminster						
Macarthur, Marcy	June 3 2010	Western Producer	Alberta	Rural						
Briere, Karen	June 3 2010	Western Producer	Sask	Last Mountain						
McMillan, D'Arce	June 3 2010	Western Producer	Prairies	Rural						
Rueters	June 3 2010	Western Producer	Prairies	Rural						
	June 8 2010	CBC News	Prairies	Rural						
	June 10 2010	CBC News	Sask	Rural						
White, Ed	June 10 2010	Western Producer	Manitoba	Red River Valley						
Briere, Karen	June 10 2010	Western Producer	Sask	Rural					AgriRecovery Program	
Briere, Karen	June 10 2010	Western Producer	Sask	Rural					AgriRecover Program	
???	June 10 2010	Western Producer								
	June 15 2010	CBC News	Sask	Rural						
Wood, James	June 16 2010	StarPhoenix	Prairies	Rural						
Adamko, Alanna	June 16 2010	StarPhoenix	Sask	Rural						
Wood, James	June 16 2010	StarPhoenix	Sask	Rural						
Wood, James	June 17 2010	StarPhoenix	Sask	Rural						
Wood, James	June 17 2010	StarPhoenix	Sask	Rural						
Hutton, David	June 17 2010	StarPhoenix	Sask	Saskatoon						
	June 17 2010	CBC News	Sask	Rural						
Cross, Brian	June 17 2010	Western Producer	Sask	Rural						
Pratt, Sean	June 17 2010	Western Producer	Sask	Rural						
Arnason, Robert	June 17 2010	Western Producer	Prairies	Rural						
Pratt, Sean	June 17 2010	Western Producer	Prairies	Rural						
Pratt, Sean	June 17 2010	Western Producer	Prairies	Rural						
Briere, Karen	June 17 2010	Western Producer	Prairies	Rural						
Adamko, Alanna	June 17 2010	Western Producer	Sask	Saskatoon						
Cowan, Pamela	June 17 2010	Regina Leader-Post	Sask	Rural						

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
	June 17 2010	Sask Watershed Authority	Sask	Rural						
	June 17 2010	Sask Watershed Authority	Sask	Rural						
	June 18 2010	CBC News	Alberta	Rural						
Government of Sask	June 18 2010	Road Conditions	Sask	Rural						
	June 18 2010	CBC News	Prairies	Rural						
	June 18 2010	Southwest TV News	Sask	Maple Creek						
	June 18 2010	Southwest TV news	Sask	Swift Current						
	June 20 2010	CBC News	Alberta	Rural						
	June 20 2010	CBC News	Prairies	Rural						
Fries, Joe	June 20 2010	Calgary Herald	Alberta	Rural						
Gerson, Jen	June 20 2010	Calgary Herald	Alberta	Rural	Evacuating families to deal with floods					
Gerson, Jen	June 21 2010	Calgary Herald	Alberta	Rural						
Gerson, Jen	June 21 2010	Calgary Herald	Prairies	Rural						
Gerson, Jen	June 21 2010	Calgary Herald	Alberta	Rural						
Gerson, Jen/Couture, Joe	June 21 2010	Canwest News Service	Alberta	Medicine Hat						
	June 21 2010	CBC News	Prairies	Rural						
	June 21 2010	CBC News	Alberta	Medecine Hat						
Couture, Joe	June 21 2010	Sask News Network	Sask	Maple Creek						
Switzer, Tim	June 21 2010	Leader Post	Sask	Maple Creek						
	June 21 2010	Macleans.ca	Prairies	Rural						
Switzer, Tim	June 22 2010	Regina Leader-Post	Sask	Maple Creek						
Johnstone, Bruce	June 22 2010	Sask News Network	Sask	Rural						
	June 22 2010	CBC News	Sask	Maple Creek						

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
Adamko, Alanna	June 22 2010	StarPhoenix	Sask	Rural					Provincial Disaster Assistance Program (PDAP)	
	June 22 2010	CBC News	Sask	Rural						
	June 22 2010	Sask News Network	Sask	Rural						
Kyle, Cassandra	June 23 2010	StarPhoenix	Sask	Rural						
Briere, Karen	June 24 2010	Western Producer	Sask	Maple Creek					Provincial Disaster Assistance Program	
Pratt, Sean	June 24 2010	Western Producer	United States	Rural	Checking crops for early signs of disease to apply fungicide					
White, Ed	June 24 2010	Western Producer	Prairies	Rural						
White, Ed	June 24 2010	Western Producer	World	Rural						
Pratt, Sean	June 24 2010	Western Producer	Prairies	Rural						
Editorial	June 24 2010	Western Producer	Prairies	Rural						
Harder, Cam	June 24 2010	Western Producer	Global	Rural						
Arnason, Robert	June 24 2010	Western Producer	Manitoba	Rural						
Wilson, Barry	June 24 2010	Western Producer	Prairies	Rural					Growing Forward Programs	
	June 28 2010	Leader Post	Sask	Maple Creek						
Kyle, Cassandra	July 7 2010	Sask News Network	Sask	Rural						
Kyle, Cassandra	July 8 2010	StarPhoenix	Prairies	Rural						
	July 8 2010	CBC News	Sask	Yorkton						
	July 8 2010	CBC news	Prairies	Rural						
Massinon, Steph/Down, John	July 13 2010	Postmedia News	Alberta	Rural						
Hall, Angela	July 13 2010	Regina Leader-Post	Sask	Rural						
	July 14 2010	CBC News	Alberta	Rural						
Switzer, Tim	July 14 2010	Regina Leader-Post	Sask	Radville						
Wilson, Bary	July 15 2010	Westen Producer	Canada	Rural					AgriRecovery	
Wilson, Barry	July 15 2010	Western Producer	Prairies	Rural						
Cross, Brian	July 15 2010	Western Producer	Sask	Yorkton						
Editorial	July 15 2010	Western Producer	Prairies	Rural						
Briere, Karen	July 15 2010	Western Producer	Sask	Yorkton	Continued government funding for aid relief				AgriStability	
Briere, Karen	July 15 2010	Western Producer	Sask	Rural						
Briere, Karen	July 15 2010	Western Producer	Sask	Rural						

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
Duckworth, Barbara	July 15 2010	Western Producer	Alberta	Rural						
Ewins, Adrian	July 15 2010	Western Producer	Global	Rural	Growing conditions at South Aussie fields are off setting losses for Veterra here					
	July 19 2010	CBC News	Prairies	Rural						
Johnstone, Bruce	July 19 2010	Regina Leader-Post	Sask	Rural						
	July 21 2010	CBC News	Sask	Yorkton						
	July 21 2010	CBC News	Prairies	Rural						
	July 21 2010	CBC News	Sask	Yorkton						
Briere, Karen	July 22 2010	Western Producer	Sask	Maple Creek						
Arnason, Robert	July 22 2010	Western Producer	Manitoba	Rural						
MacArthur, Mary	July 22 2010	Western Producer	Alberta	Rural						
(Crop Report)	July 22 2010	Western Producer	Alberta	Rural						
(Crop Report)	July 22 2010	Western Producer	Manitoba	Rural						
(Crop Report)	July 22 2010	Western Producer	Sask	Rural						
Duckworth, Barbara	July 22 2010	Western Producer	Alberta	Rural						
	July 23 2010	Postmedia News	Sask	North Battleford						
Cowan, Pamela	July 24 2010	Sask News Network	Sask	Rural						
	July 26 2010	Sask News Network	Sask	Lanigan						
Hall, Angela	July 26 2010	Regina Leader-Post	Sask	Rural						
	July 27 2010	StarPhoenix	Prairies	Rural						
	July 27 2010	CBC News	Sask	Rural						
Ewins, Adrian	July 29 2010	Western Producer	Prairies	Rural						
Pratt, Sean	July 29 2010	Western Producer	Prairies	Rural						
Arnason, Robert	July 29 2010	Western Producer	Manitoba	Arborg						
MacArthur, Mary	July 29 2010	Western Producer	Prairies	Rural						
(Crop Report)	July 29 2010	Western Producer	Alberta	Rural						
(Crop Report)	July 29 2010	Western Producer	Manitoba	Rural						
(Crop Report)	July 29 2010	Western Producer	Sask	Rural						
Briere, Karen	July 29 2010	Western Producer	Sask	Rural						
Macarthur, Mary	July 29 2010	Western Producer	Alberta	Edberg						

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
Arnason, Robert	July 29 2010	Western Producer	Manitoba	Brookdale						
Lyseng, Rob	July 29 2010	Western Producer	Prairies	Rural	Winter wheat sucks up excessive moisture, converting it to ideal for next year					
Lyseng, Rob	July 29 2010	Western Producer	Prairies	Rural						
Wilson, Barry	July 29 2010	Western Producer	Canada						Farm Credit Canada	
White, Ed	Aug 5 2010	Western Producer	Canada							
Pratt, Sean	Aug 5 2010	Western Producer	Prairies	Rural						
White, Ed	Aug 5 2010	Western Producer	Prairies	Rural					Financial Flood Relief Program	
Rueters	Aug 5 2010	Western Producer	United States	Kansas						
Briere, Karen	Aug 5 2010	Western Producer	Sask	Rural	Winter wheat requires stubble for protection					
Raine, Micheael	Aug 5 2010	Western Producer	Alberta	Rural	Using NDVI and yield maps for proper crop prediction					
Arnason, Robert	Aug 12 2010	Western Producer	Manitoba	Rural						
Arnason, Robert	Aug 12 2010	Western Producer	Prairies	Rural						
(Crop Report)	Aug 12 2010	Western Producer	Alberta	Rural						
(Crop Report)	Aug 12 2010	Western Producer	Manitoba	Rural						
(Crop Report)	Aug 12 2010	Western Producer	Sask	Rural						
Duckworth, Barbara	Aug 12 2010	Western Producer	Alberta	Rural						
Pratt, Sean	Aug 12 2010	Western Producer	Prairies	Rural						
Hamilton, Charles	Aug 12 2010	Western Producer	Prairies	Rural						
Ewins, Adrian	Aug 12 2010	Western Producer	Sask	Rural	Amended agreement to provide more money to farmers				Provincial Disaster Assistance Program	
MacArthur, Mary	Aug 12 2010	Western Producer	Sask	Rural						
Macarthur, Mary	Aug 19 2010	Western Producer	Prairies	Rural						
(Crop Report)	Aug 19 2010	Western Producer	Alberta	Rural						
(Crop Report)	Aug 19 2010	Western Producer	Manitoba	Rural						
(Crop Report)	Aug 19 2010	Western Producer	Sask	Rural						
McMillan, D'Arce	Aug 19 2010	Western Producer	Prairies	Rural						
Macbean, Sylvia	Aug 19 2010	Western Producer	Prairies	Rural						
	Aug 20 2010	CBC News	Sask	Rural						
Pratt, Sean	Aug 26 2010	Western Producer	Sask	Rural						
Ewins, Adrian	Aug 26 2010	Western Producer	Global	Rural						
Wilson, Barry	Aug 26 2010	Western Producer	Canada							
Macarthur, Mary	Aug 26 2010	Western Producer	Prairies	Rural						

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
(Crop Report)	Aug 26 2010	Western Producer	Alberta	Rural						
(Crop Report)	Aug 26 2010	Western Producer	Manitoba	Rural						
(Crop Report)	Aug 26 2010	Western Producer	Sask	Rural						
Pratt, Sean	Aug 26 2010	Western Producer	Prairies	Rural						
Pratt, Sean	Aug 26 2010	Western Producer	Prairies	Rural						
Arnason, Robert	Aug 26 2010	Western Producer	Manitoba	Rural						
Lyseng, Ron	Aug 26 2010	Western Producer	Prairies	Rural	Applying JumpStart to phosphorus fields					
Briere, Karen	Aug 26 2010	Western Producer	Sask	Rural						
Cross, Brian	Sept 2 2010	Western Producer	Alberta	Rural						
MacArthur, Mary	Sept 2 2010	Western Producer	Prairies	Rural						
(Crop Report)	Sept 2 2010	Western Producer	Alberta	Rural						
(Crop Report)	Sept 2 2010	Western Producer	Manitoba	Rural						
(Crop Report)	Sept 2 2010	Western Producer	Sask	Rural						
Pratt, Sean	Sept 2 2010	Western Producer	Prairies	Rural						
Arnason, Robert	Sept 9 2010	Western Producer	Manitoba	Rural						
(Crop Report)	Sept 9 2010	Western Producer	Alberta	Rural						
(Crop Report)	Sept 9 2010	Western Producer	Manitoba	Rural						
(Crop Report)	Sept 9 2010	Western Producer	Sask	Rural						
White, Ed	Sept 9 2010	Western Producer	Prairies	Rural						
Pratt, Sean	Sept 9 2010	Western Producer	Sask	Rural						
Guenter, Henry	Sept 9 2010	Western Producer	Prairies	Rural	Changing driving strategies to deal with mud					
Dekay, William	Sept 9 2010	Western Producer	Prairies	Rural					Excess Moisture Program	
	Sept 13 2010	CBC News	Sask	Rural						
Macarthur, Mary	Sept 16 2010	Western Producer	Prairies	Rural						
Arnason, Robert	Sept 16 2010	Western Producer	Manitoba	Rural						
Macarthur, Mary	Sept 16 2010	Western Producer	Prairies	Rural						
(Crop Report)	Sept 16 2010	Western Producer	Alberta	Rural						
(Crop Report)	Sept 16 2010	Western Producer	Manitoba	Rural						
(Crop Report)	Sept 16 2010	Western Producer	Sask	Rural						
Briere, Karen	Sept 16 2010	Western Producer	Prairies	Rural					Advanced Payment Plan	
Wilson, Barry	Sept 16 2010	Western Producer	Canada						AgriStability	
Raine, Micheal	Sept 16 2010	Western Producer	Prairies	Rural						

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
Briere, Karen	Sept 16 2010	Western Producer	Prairies	Rural						
Hall, Angela	Sept 22 2010	Sask News Network	Sask	Rural						
Briere/Ewins	Sept 23 2010	Western Producer	Prairies	Rural						
Macarthur, Mary	Sept 23 2010	Western Producer	Canada							
Wilson, Barry	Sept 23 2010	Western Producer	Prairies	Rural						
Arnason, Robert	Sept 23 2010	Western Producer	Praires	Rural						
White, Ed	Sept 23 2010	Western Producer	Prairies	Rural	Depends when they seeded, before or after rainfall					
Scott, Neil	Sept 24 2010	Regina Leader-Post	Sask	Rural						
Roth, Pam/Couture, Joe	Sept 27 2010	Regina Leader-Post	Sask	Maple Creek						
Arnason, Robert	Sept 30 2010	Western Producer	Canada		Rainfall records broken					
MacArthur, Mary	Sept 30 2010	Western Producer	Alberta	Rural						
(Crop Report)	Sept 30 2010	Western Producer	Alberta	Rural						
(Crop Report)	Sept 30 2010	Western Producer	Manitoba	Rural						
(Crop Report)	Sept 30 2010	Western Producer	Sask	Rural						
White, Ed	Sept 30 2010	Western Producer	Prairies	Rural						
McMillan, D'Arce	Sept 30 2010	Western Producer	Prairies	Rural						
Duckworth, Barbara	Sept 30 2010	Western Producer	Alberta	Rural	More money added to the disaster recovery programs					
Recksiedler, Blaine	Sept 2010	Agriview	Prairies	Rural						
Babcock, John	Sept 2010	Agriview	Sask	South Sask	Increased irrigation to the area					
AgriStability	Sept 2010	Agriview	Prairies	Rural					AgriStability	
Ministry of Ag	Sept 2010	Agriview	Prairies	Rural	Website adaptation to report excessive moisture conditions					
Pratt, Sean	Oct 7 2010	Western Producer	Prairies	Rural						
Briere, Karen	Oct 7 2010	Western Producer	Sask	Rural	Increase payment from 40 to 60 % of claim amount				Provincial Disaster Assistance Program	
Cross, Brian	Oct 7 2010	Western Producer	Prairies	Rural						
Wilson, Barry	Oct 7 2010	Western Producer	Canada							
Arnason, Robert	Oct 7 2010	Western Producer	Prairies	Rural						
White, Ed	Oct 7 2010	Western Producer	Global							
White, Ed	Oct 7 2010	Western Producer	Prairies	Rural						
Glen, Barb (editorial)	Oct 7 2010	Western Producer	Prairies	Rural						

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
Glen, Barb (editorial)	Oct 7 2010	Western Producer	Prairies	Rural						
Ewins, Adrian	Oct 7 2010	Western Producer	Prairies	Rural						
Pratt, Sean	Oct 7 2010	Western Producer	Prairies	Rural						
Macarthur, Mary	Oct 7 2010	Western Producer	Sask	Rural						
Arnason, Robert	Oct 7 2010	Western Producer	Manitoba	Rural						
Lyseng, Ron	Oct 7 2010	Western Producer	Manitoba	Rural	Rubber tracks added to combines to allow them to traverse wet fields					
Arnason, Robert	Oct 7 2010	Western Producer	Prairies	Rural	Using chains and straps to tow tractors out of the mud					
Briere, Karen	Oct 7 2010	Western Producer	Prairies	Rural						
Duckworth, Barbara	Oct 7 2010	Western Producer	Prairies	Rural						
Grognet, Jeff	Oct 7 2010	Western Producer	Prairies	Rural						
Andrews, Jacklin	Oct 7 2010	Western Producer	Prairies	Rural	Abusive relationship between spouses sprouting over frustration of bad growing conditions					
Briere, Karen	Oct 14 2010	Western Producer	Prairies	Rural						
Briere, Karen	Oct 14 2010	Western Producer	Canada						Provincial Disaster Assistance Program	
Ewins, Adrian	Oct 14 2010	Western Producer	Prairies	Rural						
Arnason, Robert	Oct 14 2010	Western Producer	Manitoba	Rural						
Glen, Barb (editorial)	Oct 14 2010	Western Producer	Prairies	Rural	Support programs needed to be more specialized					
Guenter, Henry	Oct 14 2010	Western Producer	Prairies	Rural	Replacing worn down parts due to difficulty of farmland this season					
Ewins, Adrian	Oct 14 2010	Western Producer	Praiires	Rural						
Swihart, Ric	Oct 21 2010	Western Producer	Alberta	Taber						
Dekay, William	Oct 21 2010	Western Producer	Sask	Rural						
Byers, Shirley	Oct 21 2010	Western Producer	Sask	Rural						
Wilson, Barry	Oct 21 2010	Western Producer	Prairies	Rural	Farmers adapting to environmental policies					
Arnason, Robert	Oct 21 2010	Western Producer	Prairies	Rural						
Rueters	Oct 21 2010	Western Producer	United States	Rural					Gates Foundation	
Briere, Karen	Oct 21 2010	Western Producer	Prairies	Rural						
Levy, Bryn	Oct 21 2010	Western Producer	Prairies	Rural						
	Oct 25 2010	CBC News	Prairies	Rural						
Arnason, Robert	Oct 28 2010	Western Producer	Prairies	Rural						
Briere, Karen	Oct 28 2010	Western Producer	Sask	Rural						
Briere, Karen	Oct 28 2010	Western Producer	Prairies	Rural	Increase feed aid					

Author	Date	Newspaper	Location of Article		Adaptations					
			Province	Town	Agriculture					
					crops	livestock			government programs	
					type	feed	water	economic	crop insurance	rural water
Arnason, Robert	Nov 4 2010	Western Producer	Prairies	Rural						
Glen, Barb (editorial)	Nov 4 2010	Western Producer	Prairies	Rural						
Moneo, Shannon	Nov 4 2010	Western Producer	North America	Rural						
Pratt, Sean	Nov 4 2010	Western Producer	Sask	Rural						
Levy, Bryn	Nov 4 2010	Western Producer	Sask	Rural						
Glen, Barb (editorial)	Nov 11 2010	Western Producer	Canada	Rural						
Cross, Brian	Nov 11 2010	Western Producer	Sask	Rural						
Levy, Bryn	Nov 11 2010	Western Producer	Sask	Rural						
Levy, Bryn	Nov 11 2010	Western Producer	Prairies	Rural	Relief for producers hurt by summers heavy rain				Manitoba Cattle Producers Association	
Swihart, Ric	Nov 11 2010	Western Producer	Alberta	Rural						
Pratt, Sean	Nov 18 2010	Western Producer	Prairies	Rural						
Levy, Bryn	Nov 18 2010	Western Producer	Prairies	Rural	Got per acre aid, wanted per head help for cattle					
	Nov 22 2010	CBC News	Manitoba	Rural						
Wilson, Barry	Nov 25 2010	Western Producer	Manitoba	Rural						
Swihart, Ric	Nov 25 2010	Western Producer	Prairies	Rural						
McMillan, D'Arce	Nov 25 2010	Western Producer	Prairies	Rural						
	Dec 3 2010	Western Producer	Prairies	Rural						
Pratt, Sean	Dec 9 2010	Western Producer	Prairies	Rural					Prairie Gold	
Pratt, Sean	Dec 9 2010	Western Producer	Prairies	Rural						
Briere, Karen	Dec 9 2010	Western Producer	Sask	Rural						
Rogers, Diane	Dec 9 2010	Western Producer	Sask	Rural						
Raine, Michael	Dec 9 2010	Western Producer	Alberta	Rural						
Wilson, Barry	Dec 9 2010	Western Producer	Canada							
	Dec 17 2010	CBC News	Prairies	Rural						
Kusch, Larry	Jan 1 2011	Winnipeg Free Press	Manitoba	Rural						

Author	Date	Newspaper	Location of article subject		Quotables An interesting quote from the article that shows the level of impact / adaptation required
Briere, Karen	June 24 2010	Western Producer	Sask	Maple Creek	The McDougalds had to rescue their dogs and 160 ewes and lambs after the water rose so fast that it swamped them where they stood.
Pratt, Sean	June 24 2010	Western Producer	United States	Rural	Infection levels are similar to 2005 when Kansas and Texas lost seven and 17 percent of their wheat crops respectively to the disease.
White, Ed	June 24 2010	Western Producer	Prairies	Rural	Since the beginning of June, when the impact of rain began to be realized by the markets, old crop oat prices have risen by about 35%, new crop oats 25% and canola prices increased by 12%
White, Ed	June 24 2010	Western Producer	Prairies	Rural	
Pratt, Sean	June 24 2010	Western Producer			
Briere, Karen	Jan 28 2010	Western Producer	Prairies	Rural	Neighbors were trying to contact each other to make sure they were safe. Most had phone service but no power.
McMillan, D'Arce	Jan 28 2010	Western Producer	Prairies	Rural	If strong El Nino persists into spring, it tends to produce moisture and cooler than normal conditions and that could help make up for the dry winter.
Arnason, Robert	Feb 4 2010	Western Producer	Manitoba	Red River Valley	Defined major flooding as water levels that force communities along the Red River to build dikes or evacuate homes.
Ewins, Adrian	Feb 4 2010	Western Producer	Prairies	Rural	Grasshopper population has been on the rice and farmers will have to pay particular attention early in June and keep an eye on the hatch and build up in population.
?	Feb 11 2010	Western Producer			
Arnason, Robert	Feb 18 2010	Western Producer	Manitoba	Rural	The Potential for Grasshopper populations to increase is to a very large extent determined by the number of eggs deposited.
Rueters	Feb 18 2011	Western Producer	Alberta	Rural	Environment Canada said last week that the Prairie winter looks dry but the spring and summer should be wetter than usual.
Rueters	Feb 18 2012	Western Producer	Global		El Nino's tends to promote drier winters on the Canadian Prairies, but wetter conditions occur if the weather phenomenon persists into spring.
Hursh, Kevin	Feb 23 2010	StarPhoenix	Prairies	Rural	If they have a poor crop or if grain prices are bad, or even if both of these events come to pass, they're protected.
	Feb 24 2010	Government of Sask	Sask	Rural	"Crop insurance is an important tool Sask farmers can use to protect their bottom line." - Ag Minister Gerry Ritz
Briere, Karen	Mar 4 2010	Western Producer	Sask	Rural	Overall premiums are decreasing 16% on average because of an above average crop and lower prices.
Rueters	Mar 4 2010	Western Producer	Manitoba	Red River Valley	Unfavorable weather could cause flood levels of 0.3 meters higher than last year.
Cross, Brian	Mar 4 2010	Western Producer	Sask	Rural	Supply concerns abroad have translated into higher prices for Canadian growers and strong Canadian exports
Duckworth, Barbara	Mar 4 2010	Western Producer	Prairies	Rural	With the four degrees of warming you have lost about 60 percent of the snow pack and it is melting out a month earlier - Pomeroy
Rueters	Mar 4 2010	Western Producer	Global		The decade of 2000-2009 was the hottest since 1850 as a result of warming through the 1980s and 1990s
Rueters	Mar 4 2010	Western Producer	Canada	Arctic	Payette said the sites he has studied have warmed by 2 C in the last two decades.
Briere, Karen	Mar 4 2010	Western Producer	Sask	Rural	Sask farmers will face the usual assortment of insect threats this year, but only a few are forecast to cause significant damage.
Briere, Karen	Mar 4 2010	Western Producer	Sask	Rural	Said that producers just entering the industry will benefit from inclusion in the Sask Crop Insurance Corp. program
Hartley, Scott	Mar 2010	Agriview	Sask	Rural	In 2010, producers have the option of planting midge-tolerant wheat.
Duckworth, Barbara	Mar 11 2010	Western Producer	Alberta	Rural	"More storage will have to be built to better manage the water we have. This will be essential based on long-term future growth." - Bullock
Duckworth, Barbara	Mar 11 2010	Western Producer	Alberta	Rural	"Success is managing the risk that shows up at a certain time of year." Mcgee
Macarthur, Mary	Mar 11 2010	Western Producer	Alberta	Rural	A combination of a large population last fall and a mild fall will likely increase grasshoppers in problem areas.
Arnason, Robert	Mar 18 2010	Western Producer	Manitoba	Red River Valley	Warkentin said 2010 is unlikely to repeat 2009, the second worst flood in Manitoba's history in terms of peak flow on the Red River.
Briere, Karen	Mar 18 2010	Western Producer	Prairies	Rural	"There is a lot of great canola that went into the bin last fall that's not doing so well now. Monitoring bins I'm more critical this coming spring than I think we have seen since the 80's." -Jim Bessel
Briere, Karen	Apr 1 2010	Western Producer	Prairies	Rural	Areas that were dry last fall didn't improve much over the winter.
Arnason, Robert	Apr 1 2010	Western Producer	Manitoba	Interlake	Environment Canada's weather station in Swan River only recorded 11 mm of precipitation from Jan. 1 to the end of Mar. In a more typical year, Swan River receives 68 ,mm of snow and rain in Jan, Feb and Mar.
Arnason, Robert	Apr 1 2010	Western Producer	Manitoba	Interlake	Some farmers in the region haven't harvested a crop since 2007. AgriStability is a federal-provincial income support program based on margins.
Barteski, Lloyd	Apr 2010	Agriview	Sask	Rural	In 2009, Sask Agriculture's Irrigation Branch contracted an engineering firm to develop an asset management plan to assess the pump station's condition and future sustainability.
Raine, Michael	Apr 8 2010	Western Producer	Prairies	Rural	A late harvest and a winter that closed in quickly left few post-harvest opportunities for controlling perennials and winter annuals.
Kossowan, Brenda	Apr 8 2010	Western Producer	Alberta	Rural	An insurance plan that would help cover losses when hog prices fall.

Author	Date	Newspaper	Location of article subject		Quotables An interesting quote from the article that shows the level of impact / adaptation required
Cross, Brian	Apr 8 2010	Western Producer	Alberta	Rural	Without significant rainfall this spring, many areas will face drought conditions similar to what they experienced last year.
Wingrove, Josh/Walton, Dawn	Apr 13 2010	Globe and Mail	Alberta	Rural	Precipitation shortages, compounded by the increased demand of a booming economy and growing population, have left Alberta with an unprecedented water crisis.
Briere, Karen	Apr 15 2010	Western Producer	Prairies	Rural	The spring outlook for Apr, May and June shows the entire country will be warmer and drier than normal.
Cross, Brian	Apr 22 2010	Western Producer	Prairies	Rural	"Compared to what we've had in the last long while, it was pretty significant." Walter Fast, farmer
Cross, Brian	Apr 22 2010	Western Producer	Prairies	Rural	About 25-30 millimeters of rain fell in a two-day period in the Glidden area, the first significant rainfall the area has seen since late last summer.
Kossowan, Brenda	Apr 22 2010	Western Producer	Alberta	Rural	The exposed floor of the pond belongs to a network of shallow aquifers from which the McKechnies, the Christians and 17 other farms and acreages draw the water that supplies their homes and waters their livestock.
Cross, Brian	Apr 29 2010	Western Producer	Alberta	Rural	"Basically what it does is it protects farmers from downward price movement on the bushels that they produce up to their coverage limit." - Lorelei Hulston, provincial insurance manager with Agricultural Financial Services Corp.
	May 1 2010	Canadian Press	Alberta	Rural	Alberta branch of the national relief organization opened two shelters on Friday to help house and feed more than 100 people who've been forced out of their homes by the poor living conditions.
Macarthur, Mary	May 6 2010	Western Producer	Alberta	Rural	The storm created drifts of snow in the Kolks yard and left their farm without power, but it also brought much needed moisture.
Arnason, Robert	May 6 2010	Western Producer	Prairies	Rural	"There was concern with seeding into dry soil and germination and things like that. So for what's In the ground, I think this rain is fantastic." -
Briere, Karen	May 6 2010	Western Producer	Sask	Rural	SaskWater will get more water into the dry Southwest, but people have to be prepared to pay for it.
	May 6 2010	Sask Ministry of Ag	Sask	Rural	The recent moisture has given many areas in the province adequate or surplus topsoil moisture conditions
Hall, Angela	May 11 2010	Regina Leader-Post	Sask	Rural	The government report indicated cattle farms are expected to lose an average of $5,195 in 2010 compared to previous average net operating incomes of about $11,000.
Schmidt, Lisa	May 11 2010	Calgary Herald	Alberta	Rural	That much-needed moisture over the past couple of weeks has brightened the outlook on Alberta farms this year.
	May 11 2010	CBC news	Prairies	Rural	Excess rain has washed away the hope of seeding for many farmers, said Bruce Burnett, the board's director of weather and market analysis.
Cross, Brian	May 20 2010	Western Producer	Sask	UofS	The CERC program is designed to attract world experts in selected disciplines to establish Canada as a global leader in advanced research and innovation.
Macarthur, Mary	May 20 2010	Western Producer	Alberta	Rural	More than 200 millimeters of rain have fallen since last autumn near Hanna, Alta, filling sloughs and creating hidden wet spots in fields.
Lyseng, Ron	May 20 2010	Western Producer	Prairies	Rural	WeatherFarm, Its job is to provide accurate, localized weather updates every five seconds, accessible by station display unit, computer or mobile device.
Cross, Brian	May 20 2010	Western Producer	Prairies	Rural	Environmental toxins such as ergot poisoning, sulfate poisoning and lead poisoning are closely related to weather conditions.
Swihart, Ric	May 20 2010	Western Producer	Alberta	Rural	Significant cattle losses blamed on initial storms and now a second wave of deaths has hit as pneumonia and scours take their toll.
Wilson, Barry	May 20 2010	Western Producer	Prairies	Rural	International rules must be developed to determine how national greenhouse gas emission controls are judged, what international body regulates the system and what sanctions can be brought against the laggards.
Pratt, Sean	May 27 2010	Western Producer	Prairies	Rural	Higher CO2 levels can at first increase plant productivity, but over time the elevationed concentrations inhibit photorespiration, which affects shoot nitrate assimilation.
	May 31 2010	CBC News	Manitoba	Winnipeg	"Over the weekend, my gosh, I can't believe the number of thunderstorms, 13 hours of thunderstorms, that's like a half year supply of thunderstorm hours in southern Manitoba." Dave Phillips, senior climatologist environment Canada.
	June 1 2010	CBC News	Alberta	Rural	A storm also flooded about 200 homes on the reserve at the end of Apr, forcing more than 100 people into Red Cross shelters.
Briere, Karen	June 3 2010	Western Producer	Prairies	Lloydminster	Announced up to $114 million to help producers buy feed and allow pastures that time to recover.
Macarthur, Marcy	June 3 2010	Western Producer	Alberta	Rural	"This is delaying us. We got water sitting all over the place. We've got sloughs and soft spots through fields." -Lynn Jacobson
Briere, Karen	June 3 2010	Western Producer	Sask	Last Mountain	The heavy rain has caused increased flows in nearby waterways, including Avonlea Creek, The Moose Jaw River and the Qu'Appelle River
McMillan, D'Arce	June 3 2010	Western Producer	Prairies	Rural	The delays in getting crop in the ground could push back maturity into the frost risk period of late summer.
Rueters	June 3 2010	Western Producer	Prairies	Rural	Some regions depend on rivers fed by snow, rain, glaciers and lakes in the mountains.
	June 8 2010	CBC News	Prairies	Rural	Rain showers have continued to dampen the land and spirits of farmers since then, though the amounts have been much lighter.
	June 10 2010	CBC News	Sask	Rural	As seeding is delayed, farmers are left with fewer options for what to plant and face a greater risk of late-developing crops.
White, Ed	June 10 2010	Western Producer	Manitoba	Red River Valley	Stanze estimates that 50% of his crops are dead or severely damaged, but that's the level at which crop insurance kicks in.

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Briere, Karen	June 10 2010	Western Producer	Sask	Rural	Producers in 64 Saskatchewan RMs are eligible to receive $50 per breeding head of livestock. The money is to be used to buy feed and keep animals off recovering pastures.
Briere, Karen	June 10 2010	Western Producer	Sask	Rural	As seeding progress stalled last week, Sask Crop Insurance Corp. extended the deadlines for farmers to get their crops in the ground and still have insurance.
???	June 10 2010	Western Producer			
	June 15 2010	CBC News	Sask	Rural	Bob Bjomerud (Sask's Minister of Agriculture) has toured many areas where seeding has been delayed or abandoned altogether because of prolonged rainy spells.
Wood, James	June 16 2010	StarPhoenix	Prairies	Rural	Wall said in a telephone interview that he has confidence in Ottawa's commitment to the issue.
Adamko, Alanna	June 16 2010	StarPhoenix	Sask	Rural	The situation has moved beyond being a conversation point and is now affecting people financially." -David Phillips Env Canada senior climatologist.
Wood, James	June 16 2010	StarPhoenix	Sask	Rural	After being pushed back because of the wet conditions, June 20 is now the seeding deadline for crop insurance.
Wood, James	June 17 2010	StarPhoenix	Sask	Rural	The Sask Party government has been calling on Ottawa to commit to assisting farmers beyond existing programs.
Wood, James	June 17 2010	StarPhoenix	Sask	Rural	"Certainly the agriculture situation is something we will keep our eye on... But there are programs in place to take the front-line defense of those areas and somewhere down the road we're going to have to see if we have to go further than that." -Premier Brad Wall
Hutton, David	June 17 2010	StarPhoenix	Sask	Saskatoon	The constant downpour of rain thus far in 2010 hasn't helped, but deadlines aren't in danger because of wiggle room built later in the year to ensure work gets completed.
	June 17 2010	CBC News	Sask	Rural	Ditch boarders take their equipment to water-filled areas beside a roadway and ride the surface of the water while towed by a friend in a vehicle.
Cross, Brian	June 17 2010	Western Producer	Sask	Rural	Statistics Canada reported in late Mar that Sask farmers planned to sow 33 million acres this spring. Thirty percent of that land was unseeded as of June 7, according to Sask Agriculture, which is almost 10 million acres.
Pratt, Sean	June 17 2010	Western Producer	Sask	Rural	Province wide seeding pegged at about 65 to 70 percent of what was intended
Arnason, Robert	June 17 2010	Western Producer	Prairies	Rural	Bruce Burnett (Wheat board's director of weather and market analysis) says the wet and often impossible seeding conditions caught the grain industry off guard because it was a record dry winter on parts of the Prairies
Pratt, Sean	June 17 2010	Western Producer	Prairies	Rural	"We're probably going to still see a fairly regular occurrence of weather disturbances producing additional periods of rainfall" said Drew Lerner, president of World Weather Inc.
Pratt, Sean	June 17 2010	Western Producer	Prairies	Rural	Severity of the nutrient loss depends on a number of factors, including seeding dates, the amount of rainfall received and the type of fertilizer used.
Briere, Karen	June 17 2010	Western Producer	Prairies	Rural	In case farmers don't get enough crop in the ground, financial institutions are willing to work with their clients to help them deal with declining cash flow.
Adamko, Alanna	June 17 2010	Western Producer	Sask	Saskatoon	Janelle Anderson, an employee at Fuddruckers's Grand Slam Batting Cages, said the weather has affected her hours. "Considering there are a lot of us and our hours are all spread out and limited by the weather, it really does make it hard when it does rain because we're not open during a thunderstorm."
Cowan, Pamela	June 17 2010	Regina Leader-Post	Sask	Rural	Producers can speak about money matters with people who really understand because everyone who answers calls is a past or present farmer.
	June 17 2010	Sask Watershed Authority	Sask	Rural	High Streamflow advisory for Sask.
	June 17 2010	Sask Watershed Authority	Sask	Rural	High Streamflow advisory for Sask.
	June 18 2010	CBC News	Alberta	Rural	Cardston has absorbed 84.6 millimeters of rain since Wednesday morning, exceeding the 82.6 mm it normally sees for the whole month of June.
Government of Sask	June 18 2010	Road Conditions	Sask	Rural	Listed detours in the province caused by flooding and excessive moisture.
	June 18 2010	CBC News	Prairies	Rural	The Sask government's highways hotline said the key route was closed from the border to the junction with highway 21, just north of Maple Creek Sask.
	June 18 2010	Southwest TV News	Sask	Maple Creek	Maple creek declares state of emergency due to flooding.
	June 18 2010	Southwest TV news	Sask	Swift Current	Increased flow warning for the Swift Current area.
	June 20 2010	CBC News	Alberta	Rural	Karen Kramer was out in her garden when water started rushing towards her home. She said it was like a flash flood.
	June 20 2010	CBC News	Prairies	Rural	"Were doing door-to-door checks to make sure everyone is OK, surveying the damage and giving them information on... A program if they

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					don't have insurance." Mayor Barry Rudd
Fries, Joe	June 20 2010	Calgary Herald	Alberta	Rural	In the surrounding Cardston County, perhaps as many as a dozen basements, including his own, are flooded, estimated Councilor Harlan Cahoon.
Gerson, Jen	June 20 2010	Calgary Herald	Alberta	Rural	On Friday, fire officials measured on tributary feeding the South Sask river as rising by 12.5 feet in fewer than three hours.
Gerson, Jen	June 21 2010	Calgary Herald	Alberta	Rural	The creek that runs through the land has permanently altered course and the family is now unsure how long their home will stand. They said they had no clue such a flood was even possible.
Gerson, Jen	June 21 2010	Calgary Herald	Prairies	Rural	Medicine Hat is still under a flood warning after days of heavy rain dropped 150 mm in some areas, causing massive flooding in the Cypress Hills region in Southern Alberta.
Gerson, Jen	June 21 2010	Calgary Herald	Alberta	Rural	The floods also washed out parts of the railway. A contractor who has surveyed the damage said on Sunday that parts of the track are still submerged and workers can't yet even fully assess the damage.
Gerson, Jen/Couture, Joe	June 21 2010	Canwest News Service	Alberta	Medicine Hat	Forty-four families in Medicine Hat were still getting shelter Sunday from the Red Cross evacuation center after being forced from their homes.
	June 21 2010	CBC News	Prairies	Rural	For a while after more than 100 millimeters of rain fell in a 48 hour period, about six kilometers of the highway was under water.
	June 21 2010	CBC News	Alberta	Medicine Hat	Ray John and his family were out walking... Noticed the bank had washed away under some railway tracks... Also noticed a train headed in the direction of the washout.
Couture, Joe	June 21 2010	Sask News Network	Sask	Maple Creek	The weekend's nice weather was a boon to clean-up work, and the town's 2,600 residents hope for more dry days.
Switzer, Tim	June 21 2010	Leader Post	Sask	Maple Creek	Premier Brad Wall, who toured the area on Saturday, said Monday the province will provide supplementary funding for PDAP depending on how many claims come in.
	June 21 2010	Macleans.ca	Prairies	Rural	Town officials canvassed entire neighborhoods to check on the welfare of residents trying to cope with the effects of the flooding.
Switzer, Tim	June 22 2010	Regina Leader-Post	Sask	Maple Creek	"These are fairly high-impact disasters on individuals so whatever services are needed is there." said Duane McKay of the province's fire commissioner's office.
Johnstone, Bruce	June 22 2010	Sask News Network	Sask	Rural	Flooding .. Could easily cut the size of this year's crop to 50 per cent of the long term average, (Greg Marshall Ag Producers Association of Sask president)
	June 22 2010	CBC News	Sask	Maple Creek	When the Fridays returned to their home, they encountered a flood. "There was a river of water running through our yard, it was running through the middle of our feedlot." -Fridays
Adamko, Alanna	June 22 2010	StarPhoenix	Sask	Rural	Flooding of farmers' fields, roads, highways, businesses, residences, delayed infrastructure projects and additional pressure on sewage systems have led to millions of dollars in estimated damage claims.
	June 22 2010	CBC News	Sask	Rural	Dozens of cities and towns received rain, adding to what it's turning into one of Sask's wettest springs in the region.
	June 22 2010	Sask News Network	Sask	Rural	In Sask, traffic is being rerouted past the closure by going north on Highway 4 from Swift current and west on Highway 7 into Alberta, a detour of about 150 kilometers.
Kyle, Cassandra	June 23 2010	StarPhoenix	Sask	Rural	"The rain this year has been P on our pasture and hay production. I think we're at the point where any more rain isn't really going to help." (Paul Jefferson, Western Beef Development Center vice president.)
Briere, Karen	June 24 2010	Western Producer	Sask	Maple Creek	The McDougalds had to rescue their dogs and 160 ewes and lambs after the water rose so fast that it swamped them where they stood.
Pratt, Sean	June 24 2010	Western Producer	United States	Rural	Infection levels are similar to 2005 when Kansas and Texas lost seven and 17 percent of their wheat crops respectively to the disease.
White, Ed	June 24 2010	Western Producer	Prairies	Rural	Since the beginning of June, when the impact of rain began to be realized by the markets, old crop oat prices have risen by about 35%, new crop oats 25% and canola prices increased by 12%
White, Ed	June 24 2010	Western Producer	World	Rural	In the current rain soaked situation, many farmers have less acreage seeded to crops they have pre-priced than they will need to fulfill contracts.
Pratt, Sean	June 24 2010	Western Producer	Prairies	Rural	The International Center for Agricultural Research in the Dry Areas called the outbreak an epidemic that "s expected to cause billions of dollars in crop losses."
Editorial	June 24 2010	Western Producer	Prairies	Rural	Farmer's income will clearly suffer. Crop inputs ordered but not used must be paid for. Seed planted but now drowned or rotten, and fertilizer applied but now washed away, represents huge expenses without corresponding return.
Harder, Cam	June 24 2010	Western Producer	Global	Rural	But in my own religious tradition, Noah's ark is a story of rescue and renewal… It reminds us that we do well to pay close attention to our planet because sometimes its natural expressions will tear through our human settlements with destructive force.
Arnason, Robert	June 24 2010	Western Producer	Manitoba	Rural	"A lot of plants in low spots are yellowing, and that might be because of almost anaerobic conditions" said Vikram Bisht, plant pathologist with Man Agriculture. When the plant is under stress from excess moisture, the root systems are impaired and the plant can't take up nutrients.

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Wilson, Barry	June 24 2010	Western Producer	Prairies	Rural	Gary (Richard, UofS ag economist) agreed that summer 2010 will be the first major test for the Growing Forward programs even as officials begin planning sessions and consultations to design the next policy framework that starts in 2013.
	June 28 2010	Leader Post	Sask	Maple Creek	With the reopening, attention will now turn to restoring full, four lane services.
Kyle, Cassandra	July 7 2010	Sask News Network	Sask	Rural	Meanwhile, a group of about 30 producers from the National farmers Union staged a demonstration in downtown Saskatoon .. To call attention to issues including flood aid in advance of the ministers' meeting.
Kyle, Cassandra	July 8 2010	StarPhoenix	Prairies	Rural	"Having toured many of the flooded areas and seen the impact of the extremely wet conditions first hand, we realized the urgent need for this additional support." Sask Ag Minister Bob Bjomerud
	July 8 2010	CBC News	Sask	Yorkton	The prime minister will survey the damage with Sask Premier Brad Wall and the federal and Sask agriculture ministers.
	July 8 2010	CBC news	Prairies	Rural	The majority of the money, about $360 million, will go to Sask, which has been hit by a series of flash floods and wet field conditions that have prevented farmers from planting their crops.
Massinon, Steph/Down, John	July 13 2010	Postmedia News	Alberta	Rural	"The condition of the chuckwagon track is considered unsafe at this time and so we're just not going to take a chance at this time." -Doug Fraser Stampede Spokesman.
Hall, Angela	July 13 2010	Regina Leader-Post	Sask	Rural	Heavy rains this spring and summer caused the sides of some highways to slump.
	July 14 2010	CBC News	Alberta	Rural	"What we're trying to do is locate areas of what we call new development. All we can do is reduce and minimize. We do not prevent hail." Tom Walton (Weather Modification Inc Program Manager)
Switzer, Tim	July 14 2010	Regina Leader-Post	Sask	Radville	"The trees were pointing east. The trees were pointing west. The clouds were going one way the wind was going another.. Ice cubes falling out of the sky.. A lot of crops here are pretty much done for in a certain strip." -Radvill resident Grant Engelstad
Wilson, Barry	July 15 2010	Western Producer	Canada	Rural	Federal agriculture minister Gery Ritz said the AgriRecovery package to help farmers maintain flooded land for next year's crop was unprecedented in size and speed under AgriRecovery.
Wilson, Barry	July 15 2010	Western Producer	Prairies	Rural	"There is no government program that can or should cover all of the vagaries out there in agriculture. We don't want to mask market signals. We don't want to stifle innovation with programs that would do that. Certainly, we want farmers looking to the marketplace and not the mailbox." -Gerry Ritz (federal minister)
Cross, Brian	July 15 2010	Western Producer	Sask	Yorkton	Dave Akister, executive director of the Sask Seed Growers Association, said the administrative offices of the SSGA were completed waterlogged this month when a sudden downpour flooded homes, streets and commercial buildings in Yorkton, Sask.
Editorial	July 15 2010	Western Producer	Prairies	Rural	SO yes the $450 million available through AgriRecover will be helpful.. But it is likely that additional assistance will be needed, and in that respect the WCWGA and other farm groups are aright in their call for more reliable risk management programs.
Briere, Karen	July 15 2010	Western Producer	Sask	Yorkton	About eight million Sask acres went unseeded and up to four million more could be drowned out, according to the province's agriculture ministry.
Briere, Karen	July 15 2010	Western Producer	Sask	Rural	Application must be made within six months of the disaster and repairs completed within one year. Adjusters assess each claim to determine eligibility. Generally, claimants get an advance payment of 40 percent of the total eligible amount.
Briere, Karen	July 15 2010	Western Producer	Sask	Rural	A producer who farms 1,000 acres and normally seeds 85 percent but can only seed 60 percent in a given year, and carries an insurance intensity of 83 percent, would receive $50 per acre on 185 acres, or $9,250
Duckworth, Barbara	July 15 2010	Western Producer	Alberta	Rural	(Kelly) Turkington (of Agriculture Canada) is studying how to use DNA assessments of canola flowers to more rapidly detect the sclerotinia pathogen. Which will alert famers on whether they should spray or not.
Ewins, Adrian	July 15 2010	Western Producer	Global	Rural	Viterra estimated seeded acreage in Western Canada will be in the range of 50 to 52 million acres, compared with the five-year average of 60 million.
	July 19 2010	CBC News	Prairies	Rural	"Roughly 20 per cent of total acreage in the Prairies has yet to be seeded, and with the seeding deadlines having passed, these areas - estimated to be as large as five million hectares - are likely to remain unseeded this year."
Johnstone, Bruce	July 19 2010	Regina Leader-Post	Sask	Rural	With eight million acres likely to be left unseeded this year, the N impact on GDP growth in the province could be as large as two percentage points.
	July 21 2010	CBC News	Sask	Yorkton	Cleanup crews have been working over the summer to get rid of parts of the school that may be contaminated. That means desks; chalkboards and chairs have to be thrown away.
	July 21 2010	CBC News	Prairies	Rural	Sask had the single steepest decline among the provinces with sales off 12.3 per cent. That was the biggest drop the province has seen since Mar 2005.
	July 21 2010	CBC News	Sask	Yorkton	Piles of furniture and other damaged goods are stacked up in front of yards, on driveways and along streets waiting to be hauled to the landfill- and now, some people are worried about scroungers helping themselves to the items.
Briere, Karen	July 22 2010	Western Producer	Sask	Maple Creek	Hanley, the SWA's director of science and information monitoring, said the failure of half of the private wells to meet standards wasn't

Author	Date	Newspaper	Location of article subject		Quotables An interesting quote from the article that shows the level of impact / adaptation required
					completely unexpected given the extensive flooding.
Arnason, Robert	July 22 2010	Western Producer	Manitoba	Rural	The incessant precipitation has forced some cattle producers in the region to move their cattle to pasture on higher ground.
MacArthur, Mary	July 22 2010	Western Producer	Alberta	Rural	It may rain one or two tenths at a time, not enough to stop the wheat from beginning to shrivel and burn.
(Crop Report)	July 22 2010	Western Producer	Alberta	Rural	Rain kept most farmers out of their field and halted haying.
(Crop Report)	July 22 2010	Western Producer	Manitoba	Rural	Much of the canola crop is flowering with podding occurring in the more advanced fields… cereal crops are headed out and canola crops are in the flowering stage.
(Crop Report)	July 22 2010	Western Producer	Sask	Rural	Ascochyta blight and leaf diseases are beginning to cause crop damage because of high moisture throughout the season.
Duckworth, Barbara	July 22 2010	Western Producer	Alberta	Rural	The coalition, an umbrella organization made up of 45 organizations called Our Water is Not for Sale, has asked the provincial government to place ecosystem health and human need above the ability to pay while it reviews water allocation policies.
	July 23 2010	Postmedia News	Sask	North Battleford	The rain overwhelmed the city's sewer system and reports of flooding and sewer backups started flowing into City Hall.
Cowan, Pamela	July 24 2010	Sask News Network	Sask	Rural	Conditions continue to be optimal for the development of culex tarsalis throughout most of the province and some traps are reporting extremely high numbers of mosquitoes.
	July 26 2010	Sask News Network	Sask	Lanigan	The threat of tornadoes was expected to last into the evening Sunday due to intense storms over the Humboldt region, with the potential to produce more tornadoes.
Hall, Angela	July 26 2010	Regina Leader-Post	Sask	Rural	More than 100 Sask communities have declared disasters so far this spring and summer due to excessive moisture and millions of acres of farmland have gone unseeded.
	July 27 2010	StarPhoenix	Prairies	Rural	"We want to assist our farm customers that were affected by the flooding. This program will help alleviate the difficulties being faced by farmers in affected communities across Canada's Prairies." BMO vice-president Robert Hayes.
	July 27 2010	CBC News	Sask	Rural	The summer of 2010 may be remembered as the summer of wild weather in Sask.. "This has pushed our resources to the limit" - Duane McKay, province's fire commissioner
Ewins, Adrian	July 29 2010	Western Producer	Prairies	Rural	The number of cars expected to ship this year will be down.. No single reason, though weather was a factor.
Pratt, Sean	July 29 2010	Western Producer	Prairies	Rural	Harry Brook (crop specialist with Alberta Agriculture) says under the worst circumstances there could be massive downgrading of crops if the frost was early and widespread.
Arnason, Robert	July 29 2010	Western Producer	Manitoba	Arborg	"Were already battling the brand of inconsistency and unreliability when it comes to shipping. Labour disruptions that seem to arise every year do serious damage to our ability to market based on consistent and reliable quality and supply." Greg Cherewyk - Exec director of Pulse Canada
MacArthur, Mary	July 29 2010	Western Producer	Prairies	Rural	However, most of the hail damage this summer has happened in the city rather than in the country.
(Crop Report)	July 29 2010	Western Producer	Alberta	Rural	Thirty to 100 millimeters of precipitation have fallen in the past two weeks.
(Crop Report)	July 29 2010	Western Producer	Manitoba	Rural	Crop uniformity is better in southern areas where less precipitation has fallen. In other areas, uneven development will be an issue.
(Crop Report)	July 29 2010	Western Producer	Sask	Rural	Spotty showers and thunderstorms were reported over the past week. The region has now received 233 to 619 mm of rain (east central)
Briere, Karen	July 29 2010	Western Producer	Sask	Rural	First cut haying operations typically begin in earnest after the July long weekend, but it is now four weeks past that and there is a significant amount of hay that hasn't been cut.
Macarthur, Mary	July 29 2010	Western Producer	Alberta	Edberg	With more than 300 millimeters of precipitation the crops look lush and are staying ahead of the weeds.
Arnason, Robert	July 29 2010	Western Producer	Manitoba	Brookdale	"We want to be linked to sustainability and be linked and identified that way.. We want to make sure that people know we're not working just for the zero tillers." -Lindsay Coulthard
Lyseng, Rob	July 29 2010	Western Producer	Prairies	Rural	Winter wheat prefers lots of water at seeding time, and if managed according to recommendations, can produce a bountiful crop next summer.
Lyseng, Rob	July 29 2010	Western Producer	Prairies	Rural	The weed usually shuts down by this time of year.. However this year's moisture has kept dandelions actively growing especially with no competition from a crop.
Wilson, Barry	July 29 2010	Western Producer	Canada		"Last year we had a terrific year. It means it was good for most of our customers despite tough times in some sectors." -Greg Stewart, Farm Credit Canada President
White, Ed	Aug 5 2010	Western Producer	Canada		"If we did have an early frost, because so much of the crop was seeded late and is behind development because of cooler conditions, the impact would be very significant." -Stuart McMillan wheatboard crop conditions analyst.
Pratt, Sean	Aug 5 2010	Western Producer	Prairies	Rural	Flax Market report … predicts harvested area will fall to range of 650,000 to 815,000 acres.. This will position flax production and carryover to be the second smallest since 94-95.
White, Ed	Aug 5 2010	Western Producer	Prairies	Rural	If a producer has a large annual payment or several payments due this fall on a loan, BMO will allow its clients to extend the duration of the

Author	Date	Newspaper	Location of article subject		Quotables An interesting quote from the article that shows the level of impact / adaptation required
					loan.
Rueters	Aug 5 2010	Western Producer	United States	Kansas	The intense heat and humidity that blanketed central Kansas starting in late July has killed more than 2,000 cattle.
Briere, Karen	Aug 5 2010	Western Producer	Sask	Rural	Winterkill is a huge risk without enough stubble (to protect the winter wheat).
Raine, Micheael	Aug 5 2010	Western Producer	Alberta	Rural	Research shows that NDVI and topographical maps can reliably predict yield trends when making maps and planning for field nutrient prescriptions.
Arnason, Robert	Aug 12 2010	Western Producer	Manitoba	Rural	MCPA representatives have spoken with provincial officials and proposed various schemes to compensate cattle farmers, but so far the government has offered only a loan program.
Arnason, Robert	Aug 12 2010	Western Producer	Prairies	Rural	"The severity of the (winter wheat seed) shortage is going to depend on what happens the next few weeks and how soon some of these (Winter wheat) crops come off." -Jake Davidson, executive manager of Winter Cereals Canada.
(Crop Report)	Aug 12 2010	Western Producer	Alberta	Rural	Rain hampered haying. Hot temperatures continued causing severe problems for farmers in the drought0stricken region.
(Crop Report)	Aug 12 2010	Western Producer	Manitoba	Rural	Winter wheat harvest continued.. About 85 percent of the wheat crop is in the dough stage ..
(Crop Report)	Aug 12 2010	Western Producer	Sask	Rural	Thunderstorms rolled in, leaving more puddles. About three-quarters of the hay is cut and about half put up in bales or silage.
Duckworth, Barbara	Aug 12 2010	Western Producer	Alberta	Rural	Prices are expected to be pushed lower by a big Canadian crop and slumping demand from importers.
Pratt, Sean	Aug 12 2010	Western Producer	Prairies	Rural	Rod Merryweather, North American director of seeds and traits for Bayer, is also forecasting a lower production number.
Hamilton, Charles	Aug 12 2010	Western Producer	Prairies	Rural	Increased grain feed prices, flooding and closed overseas markets have affected producer's bottom line, resulting in extended repayment timeline.
Ewins, Adrian	Aug 12 2010	Western Producer	Sask	Rural	Increased max financial assistance, eliminated residency requirements, reduced deductible for private claimants
MacArthur, Mary	Aug 12 2010	Western Producer	Sask	Rural	Farmers with heavy crops will likely have problems with large swaths or windrows. A combination of heavy dew and cooler weather will make the large swaths harder to dry.
Macarthur, Mary	Aug 19 2010	Western Producer	Prairies	Rural	"We just have to wait for the weather. There is no magic spray in the bottle for us guys. We don't have a lot of options." -Frank Cole, farmer
(Crop Report)	Aug 19 2010	Western Producer	Alberta	Rural	Most of the area has been declared an agricultural disaster (peace river)
(Crop Report)	Aug 19 2010	Western Producer	Manitoba	Rural	Rain hampered field operations.
(Crop Report)	Aug 19 2010	Western Producer	Sask	Rural	Rain in most areas has halted haying. Hay swaths are slow to cure because of the high humidity.
McMillan, D'Arce	Aug 19 2010	Western Producer	Prairies	Rural	"The unseasonably wet weather in the second quarter adversely affected the operations of many of our construction and agriculture customers and consequently resulted in lower revenues in Q2." Matt Campbell, chair and chief executive officer (Rocky Mountain Dealership)
Macbean, Sylvia	Aug 19 2010	Western Producer	Prairies	Rural	A disease called late blight may be the culprit, the same disease which caused the Irish Potato Famine of the 1800;s. It kills potato and tomato plants.
	Aug 20 2010	CBC News	Sask	Rural	Finance Minister Ken Krawetz said the increase in revenues is primarily due to sales of land for oil and gas exploration.
Pratt, Sean	Aug 26 2010	Western Producer	Sask	Rural	Lentil fields were so lush and had such a dense canopy that it created a microlimate underneath the canopy that was humid, warm and ideal for disease propagation.
Ewins, Adrian	Aug 26 2010	Western Producer	Global	Rural	"The market is going to remain in a flux as long as there is uncertainty about the Black Sea situation and all these other things." -Bruce Burnett, Canadian Wheat Board
Wilson, Barry	Aug 26 2010	Western Producer	Canada		"Farmers want to know what is happening with the weather and with the decline in Environment Canada's data; we are trying to fill some of those gaps." -Bruce Burnett
Macarthur, Mary	Aug 26 2010	Western Producer	Prairies	Rural	
(Crop Report)	Aug 26 2010	Western Producer	Alberta	Rural	
(Crop Report)	Aug 26 2010	Western Producer	Manitoba	Rural	
(Crop Report)	Aug 26 2010	Western Producer	Sask	Rural	
Pratt, Sean	Aug 26 2010	Western Producer	Prairies	Rural	Rod Merryweather, North American director of seeds and traits for Bayer Inc, said the agency is off base on its canola estimate of 16.6 million seeded acres and 15.5 million harvested. He thinks those numbers should be 15 million and 13.5 million respectively.
Pratt, Sean	Aug 26 2010	Western Producer	Prairies	Rural	Dean Erickson, a farmer from Birchay, Sask, said a frost during the first week of Sept would be an epic disaster.
Arnason, Robert	Aug 26 2010	Western Producer	Manitoba	Rural	In a government news release, (Stan) Struthers (provincial agriculture minister) said the province is monitoring the livestock feed situation and is working with the federal government on programs for cattle producers affected by excess moisture this spring and summer.
Lyseng, Ron	Aug 26 2010	Western Producer	Prairies	Rural	Winter wheat field trials conducted by North Dakota State University compared seedling emergence with and without JumpStart. With no applied phosphorus, JumpStart scored one more plant per meter of row length.

Author	Date	Newspaper	Location of article subject		Quotables An interesting quote from the article that shows the level of impact / adaptation required
Briere, Karen	Aug 26 2010	Western Producer	Sask	Rural	Most of the extra spending is $144 million for the province's share of the $30 dollar per acre excess moisture program available to producers who couldn't seed.
Cross, Brian	Sept 2 2010	Western Producer	Alberta	Rural	"I've heard guys say that it's probably one of the hardest places to farm in Alberta because we're more prone to drought and we're more prone to different weather situations... But in the end, if I didn't think we could make it here, I wouldn't have seeded a crop this spring." -Charles Schmidt (Farmer)
MacArthur, Mary	Sept 2 2010	Western Producer	Prairies	Rural	"We have some barley that's terrible. The barley is barely six inches tall and is very hard to combine." -Barry Critcher, farmer
(Crop Report)	Sept 2 2010	Western Producer	Alberta	Rural	Rain and cool weather have halted harvest progress... Rain and cold weather have slowed harvest progress... Rain has hampered harvest operations and may downgrade remaining crops.
(Crop Report)	Sept 2 2010	Western Producer	Manitoba	Rural	Rain over the past week slowed harvest.. Most of the canola is swathed, but little has been combined.
(Crop Report)	Sept 2 2010	Western Producer	Sask	Rural	Heavy rain across the region slowed harvest… rain slowed the start of harvest.. Rain stalled hopes of starting harvest.. Rain was widespread throughout the region (northwest)
Pratt, Sean	Sept 2 2010	Western Producer	Prairies	Rural	Frost will hopefully be delayed until the end of Sept, with warm dry weather helping farmers to get all or most of the crop in the bin and in good shape - Grant McLean - spokesperson of Ag Ministry
Arnason, Robert	Sept 9 2010	Western Producer	Manitoba	Rural	"Most of the native hay is in water. Anybody that had marshland and marshes by lakes, all those are filled in with water." -Lionel Kaskiw farm production adviser with Manitoba Ag
(Crop Report)	Sept 9 2010	Western Producer	Alberta	Rural	Canola swathing well underway .. Frost was reported.. Harvest is off to a slow start because of frequent showers.. Frequent showers have slowed harvest and haying progress...
(Crop Report)	Sept 9 2010	Western Producer	Manitoba	Rural	Heavy rains, with 50 to 100 mm around Steinbach, will delay the harvest of remaining cereal and canola crops..
(Crop Report)	Sept 9 2010	Western Producer	Sask	Rural	Harvest was progressing until rain arrived.. Good haying progress was made although some farmers have more mowing and baling to do...
White, Ed	Sept 9 2010	Western Producer	Prairies	Rural	Supplies are generally seen as adequate by the industry, and while there are weather concerns around the new crop yet to be harvested, few believe that frost or other factors will cause enough damage to leave demand short.
Pratt, Sean	Sept 9 2010	Western Producer	Sask	Rural	An average yield of 32 bu. Would result in 2.8 million tons of peas, down from Statistics Canada's 3.1 million tonne estimate.
Guenter, Henry	Sept 9 2010	Western Producer	Prairies	Rural	Farmers who have never driven a combine equipped with a rear wheel drive assembly will have to be careful.
Dekay, William	Sept 9 2010	Western Producer	Prairies	Rural	Sept 30th is the deadline for applying for compensation under the federal provincial Excess Moisture Program.
	Sept 13 2010	CBC News	Sask	Rural	"SO far overall, I think the response to the disasters in various communities has been, on the part of our officials.. Swift." -Sask Premier Brad Wall
Macarthur, Mary	Sept 16 2010	Western Producer	Prairies	Rural	"When you've got cattails growing on fields, you know you've got a problem" said (Mervin) Maryniak, who has not seen such a wet season in his farming career.
Arnason, Robert	Sept 16 2010	Western Producer	Manitoba	Rural	"The yield ranges have been in the low 20s to the badly flooded areas; to we've seen some fields run well up over 60." -Ron Rabe (sales rep)
Macarthur, Mary	Sept 16 2010	Western Producer	Prairies	Rural	The quality ranges from excellent to extremely poor. The hay put up earlier in the season tends to be higher quality.
(Crop Report)	Sept 16 2010	Western Producer	Alberta	Rural	Rain halted harvest progress.. Harvested has stalled with rain and cool weather.. Little harvest was done last week frost... A combination of heavy rain, dew and drizzle has halted harvest progress.
(Crop Report)	Sept 16 2010	Western Producer	Manitoba	Rural	Rainfall slowed harvest.. General rainfall halted harvest.. Heavy rain across the region halted harvest progress..
(Crop Report)	Sept 16 2010	Western Producer	Sask	Rural	Some areas saw more than 60 millimeters of rain, which shut down harvest.. Rain fell across most parts of the region halting progress... Some areas reported more than 100 mm of rain.. Up to 80 mm of rain fell in the past week... Some rain in the area stalled harvest
Briere, Karen	Sept 16 2010	Western Producer	Prairies	Rural	Livestock producers who think they might have more time to repay cash advances might want to make sure they are eligible for the stay of default announced last month.
Wilson, Barry	Sept 16 2010	Western Producer	Canada		"There was an acknowledgement that after N margin years, specifically targeted to livestock, there was an acknowledgement that the program is not working and that there needs to be adjustments." -Carol Mitchell (Ontario agriculture minister)
Raine, Micheal	Sept 16 2010	Western Producer	Prairies	Rural	"Unfortunately there isn't a white knight coming to save the crop from frost like last year." (Larry Flysask of Environment Canada)
Briere, Karen	Sept 16 2010	Western Producer	Prairies	Rural	In July, Viterra estimated that the loss in fertilizer and chemical sales due to unseeded acres and wet weather would be 15 to 17 percent.
Hall, Angela	Sept 22 2010	Sask News Network	Sask	Rural	(Sask Assoc of Rural Municipalities, David) Marit said there's still time for the weather to improve to give farmers a chance to salvage the harvest - although the weather is the worst in recent memory.
Briere/Ewins	Sept 23 2010	Western Producer	Prairies	Rural	By the night of Sept. 17th and early morning hours of Sept 18th, most of eastern Alberta, Sask and Wester Manitoba had all experienced temperatures of -4C to -5C.
Macarthur, Mary	Sept 23 2010	Western Producer	Canada		"Everyone from farmers to exporters are caught in this. It's going to be a scramble and growers just don't have the product to deliver." -

Author	Date	Newspaper	Location of article subject		Quotables An interesting quote from the article that shows the level of impact / adaptation required
					Errol Anderson
Wilson, Barry	Sept 23 2010	Western Producer	Prairies	Rural	The decline in fresh water supplies over the 34-year study period is equal to "roughly one-half of the long-term average of annual water yield."
Arnason, Robert	Sept 23 2010	Western Producer	Prairies	Rural	"We had a lot of orders from northern Sask cancelled in Aug because it was too wet." -Dale Hicks (farmer)
White, Ed	Sept 23 2010	Western Producer	Prairies	Rural	The happy story comes from farmers who seeded before it started to rain this spring and who harvested before the fall rain began to fall.
Scott, Neil	Sept 24 2010	Regina Leader-Post	Sask	Rural	An accumulated total of 18 percent of the crop had been combined by the end of the seven-day period, up by four per cent compared to a week earlier.
Roth, Pam/Couture, Joe	Sept 27 2010	Regina Leader-Post	Sask	Maple Creek	Following a soggy spring, the severe weather began in mid-June when the Maple Creek area received more than 100 millimeters of rain.
Arnason, Robert	Sept 30 2010	Western Producer	Canada		For instance, 100 mm of rain fell in Yorkton, in July. It wasn't a record, but rain was recorded on 24 days, which meant there were only seven days when it didn't rain that month in Yorkton.
MacArthur, Mary	Sept 30 2010	Western Producer	Alberta	Rural	Ray Como was leaning over the engine to get a serial number off the oil filter when he slid forward and got stuck.
(Crop Report)	Sept 30 2010	Western Producer	Alberta	Rural	Harvest resumed.. Harvest finally restarted again with warm, sunny fall weather.. Farmers got machinery into fields on the weekend after weeks of wet, cool weather.
(Crop Report)	Sept 30 2010	Western Producer	Manitoba	Rural	Rainfall limited harvest.. Rain prevented harvest..
(Crop Report)	Sept 30 2010	Western Producer	Sask	Rural	Good harvest weather allowed farmers to restart harvest… Farmers are back in their fields after drizzly weather.. Harvest is underway after rain and frost
White, Ed	Sept 30 2010	Western Producer	Prairies	Rural	Analysts and advisers caution farmers to research where to get the best price or find interest in their feed grains this winter, because conditions vary widely due to varied growing conditions and frosts at harvest.
McMillan, D'Arce	Sept 30 2010	Western Producer	Prairies	Rural	If overseas suppliers want to service the world's largest import market, it is imperative they offer peas and lentils at prices that are consumer friendly. -G. Chandrashekhar (Editor Hindu Business Line)
Duckworth, Barbara	Sept 30 2010	Western Producer	Alberta	Rural	The requirement for farmers to receive a minimum of 20 percent of their gross annual income from the business was lifted and larger farms employing more than 20 people may also qualify for help.
Recksiedler, Blaine	Sept 2010	Agriview	Prairies	Rural	Time and pest management, higher yield, marketing flexibility and economics have been some of the key drivers behind the interest in winter wheat.
Babcock, John	Sept 2010	Agriview	Sask	South Sask	The infrastructure plan would see the replacement of flood irrigation ditches with clusters of center pivots served by pressurized mainlines.
AgriStability	Sept 2010	Agriview	Prairies	Rural	Deadline for submitting AgriStability program forms reminder
Ministry of Ag	Sept 2010	Agriview	Prairies	Rural	The Ministry of Agriculture developed a collection of resources on our website to help producers who are dealing with excess moisture.
Pratt, Sean	Oct 7 2010	Western Producer	Prairies	Rural	Statistics Canada issued its second production estimate of the year, forecasting an 18.5 percent drop in prairie wheat production and a 16.3 percent decline in canola production from 2009 levels.
Briere, Karen	Oct 7 2010	Western Producer	Sask	Rural	Sometimes it takes a disaster to show how a program does or doesn't work -Public safety minister Yogi Huyghbaert
Cross, Brian	Oct 7 2010	Western Producer	Prairies	Rural	After a promising start, excess rain has saturated fields in many areas, leaving millions of acres of farmland filled with ruts, water and weeds.
Wilson, Barry	Oct 7 2010	Western Producer	Canada		"We're really just giving governments a heads up to be ready. There are areas across the Prairies that have had a brutal year. I think in the end, they may have to step up and do something ad hoc." -Gerry Ritz, Ag Manager
Arnason, Robert	Oct 7 2010	Western Producer	Prairies	Rural	The disease types and affected crops were different in Manitoba, Sask and Alberta, but the impact was the same.
White, Ed	Oct 7 2010	Western Producer	Global		This year, problems here are being matched by problems overseas, and that's opening up export possibilities.
White, Ed	Oct 7 2010	Western Producer	Prairies	Rural	Many farmers might prematurely assume they have extremely low crop quality, when careful sampling might show that they have midgrade's that could be worth substantially more money.
Glen, Barb (editorial)	Oct 7 2010	Western Producer	Prairies	Rural	This year's inclement weather crept up on the Prairies. Each week brought hope of better conditions that would allow seeding, spraying, harvest. But poor weather inexorably continued.
Glen, Barb (editorial)	Oct 7 2010	Western Producer	Prairies	Rural	Farmers in the affected areas need financial help, AgriStability does not work, and it is based on the assumption that you will only have one bad year.
Ewins, Adrian	Oct 7 2010	Western Producer	Prairies	Rural	An early spring had everyone's hopes up, but incessant rain throughout the growing season resulted in unworkable fields and thousands of flooded acres.
Pratt, Sean	Oct 7 2010	Western Producer	Prairies	Rural	Some growers are actually hoping for frost because it would firm up the land and allow them to speed up their harvest work.
Macarthur, Mary	Oct 7 2010	Western Producer	Sask	Rural	"There was no single area that was exceptional, it was on a field by field basis." -De Rocquigny
Arnason, Robert	Oct 7 2010	Western Producer	Manitoba	Rural	Wet conditions provided ideal conditions for the fungal disease.

Author	Date	Newspaper	Location of article subject		Quotables An interesting quote from the article that shows the level of impact / adaptation required
Lyseng, Ron	Oct 7 2010	Western Producer	Manitoba	Rural	The triangular tracks Case puts under its combines are the same 36 inch wide belts it employs on its Quadtrac tractors.
Arnason, Robert	Oct 7 2010	Western Producer	Prairies	Rural	Chains can break, and straps can stretch during a tow.
Briere, Karen	Oct 7 2010	Western Producer	Prairies	Rural	Producers couldn't get their animals into pastures and they couldn't hay, leading to a significant feed shortage.
Duckworth, Barbara	Oct 7 2010	Western Producer	Prairies	Rural	Owners reduced the number of animals per pend and mud on hides was a problem. Mud and manure on the hide can harbor diseases like E. coli, even though packers wash hides before skinning and evisceration.
Grognet, Jeff	Oct 7 2010	Western Producer	Prairies	Rural	A sudden death is the first indication of dicoumarol poisoning, but it's more common for producers to notice that several animals are stiff and lame. This is due to bleeding in joints and muscles.
Andrews, Jacklin	Oct 7 2010	Western Producer	Prairies	Rural	If your husband is locked into N habits, taking risky and unnecessary chances or has given up, his stress level may be overwhelming.
Briere, Karen	Oct 14 2010	Western Producer	Prairies	Rural	IN Sask, the government estimated 60 percent of the crop was in the bin by Oct. 7 compared to 29 percent the previous week.
Briere, Karen	Oct 14 2010	Western Producer	Canada		Agricultural claims include erosion, essential fencing, emergency transportation of livestock and emergency feeding.
Ewins, Adrian	Oct 14 2010	Western Producer	Prairies	Rural	Agriculture and Canadian Wheat Board minister Gerry Ritz announced last week a "stay of default" on repayment until Apr 30, 2011 for producers who received an advance through the board.
Arnason, Robert	Oct 14 2010	Western Producer	Manitoba	Rural	Thanks to the drying weather, soybean growers have been able to harvest a crop that is generating excellent yields on most fields in Manitoba.
Glen, Barb (editorial)	Oct 14 2010	Western Producer	Prairies	Rural	Study outlines discontent with the level of direct payments to agriculture and documents the fact that, while public spending on business risk management programs has generally increased since 1990, farm income has not been improved to any lasting degree,
Guenter, Henry	Oct 14 2010	Western Producer	Prairies	Rural	In this tough harvesting season, farmers should consider replacing parts that they would have replaced in a year or two anyway.
Ewins, Adrian	Oct 14 2010	Western Producer	Prairies	Rural	For Canada, overall, farmland values rose by three percent during the six months ending July 31.
Swihart, Ric	Oct 21 2010	Western Producer	Alberta	Taber	The quality of the beets is very good and the average sugar extraction is higher than 18 percent.
Dekay, William	Oct 21 2010	Western Producer	Sask	Rural	Bruce Hill, president of the Canadian Cherry Producers Inc, said Statistics Canada has no programs in place to look at fruit production on the Prairies.
Byers, Shirley	Oct 21 2010	Western Producer	Sask	Rural	Field and pen checks were difficult in wet conditions... Feed shortages will prevent some producers from backgrounding their calves this year.
Wilson, Barry	Oct 21 2010	Western Producer	Prairies	Rural	"These need to be continued (environmental policies) in all agricultural areas of the country and expanded particularly in areas where crop type and tillage practice leave the soil exposed and vulnerable to erosive forces." -Agriculture Canada report.
Arnason, Robert	Oct 21 2010	Western Producer	Prairies	Rural	Severity of disease rated on a 0 to 5 scale.. Sask 2.7 .. Manitoba 2.4… Alberta 64% of (canola) fields had the disease.
Rueters	Oct 21 2010	Western Producer	United States	Rural	"We've known for years that farmers were going to have to contend with harsher weather, but now we're getting a clear idea of the scale and scope of the crisis." -Jeff Raikes, chief executive officer of the Gates Foundation
Briere, Karen	Oct 21 2010	Western Producer	Prairies	Rural	Most producers will need to add grain to their feeding rations to make up for shortages .. Caused by wet conditions.
Levy, Bryn	Oct 21 2010	Western Producer	Prairies	Rural	This year's growing conditions have also created an ideal breeding ground for fusarium head blight in wheat, barley and corn.
	Oct 25 2010	CBC News	Prairies	Rural	"Its feed grade because the frost causes kernels to shrivel. And I haven't heard of a lot of people in our region here that have had wheat quality that will make milling grade." -Murray Marsh (Farmer, Carstairs Alberta)
Arnason, Robert	Oct 28 2010	Western Producer	Prairies	Rural	"Cool weather years are open season on farmers." he (Jeff Simpson, farmer) said explaining the grading system works against producers in wet years.
Briere, Karen	Oct 28 2010	Western Producer	Sask	Rural	Establishment benefit claims, which pay out when crops don't establish due to insurable causes, also topped the previous 10-year high at 4,913 claims worth $14 million.
Briere, Karen	Oct 28 2010	Western Producer	Prairies	Rural	"there's always some producers that get left out in the cold" -Bill Jameson, SCA director district 2
Arnason, Robert	Nov 4 2010	Western Producer	Prairies	Rural	Average of 195 lb. of honey per hive, which was below the average of 225 lb., but not a total disaster considering the conditions in the region this summer.
Glen, Barb (editorial)	Nov 4 2010	Western Producer	Prairies	Rural	The excess moisture program provided assistance to crop farmers. It is obviously unfair to exclude livestock producers from a similar assistance program.
Moneo, Shannon	Nov 4 2010	Western Producer	North America	Rural	A cool, rainy June and July in BC resulted in late pollination blossoms that sat unopened and a poor bud set.
Pratt, Sean	Nov 4 2010	Western Producer	Sask	Rural	The government has allocated $1 million this year to repair the 22.5 kilometer m1 Canal, which is the main waterway between the east side pump station of Dief lake and the Broderick reservoir.
Levy, Bryn	Nov 4 2010	Western Producer	Sask	Rural	Wheater said Western Canada's rivers are not exempt from a global trend of reduced river flows.
Glen, Barb (editorial)	Nov 11 2010	Western Producer	Canada	Rural	Municipalities are frustrated because they are forced to build infrastructure necessary to accommodate public travel on bodies of water that

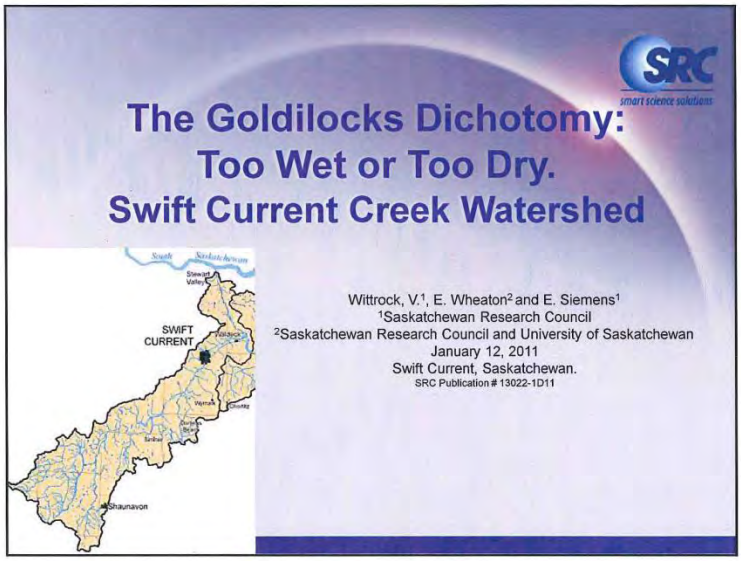
Author	Date	Newspaper	Location of article subject		Quotables An interesting quote from the article that shows the level of impact / adaptation required
					have not seen a canoe in 100 years, if ever.
Cross, Brian	Nov 11 2010	Western Producer	Sask	Rural	"The cereals and the pulses in particular will be downgraded considerably by the wet weather that we had in Sept." Grant McLean, Sask Ag.
Levy, Bryn	Nov 11 2010	Western Producer	Sask	Rural	The flooding caps nearly a decade of hard times for the region's cattle producers, who are now looking to their association and the federal and provincial governments for help.
Levy, Bryn	Nov 11 2010	Western Producer	Prairies	Rural	"The tax deferral is a good start to help livestock producers who have been affected by excess moisture." Rob Brunel, President of Keystone Agricultural Producers.
Swihart, Ric	Nov 11 2010	Western Producer	Alberta	Rural	In much of the irrigated areas, especially further east and south, many crops suffered from saturated soils.
Pratt, Sean	Nov 18 2010	Western Producer	Prairies	Rural	"The start of the growing season is not going to be real pleasant. We will be slow in getting the crops in the ground next year." -Drew Lerner, president of World Weather Inc.
Levy, Bryn	Nov 18 2010	Western Producer	Prairies	Rural	Hopeful that federal agriculture minister Gerry Ritz will eventually work with Bjornerud on a per head payment.
	Nov 22 2010	CBC News	Manitoba	Rural	About five homes have been flooded and a number of band members with health conditions have been moved to Pelican Rapids.
Wilson, Barry	Nov 25 2010	Western Producer	Manitoba	Rural	Assistant deputy agriculture minister Rita Moritz, who is in charge of the farm financial programs branch, told committee members that officials are assessing feed issues in the Interlake to determine how much other programs likely will pay and whether that meets the need.
Swihart, Ric	Nov 25 2010	Western Producer	Prairies	Rural	Good beet quality should translate into good sugar extraction, while continuing high world sugar prices could translate into decent returns for most growers.
McMillan, D'Arce	Nov 25 2010	Western Producer	Prairies	Rural	Damage not proven to collect.. Any industry affected by weather could use the product to recover.
	Dec 3 2010	Western Producer	Prairies	Rural	Large quantity of weather damaged feed wheat produced this year has prompted the Canadian Wheat Board to introduce new pricing program.
Pratt, Sean	Dec 9 2010	Western Producer	Prairies	Rural	In a recent report, Biomass Advisors forecast 13.1 million acres of the crop in North America by 2025, including 3.2 million acres planted on the Canadian Prairies. (camelina and Brassica carinata to make lubricants, greases etc..)
Pratt, Sean	Dec 9 2010	Western Producer	Prairies	Rural	That is nearly nine million acres that growers reported as unseeded, so it's hard to fathom how fallow increased by only 5.4 million acres over last year summer.
Briere, Karen	Dec 9 2010	Western Producer	Sask	Rural	Agriculture Minister Bob Bjornerud has said that there will be no per head payments from the province.
Rogers, Diane	Dec 9 2010	Western Producer	Sask	Rural	"Everybody I know, even those on sand, still had fungal problems and pollination problems." Keith Jorgenson, farmer
Raine, Michael	Dec 9 2010	Western Producer	Alberta	Rural	Fusarium head blight has been on a steady Mar west from the wetter prairie provinces since the early 1990's.
Wilson, Barry	Dec 9 2010	Western Producer	Canada		"We realized when we took the loans out for the advance payment program that they were loans and we would have to pay them back but we cannot realistically afford to do so within the current proposed framework." -Ernie Mutch president of the PEI Federation of Agriculture
	Dec 17 2010	CBC News	Prairies	Rural	But with record high water levels also plaguing the Assiniboine near Brandon of late, Mayor Shari Dectar Hirst said she's concerned Sask is fobbing off its own flooding issue and creating one for their neighbors.
Kusch, Larry	Jan 1 2011	Winnipeg Free Press	Manitoba	Rural	The snow banks are high and the frozen soils are saturated south of the border, spelling potential flood grief for Manitobans this spring.

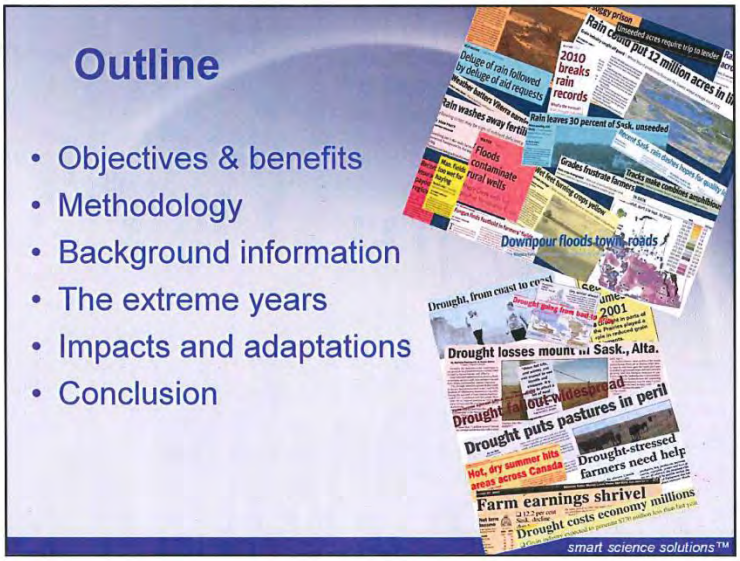
Legend for Media Table:

N = Negative
P = Positive
1 = Flood
2 = Drought

APPENDIX 4

Presentations to the Swift Current Creek, Assiniboine River, Upper Souris River and North Saskatchewan River Watershed Associations


The Goldilocks Dichotomy:
Too Wet or Too Dry.
Swift Current Creek Watershed
SRC
smart science solutions
SWIFT CURRENT
Shaunavon
Wittrock, V.[1], E. Wheaton[2] and E. Siemens[1]
[1]Saskatchewan Research Council
[2]Saskatchewan Research Council and University of Saskatchewan
January 12, 2011
Swift Current, Saskatchewan.
SRC Publication # 13022-1D11


Outline
• Objectives & benefits
• Methodology
• Background information
• The extreme years
• Impacts and adaptations
• Conclusion
Deluge of rain followed by deluge of aid requests
2010 breaks rain records
Rain leaves 30 percent of Sask. unseeded
Floods contaminate rural wells
Downpour floods town roads
Drought losses mount in Sask., Alta.
Drought puts pastures in peril
Drought-stressed farmers need help
Farm earnings shrivel
Drought costs economy millions
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Objectives
SRC
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• To characterize drought and excessive moisture events for selected watersheds during the past century.
• Compare and contrast driest and wettest patterns to help determine characteristics for risk assessments and planning.
• Consider the implications for impacts and adaptations directly related to the watershed.
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Benefits of Examining the Past
SRC
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• Assist communities, local municipalities, provincial and federal governments with risk management and planning strategies for extreme events.
• Avoid damages and decrease the costs of climate events by learning from the past.
• Help to lower the costs of the impacts of future climatic events.
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What is a Drought?

- A deficiency of precipitation from expected or "normal" that, when extended over a season or longer, is insufficient to meet the demands of human activities and the environment
- Four major types of drought including Meteorological, Agricultural, Hydrological and Socio-economic

• Or when it hasn't rained, the fields are dry, the lakes or rivers are really low and it impacts the economy, environment and our way of life

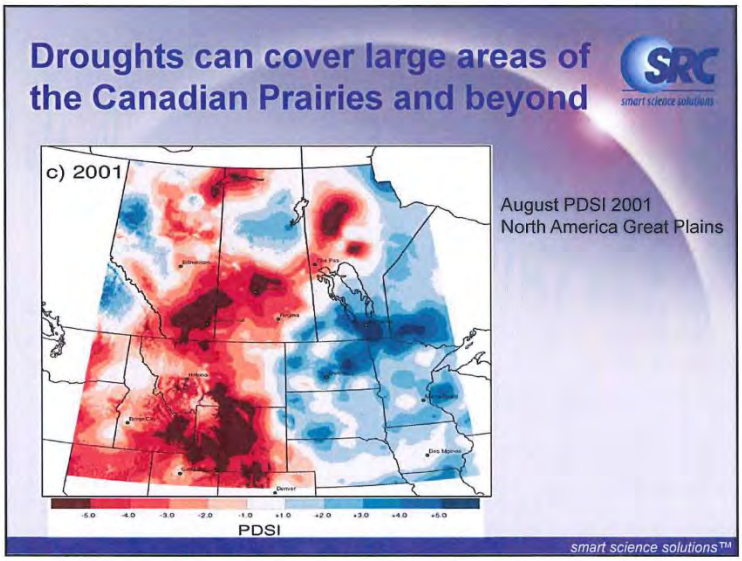
Photo: AAFC

What is Excessive Moisture?

- An excess of precipitation from expected or "normal" that, when extended over a season or longer, is too much to meet the demands of human activities and the environment
- Four major types of excess moisture including Meteorological, Agricultural, Hydrological and Socio-economic

• Or it won't quit raining, the fields are saturated, the lakes or rivers are over flowing their banks and it impacts the economy, environment and our way of life.

Photo: Wucher, L. St. Gregor SK Sept 6, 2010


Droughts can cover large areas of the Canadian Prairies and beyond
SRC
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c) 2001
August PDSI 2001
North America Great Plains
-5.0 -4.0 -3.0 -2.0 -1.0 +1.0 +2.0 +3.0 +4.0 +5.0
PDSI
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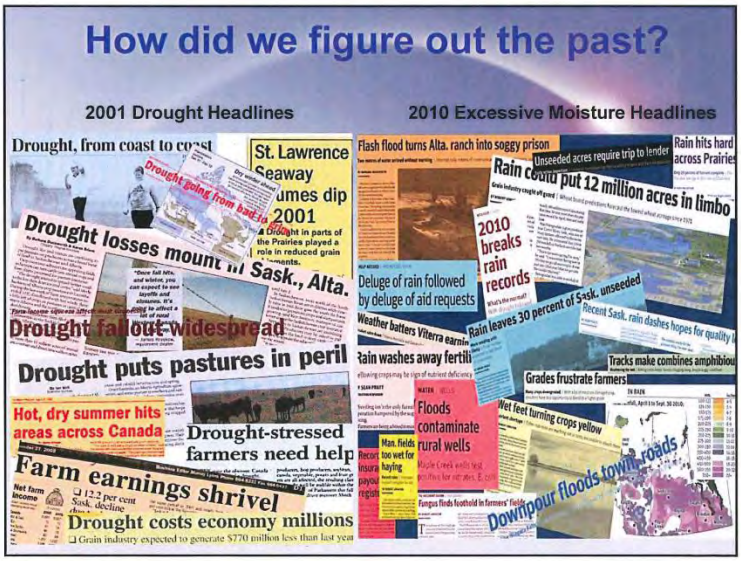
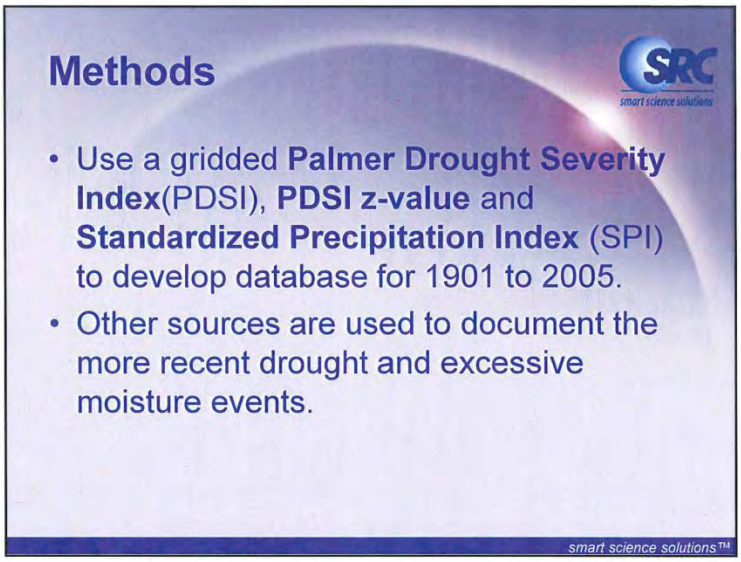

How did we figure out the past?
2001 Drought Headlines
2010 Excessive Moisture Headlines
Drought, from coast to coast
St. Lawrence Seaway
2001
Drought losses mount in Sask., Alta.
Drought fallout widespread
Drought puts pastures in peril
Hot, dry summer hits areas across Canada
Drought-stressed farmers need help
Farm earnings shrivel
Drought costs economy millions
Flash flood turns Alta. ranch into soggy prison
Unseeded acres require trip to lender
Rain hits hard across Prairies
Rain could put 12 million acres in limbo
2010 breaks rain records
Deluge of rain followed by deluge of aid requests
Rain leaves 30 percent of Sask. unseeded
Recent Sask. rain dashes hopes for quality
Weather batters Viterra earnin
Tracks make combines amphibious
Grades frustrate farmers
Floods contaminate rural wells
Wet feet turning crops yellow
Downpour floods town roads


Methods
SRC
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• Use a gridded **Palmer Drought Severity Index**(PDSI), **PDSI z-value** and **Standardized Precipitation Index** (SPI) to develop database for 1901 to 2005.
• Other sources are used to document the more recent drought and excessive moisture events.
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Methods continued
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• **Rank** the 10 driest and 10 wettest years in the watershed
• **Spatial variability** is determined from these rankings.
• Literature review and media analysis to determine the **impacts** and **adaptation** strategies undertaken
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How do we classify severe drought, excessive moisture or average conditions?

Source: V. Wittrock Aug 1 2009
Drought & cold stressed crop (short & thin) (Field near Neidpath)

Source: SW Booster June 17 2010
Swift Current Creek high water levels due to Duncairn Reservoir water release (Bridge is in Swift Current)

Palmer Drought Severity Index (PDSI)

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- One of the most widely used drought and excessive moisture indices
- Primarily a hydrological drought index
- Derived using a soil moisture/water balance model which requires information on the available soil water content along with daily/monthly precipitation and temperature data
- Values contain a long term memory of the previous moisture conditions because the calculated value.

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What do PDSI values mean?

Classification		PDSI Value
Drought	Exceptional	≤ -5
	Extreme	> -5.0 to -4.0
	Severe	> -4.0 to -3.0
	Moderate	> -3.0 to -2.0
	Mild	> -2.0 to -1.0
Near Normal		> -1.0 to 1.0
Wet	Mild	1.0 to < 2.0
	Moderate	2.0 to < 3.0
	Severe	3.0 to < 4.0
	Extreme	4.0 to < 5.0
	Exceptional	≥ 5.0

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Top 10 Extreme Years and Wheat Yields

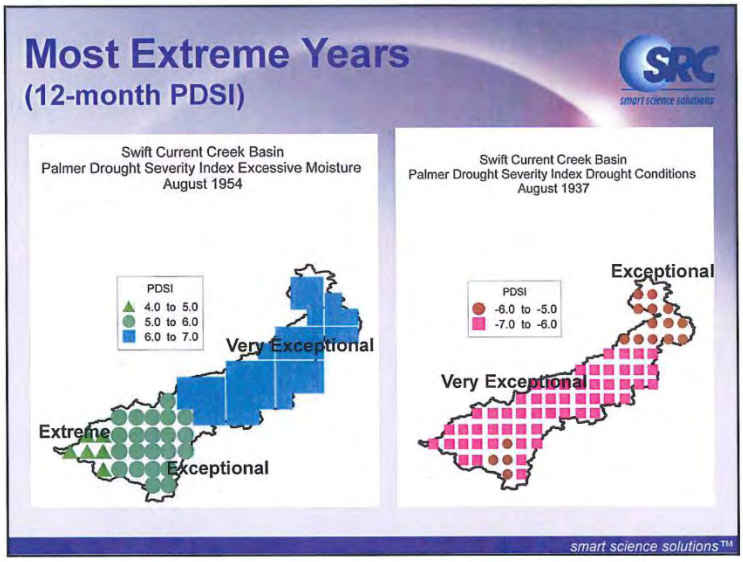
Palmer Drought Severity Index for the Swift Current Creek Watershed
(1901-2005 Agriculture Year (Sept to Aug))

Excessive Moisture		
Year	Value	Change in Wheat Yield*
1954	6.8	-41.0
1966	6.7	5.4
2004	5.8	21.6
1951	5.6	-44.6
1953	5.6	-17.6
1916	5.5	Not Available
1965	5.4	-16.5
1991	5.1	18.7
1907	5.1	Not Available
1975	5.0	-16.9

Drought		
Year	Value	Change in Wheat Yield*
1937	-6.5	Not Available
1931	-6.0	Not Available
1988	-5.9	-58.3
1919	-5.9	Not Available
1946	-5.8	-73.4
1936	-5.6	Not Available
1949	-5.4	-91.0
1905	-5.3	Not Available
1961	-5.2	-77.3
1914	-4.6	Not Available

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Averaged over entire watershed

Wheat Yield data:
SK Ministry of Agriculture


Most Extreme Years
(12-month PDSI)
SRC
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Swift Current Creek Basin
Palmer Drought Severity Index Excessive Moisture
August 1954
PDSI
4.0 to 5.0
5.0 to 6.0
6.0 to 7.0
Very Exceptional
Extreme
Exceptional
Swift Current Creek Basin
Palmer Drought Severity Index Drought Conditions
August 1937
PDSI
-6.0 to -5.0
-7.0 to -6.0
Exceptional
Very Exceptional
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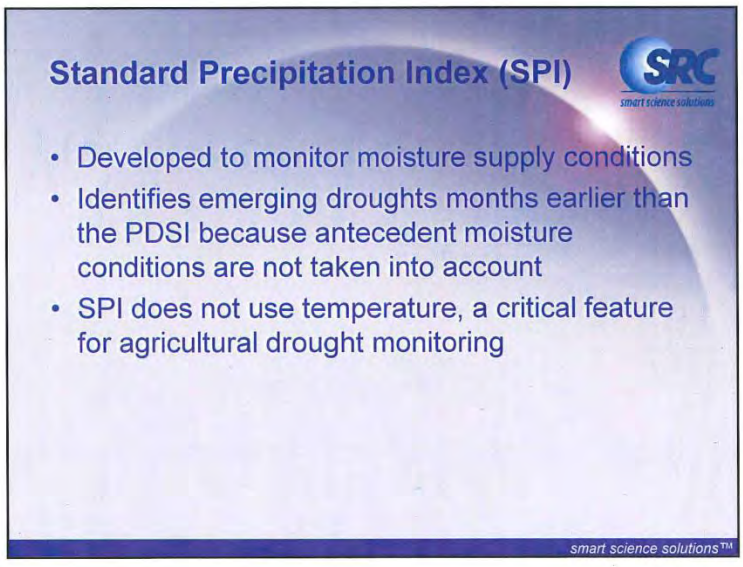
Standard Precipitation Index (SPI)
SRC
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• Developed to monitor moisture supply conditions
• Identifies emerging droughts months earlier than the PDSI because antecedent moisture conditions are not taken into account
• SPI does not use temperature, a critical feature for agricultural drought monitoring
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What do SPI values mean?

Classification		SPI Value
Drought	Exceptional	≤ -2.5
	Extreme	> -2.5 to -2.0
	Severe	> -2.0 to -1.5
	Moderate	> -1.5 to -1.0
	Mild	> -1.0 to -0.5
Near Normal		> -0.5 to 0.5
Wet	Mild	0.5 to < 1.0
	Moderate	1.0 to < 1.5
	Severe	1.5 to < 2.0
	Extreme	2.0 to < 2.5
	Exceptional	≥ 2.5

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Top Ten - 1 Month Extremes
Standardized Precipitation Index (1901-2005)

Excessive Moisture			
Year	Month	Value	Change in Wheat Yield*
1927	5	3.1	Not Available
1971	1	2.9	-25.5
1986	9	2.8	17.6
1967	1	2.7	-52.2
1955	7	2.7	-20.5
1993	8	2.7	14.0
1977	12	2.6	-1.8
1904	3	2.6	Not Available
1938	2	2.6	-66.9
1964	12	2.5	-42.1

Drought			
Year	Month	Value	Change in Wheat Yield*
1967	6	-3.9	-52.2
1959	12	-3.5	-45.7
1973	1	-3.5	-38.5
1985	6	-3.3	-66.5
1952	12	-3.1	-8.6
1917	11	-3.1	Not Available
1961	8	-2.9	-77.3
1903	12	-2.9	Not Available
2001	8	-2.9	-36.7
1952	5	-2.8	-8.6

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Averaged over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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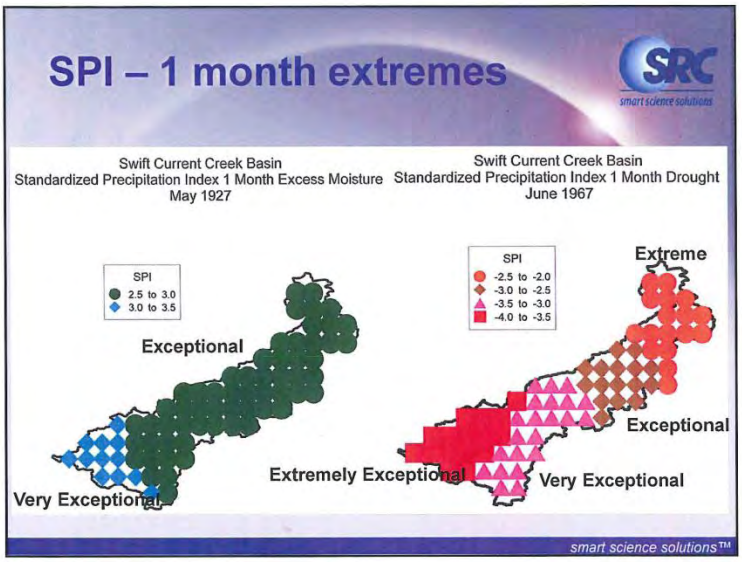
SPI – 1 month extremes
SRC
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Swift Current Creek Basin
Standardized Precipitation Index 1 Month Excess Moisture
May 1927
SPI
2.5 to 3.0
3.0 to 3.5
Exceptional
Very Exceptional
Swift Current Creek Basin
Standardized Precipitation Index 1 Month Drought
June 1967
SPI
-2.5 to -2.0
-3.0 to -2.5
-3.5 to -3.0
-4.0 to -3.5
Extreme
Exceptional
Extremely Exceptional
Very Exceptional
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What about 2009 and 2010?
SRC
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• 2009 had a drought in many areas which continued to April 2010 and then a dramatic switch occurred.
• What did it look like?
Source: V. Wittrock Aug 1 2009
Drought & cold stressed crop
(short & thin ~1 month behind)
8:00am, June 19
Source: SW TV News June 19 2010
Swift Current Creek high water levels
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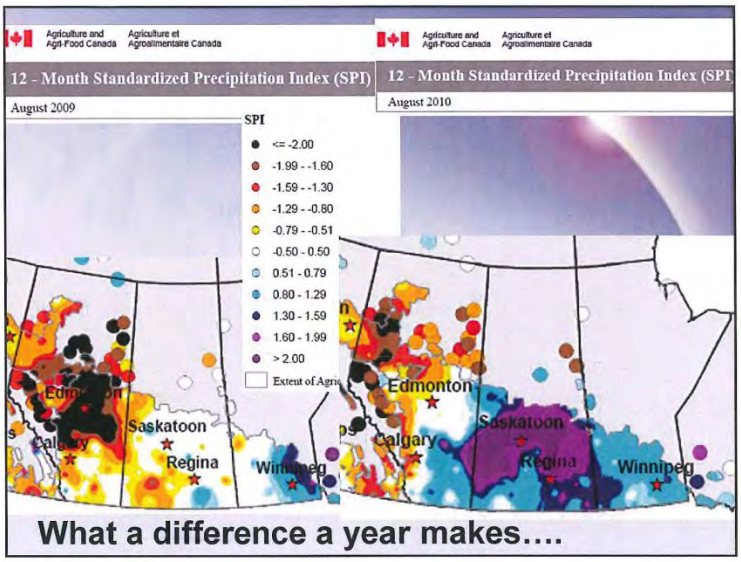
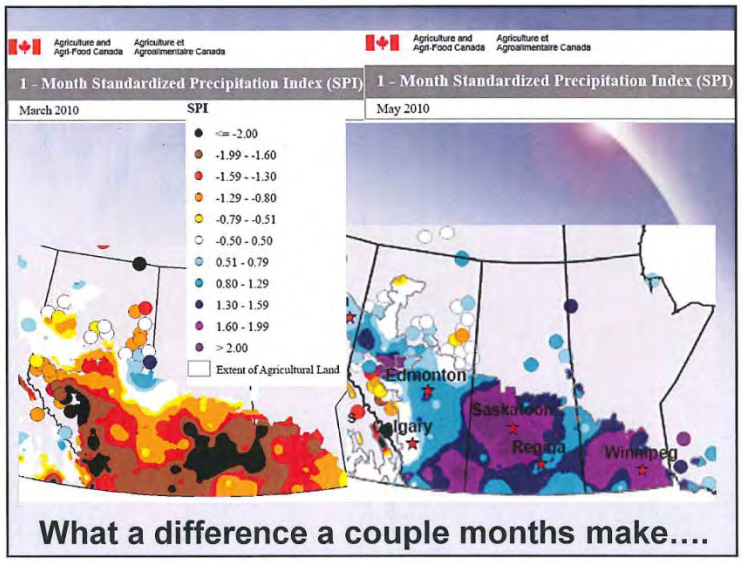

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
12 - Month Standardized Precipitation Index (SPI)
August 2009
SPI
<= -2.00
-1.99 - -1.60
-1.59 - -1.30
-1.29 - -0.80
-0.79 - -0.51
-0.50 - 0.50
0.51 - 0.79
0.80 - 1.29
1.30 - 1.59
1.60 - 1.99
> 2.00
Saskatoon
Regina
12 - Month Standardized Precipitation Index (SPI)
August 2010
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
What a difference a year makes....


Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
1 - Month Standardized Precipitation Index (SPI)
March 2010
SPI
<= -2.00
-1.99 - -1.60
-1.59 - -1.30
-1.29 - -0.80
-0.79 - -0.51
-0.50 - 0.50
0.51 - 0.79
0.80 - 1.29
1.30 - 1.59
1.60 - 1.99
> 2.00
Extent of Agricultural Land
1 - Month Standardized Precipitation Index (SPI)
May 2010
Edmonton
Saskatoon
Regina
Winnipeg
What a difference a couple months make....

These Extreme Years have Impacted Everyone and Adaptation Strategies have been Applied

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Impacts from Droughts

- Soil erosion
- Water shortages
- Feed shortages
- Poor yielding crops
- Economic instability
- etc

Photo Source: AAFC

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Adaptations to Droughts

- Installation of dams that allow for more stable water supply (e.g., Duncairn Dam)
- Increased irrigation projects (e.g., Waldeck, Rush Lake, Herbert)
- Drought tolerant crops
- Minimum tillage
- Water conservation
- etc

Photo Source: E. Stratton circa 2002
St. Mary's Irrigation District

Photo source: Swift Current Creek Watershed Stewards 2002
Duncairn Dam & Reid Lake

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Impacts from Excess Moisture

- Soil erosion
- Water quality issues (both surface and ground water)
- Degraded crops (crops under water) decreased yield and quality
- Infrastructure problems
- etc

Photo Source: Leader Post June 2010
Highway #1 by Maple Creek

Flooded agricultural land east of Vanguard July 2000 (Hunter et al. 2003 Photo: SWA)

Adaptations to Excess Moisture

- Installation of dams that allow for flood control (e.g., Duncairn Dam)
- Different crops to adapt to diseases and excess moisture conditions
- Minimum tillage
- Re-establishment of riparian zones
- etc

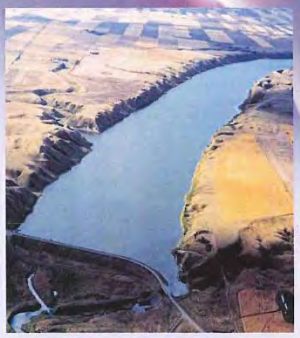

Photo source: Swift Current Creek Watershed Stewards 2002
Duncairn Dam & Reid Lake

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Conclusion and Questions

- Swift Current Creek Watershed has always had extreme events and future ones could be worse…
- **But** the trick is to learn from the past to better adapt to our ever evolving future.
- Many questions can be asked..
  - What if the Vanguard rain event had occurred upstream of the Duncairn Dam?
  - What if 2011 is as wet as 2010?
  - What if we have a 10 year drought, how will we be impacted, how will we adapt?

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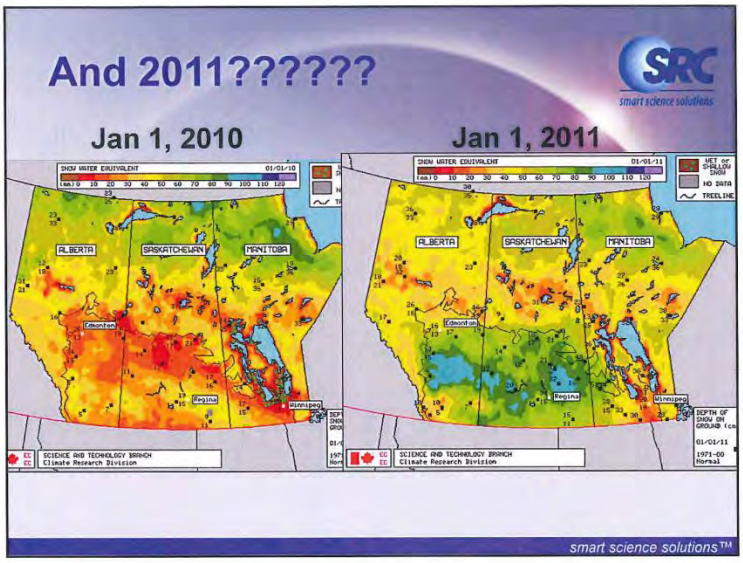
- Temperature and precipitation outlooks: Environment Canada website: http://www.weatheroffice.gc.ca/saisons/index_e.html
- Crop Yields: Ministry of Saskatchewan Agriculture website: http://www.agriculture.gov.sk.ca/rmyields
- Snow Water Equivalent Maps: Environment Canada, Climate Research Division, Science and Technology Branch web site: http://www.ccin.ca/cms/en/socc/currentSnow.aspx
- Photos:
  - Cracked Earth and soil drifts– Agriculture and Agri-Food Canada (AAFC)
  - Tractor stuck photo: Wucher, L. St. Gregor SK Sept 6, 2010
  - Drought and cold stress crop – V. Wittrock Aug 1, 2009
  - Swift Current Creek at Swift Current – Southwest Booster June 17 2010
  - Swift Current Creek – SW TV News June 19, 2010
  - St. Mary's Irrigation District - E. Stratton circa 2002
  - Duncalm Dam & Reid Lake – Swift Current Creek Watershed Stewards 2002
  - Vanguard Flood – Saskatchewan Watershed Authority 2000
  - #1 Highway washout – Leader Post June 2010
  - Rainbow – V. Wittrock May 2009


And 2011??????
SRC
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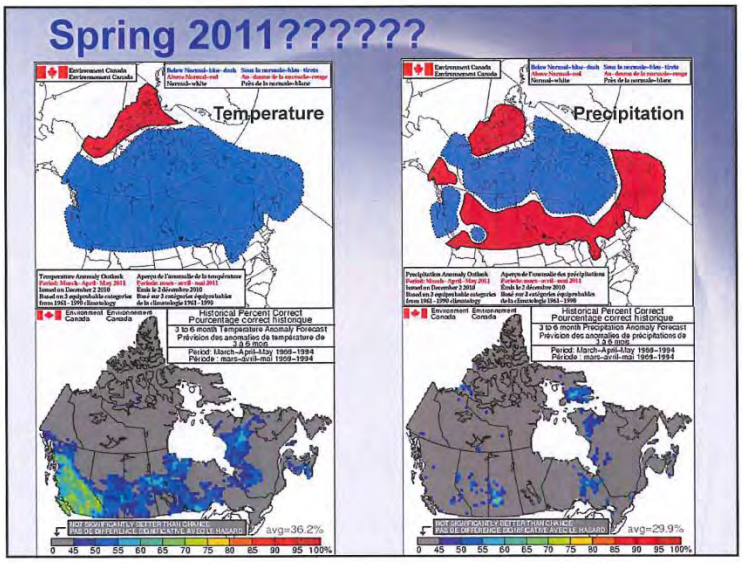
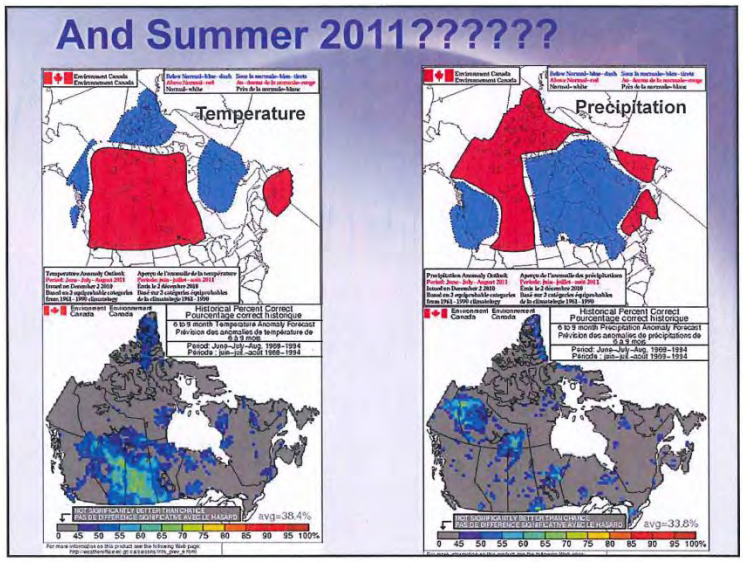
Jan 1, 2010
Jan 1, 2011
ALBERTA
SASKATCHEWAN
MANITOBA
Edmonton
Regina
Winnipeg
Minnipeg
SCIENCE AND TECHNOLOGY BRANCH
Climate Research Division
smart science solutions™


Spring 2011??????
Temperature
Precipitation
Historical Percent Correct
Pourcentage correct historique
3 to 6 month Temperature Anomaly Forecast
Prévision des anomalies de température de 3 à 5 mois
3 to 6 month Precipitation Anomaly Forecast
Prévision des anomalies de précipitations de 3 à 5 mois
Period: March-April-May 1969-1994
Période : mars-avril-mai 1969-1994
avg=36.2%
avg=29.9%


And Summer 2011??????
Temperature
Precipitation
Historical Percent Correct
Pourcentage correct historique
avg=38.4%
avg=33.8%


What next?
SRC
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• Study of 2010 for excessive moisture
• Future drought and excessive moisture
• etc
• Still in the develop process
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Gridded data

- Gridded data sets preferred over station data due to improved spatial/temporal coverage
- Gridding data procedure removes unnecessary noise, resulting in smoother data for mapping
- PDSI and SPI derived from the ANUSPLIN data set
- ANUSPLIN was chosen for ability to capture several significant precipitation events, for better comparability with observed data and for area covered in North America
- Develop data bases of PDSI and SPII for the watersheds (10 KM grid)

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Top 10 extreme years

PDSI Z-Value

(1901-2005 Agriculture Year (Sept to Aug))

Excess Moisture		
Year	Value	Change in Wheat Yield*
1993	9.15	14.0
2002	8.13	-13.7
1954	7.43	-41.0
1951	7.18	-44.6
1974	6.75	-28.4
2004	6.6	21.6
1965	5.67	-16.5
1995	5.66	10.4
1907	5.66	Not available
1989	4.67	5.4

Drought		
Year	Value	Change in Wheat Yield*
1961	-5.23	-77.3
2001	-4.76	-36.7
1971	-4.02	-25.5
2003	-3.85	-16.5
1967	-3.73	-52.2
1984	-3.32	-38.1
1940	-3.27	-55.8
1988	-3.19	-58.3
1930	-3.15	Not available
1901	-3.11	Not available

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Average over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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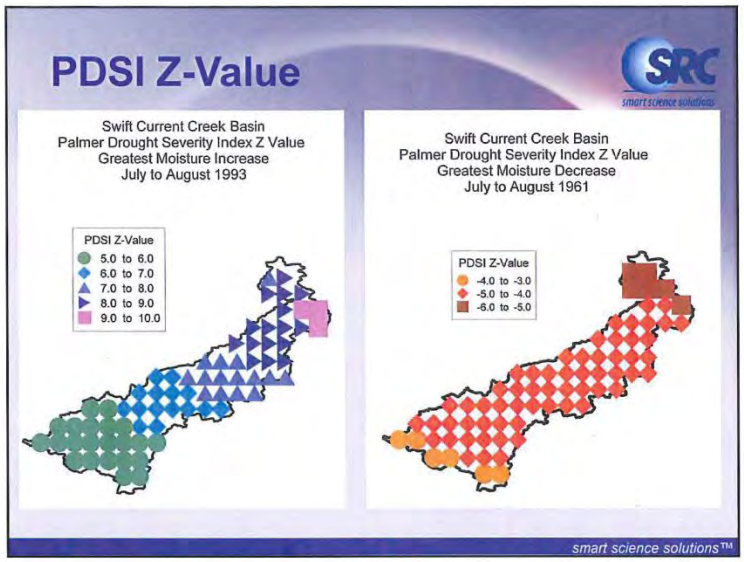

Top 10 most extreme years

SPI – 12 Month (Sept-Aug)(1901-2005)

Excessive Moisture		
Year	Value	Change in Wheat Yield*
2004	2.06	17.4
1965	2.01	-16.5
1927	1.85	Not Available
1974	1.8	-28.4
1991	1.78	18.7
1916	1.78	Not Available
1966	1.72	5.4
1954	1.66	-41.0
1907	1.63	Not Available
1951	1.6	-44.6

Drought		
Year	Value	Change in Wheat Yield*
1937	-2.39	Not Available
1929	-2.38	Not Available
1961	-2.29	-77.3
1984	-2.19	-38.1
1988	-2.13	-58.3
1936	-2.09	Not Available
1949	-2.04	-90.6
1919	-2	Not Available
1914	-1.83	Not Available
1945	-1.82	-79.5

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Average over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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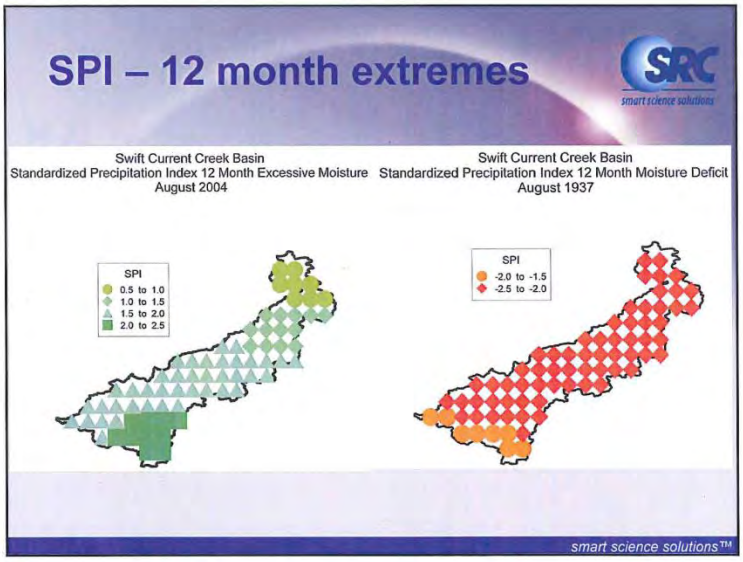
SPI – 12 month extremes
SRC
smart science solutions
Swift Current Creek Basin
Standardized Precipitation Index 12 Month Excessive Moisture
August 2004
SPI
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 2.5
Swift Current Creek Basin
Standardized Precipitation Index 12 Month Moisture Deficit
August 1937
SPI
-2.0 to -1.5
-2.5 to -2.0
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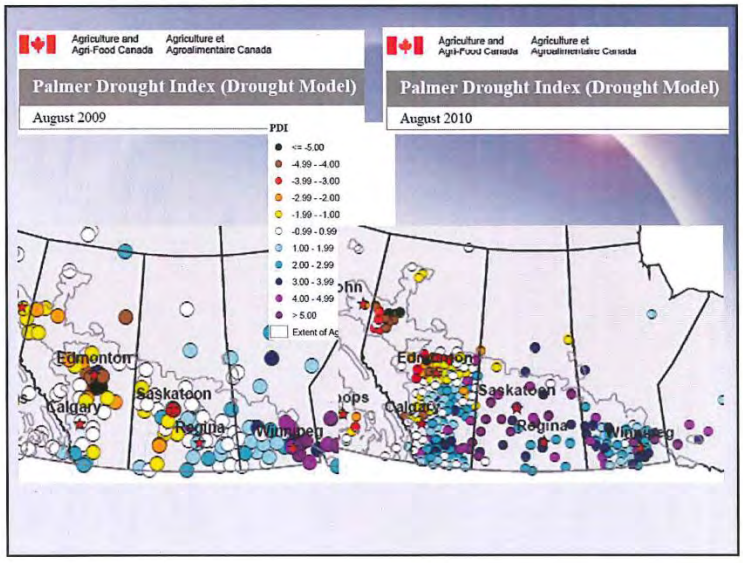
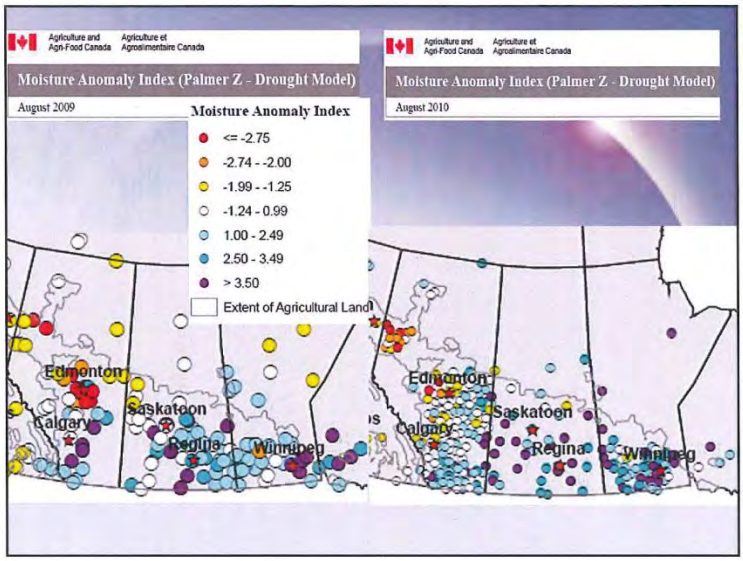
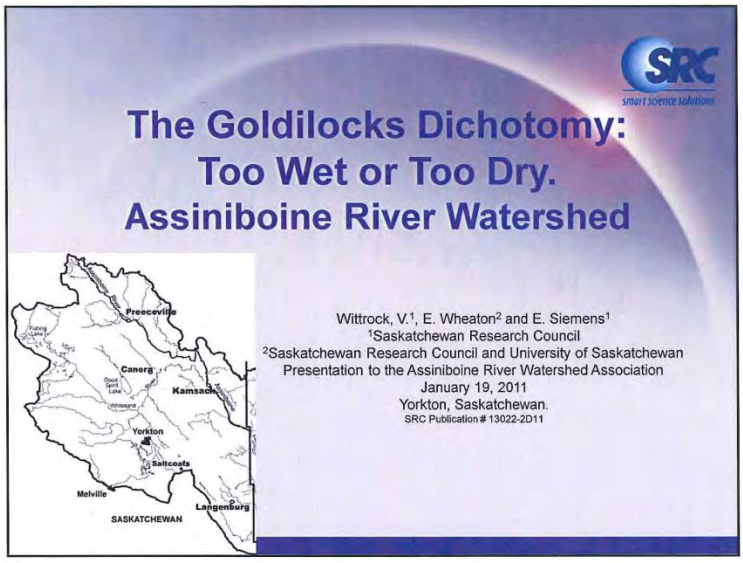

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Palmer Drought Index (Drought Model)
August 2009
PDI
<= -5.00
-4.99 - -4.00
-3.99 - -3.00
-2.99 - -2.00
-1.99 - -1.00
-0.99 - 0.99
1.00 - 1.99
2.00 - 2.99
3.00 - 3.99
4.00 - 4.99
> 5.00
Edmonton
Saskatoon
Calgary
Regina
Winnipeg
Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Palmer Drought Index (Drought Model)
August 2010
Edmonton
Saskatoon
Calgary
Regina
Winnipeg


Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Moisture Anomaly Index (Palmer Z - Drought Model)
August 2009
Moisture Anomaly Index
<= -2.75
-2.74 - -2.00
-1.99 - -1.25
-1.24 - 0.99
1.00 - 2.49
2.50 - 3.49
> 3.50
Extent of Agricultural Land
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Moisture Anomaly Index (Palmer Z - Drought Model)
August 2010
Edmonton
Calgary
Saskatoon
Regina
Winnipeg


SRC
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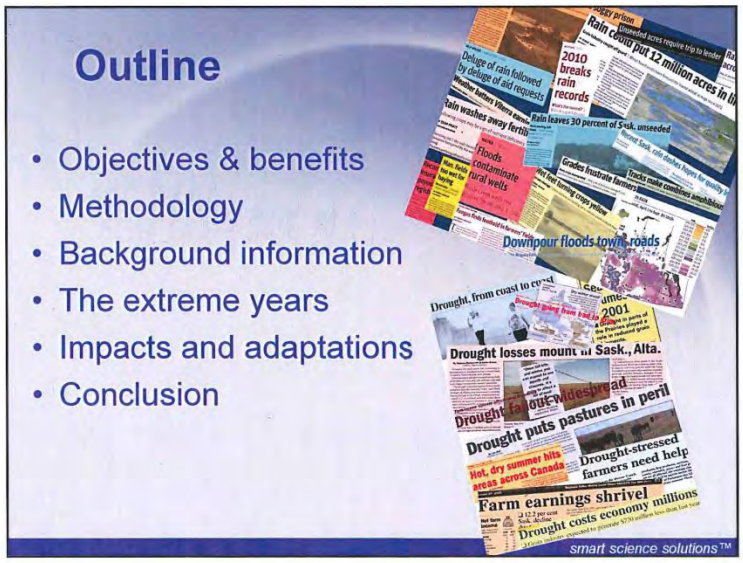
The Goldilocks Dichotomy:
Too Wet or Too Dry.
Assiniboine River Watershed
Preeceville
Canora
Kamsack
Yorkton
Saltcoats
Melville
Langenburg
SASKATCHEWAN
Wittrock, V.[1], E. Wheaton[2] and E. Siemens[1]
[1]Saskatchewan Research Council
[2]Saskatchewan Research Council and University of Saskatchewan
Presentation to the Assiniboine River Watershed Association
January 19, 2011
Yorkton, Saskatchewan.
SRC Publication # 13022-2D11


Outline
• Objectives & benefits
• Methodology
• Background information
• The extreme years
• Impacts and adaptations
• Conclusion
Rain could put 12 million acres in
2010 breaks rain records
Deluge of rain followed by deluge of aid requests
Rain washes away fertil
Rain leaves 30 percent of Sask. unseeded
Floods contaminate rural wells
Downpour floods town, roads
Drought losses mount in Sask., Alta.
2001
Drought puts pastures in peril
Drought-stressed farmers need help
Hot, dry summer hits areas across Canada
Farm earnings shrivel
Drought costs economy millions
smart science solutions™


Objectives
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• To characterize drought and excessive moisture events for selected watersheds during the past century.
• Compare and contrast driest and wettest patterns to help determine characteristics for risk assessments and planning.
• Consider the implications for impacts and adaptations directly related to the watershed.
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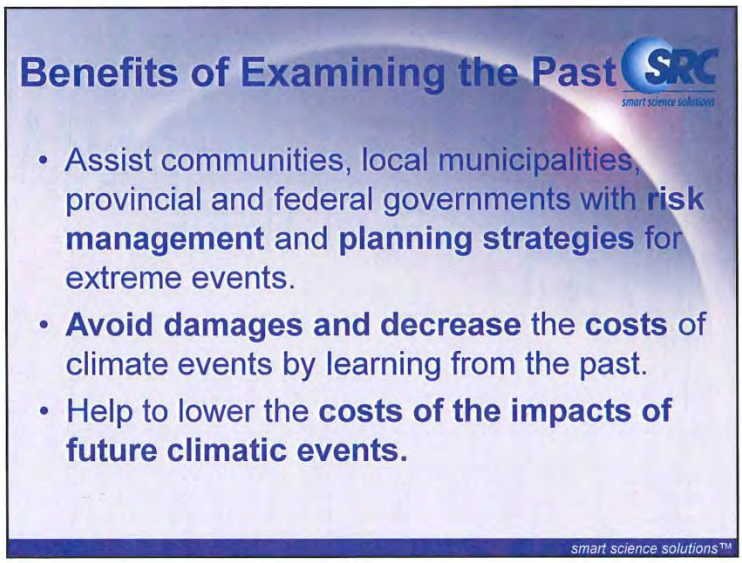
Benefits of Examining the Past
SRC
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• Assist communities, local municipalities, provincial and federal governments with risk management and planning strategies for extreme events.
• Avoid damages and decrease the costs of climate events by learning from the past.
• Help to lower the costs of the impacts of future climatic events.
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What is a Drought?

- A deficiency of precipitation from expected or "normal" that, when extended over a season or longer, is insufficient to meet the demands of human activities and the environment
- Four major types of drought including Meteorological, Agricultural, Hydrological and Socio-economic

• Or when it hasn't rained, the fields are dry, the lakes or rivers are really low and it impacts the economy, environment and our way of life

Photo: AAFC

What is Excessive Moisture?

- An excess of precipitation from expected or "normal" that, when extended over a season or longer, is too much to meet the demands of human activities and the environment
- Four major types of excess moisture including Meteorological, Agricultural, Hydrological and Socio-economic

• Or it won't quit raining, the fields are saturated, the lakes or rivers are over flowing their banks and it impacts the economy, environment and our way of life.

Photo: Wucher, L. St. Gregor SK Sept 6, 2010

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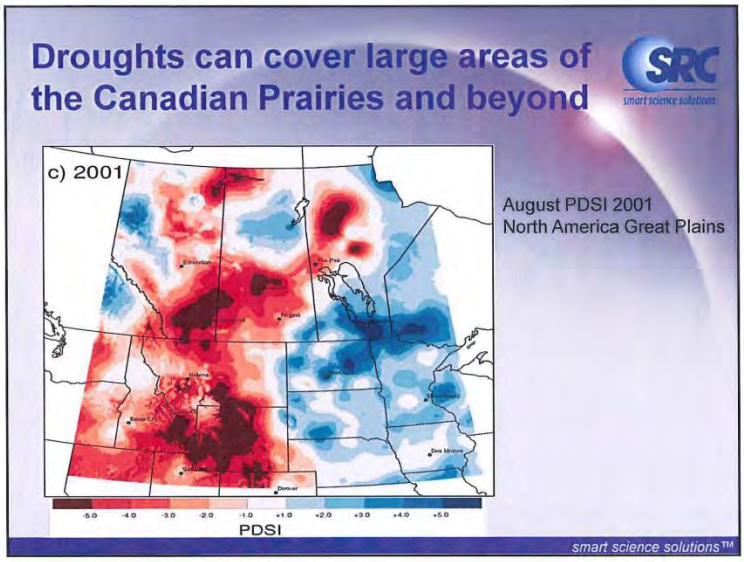
Droughts can cover large areas of the Canadian Prairies and beyond
SRC
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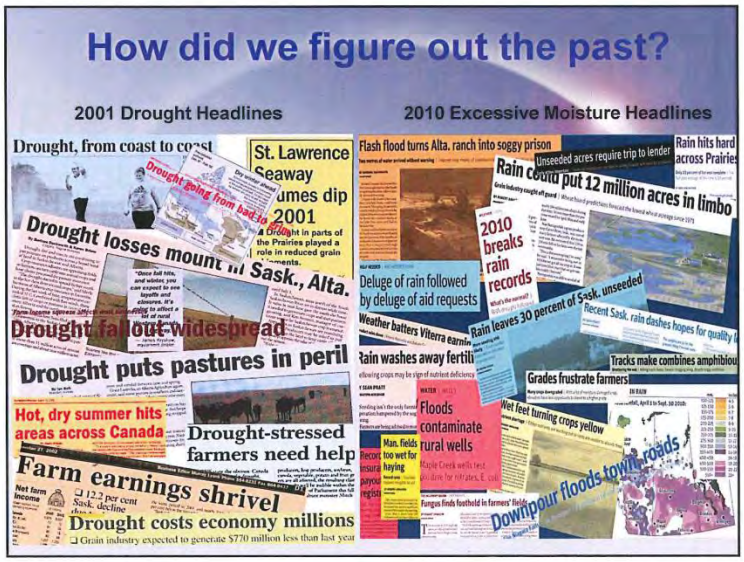
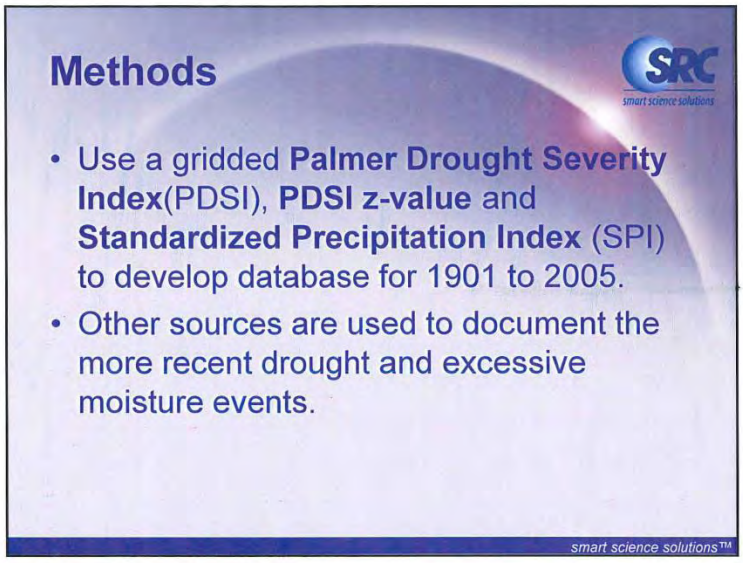
c) 2001
August PDSI 2001
North America Great Plains
-5.0 -4.0 -3.0 -2.0 -1.0 +1.0 +2.0 +3.0 +4.0 +5.0
PDSI
smart science solutions™


How did we figure out the past?
2001 Drought Headlines
2010 Excessive Moisture Headlines
Drought, from coast to coast
Drought losses mount in Sask., Alta.
Drought fallout widespread
Drought puts pastures in peril
Hot, dry summer hits areas across Canada
Drought-stressed farmers need help
Farm earnings shrivel
Drought costs economy millions
Flash flood turns Alta. ranch into soggy prison
Rain could put 12 million acres in limbo
2010 breaks rain records
Deluge of rain followed by deluge of aid requests
Rain leaves 30 percent of Sask. unseeded
Rain washes away fertil
Floods contaminate rural wells
Wet feet turning crops yellow
Downpour floods town roads
Grades frustrate farmers


Methods
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• Use a gridded Palmer Drought Severity Index(PDSI), PDSI z-value and Standardized Precipitation Index (SPI) to develop database for 1901 to 2005.
• Other sources are used to document the more recent drought and excessive moisture events.
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Methods continued
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• Rank the 10 driest and 10 wettest years in the watershed
• Spatial variability is determined from these rankings.
• Literature review and media analysis to determine the impacts and adaptation strategies undertaken
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How do we classify severe drought, excessive moisture or average conditions?

Source: V. Wittrock Aug 1 2009
Drought & cold stressed crop (short & thin)
(SouthWest Sask)

Source: Calgary Herald July 1 2010
Major flooding in Yorkton

Palmer Drought Severity Index (PDSI)

- One of the most widely used drought and excessive moisture indices
- Primarily a hydrological drought index
- Derived using a soil moisture/water balance model which requires information on the available soil water content along with daily/monthly precipitation and temperature data
- Value contain a long term memory of the previous moisture conditions because the calculated value.

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What do PDSI values mean?

Classification		PDSI Value
Drought	Exceptional	≤ -5
	Extreme	> -5.0 to -4.0
	Severe	> -4.0 to -3.0
	Moderate	> -3.0 to -2.0
	Mild	> -2.0 to -1.0
Near Normal		> -1.0 to 1.0
Wet	Mild	1.0 to < 2.0
	Moderate	2.0 to < 3.0
	Severe	3.0 to < 4.0
	Extreme	4.0 to < 5.0
	Exceptional	≥ 5.0

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Top 10 Extreme Years and Wheat Yields

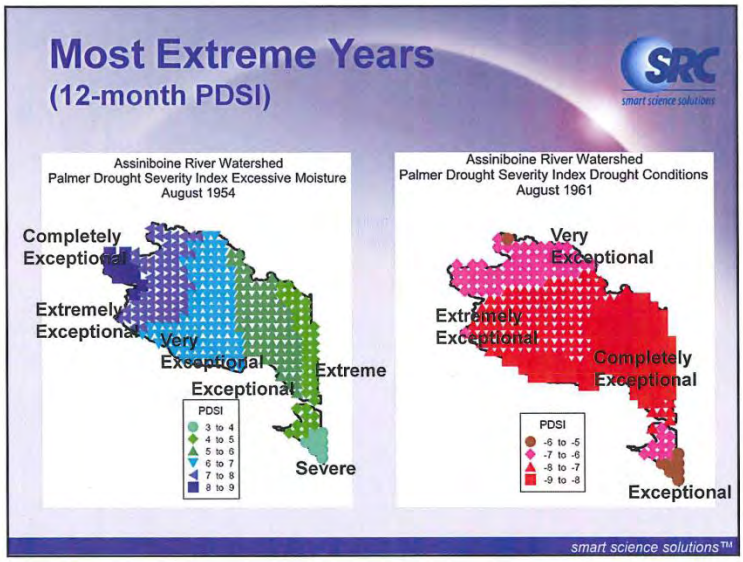
Palmer Drought Severity Index for the Assiniboine River Watershed
(1901-2005 Agriculture Year(Sept to Aug))

Excessive Moisture		
Year	Value	Change in Wheat Yield*
1954	8.4	-71.3
1995	6.1	-15.8
1996	5.9	-6.1
1993	5.6	-29.2
2005	5.5	9.9
1953	5.3	-24.3
1950	5.3	-38.6
1994	5.1	-19.0
1942	5.0	-20.8
1966	4.8	-11.7

Drought		
Year	Value	Change in Wheat Yield*
1961	-8.7	-80.1
1941	-7.0	-55.0
1958	-5.8	-41.8
1984	-5.8	-18.1
1915	-5.7	Not Available
1959	-5.6	-30.1
1937	-5.5	Not Available
1931	-5.4	Not Available
1944	-5.3	-33.3
1934	-5.2	Not Available

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Averaged over entire watershed

Wheat Yield data:
SK Ministry of Agriculture


Most Extreme Years
(12-month PDSI)
SRC
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Assiniboine River Watershed
Palmer Drought Severity Index Excessive Moisture
August 1954
Completely Exceptional
Extremely Exceptional
Very Exceptional
Exceptional
Extreme
Severe
PDSI
3 to 4
4 to 5
5 to 6
6 to 7
7 to 8
8 to 9
Assiniboine River Watershed
Palmer Drought Severity Index Drought Conditions
August 1961
Very Exceptional
Extremely Exceptional
Completely Exceptional
Exceptional
PDSI
-6 to -5
-7 to -6
-8 to -7
-9 to -8
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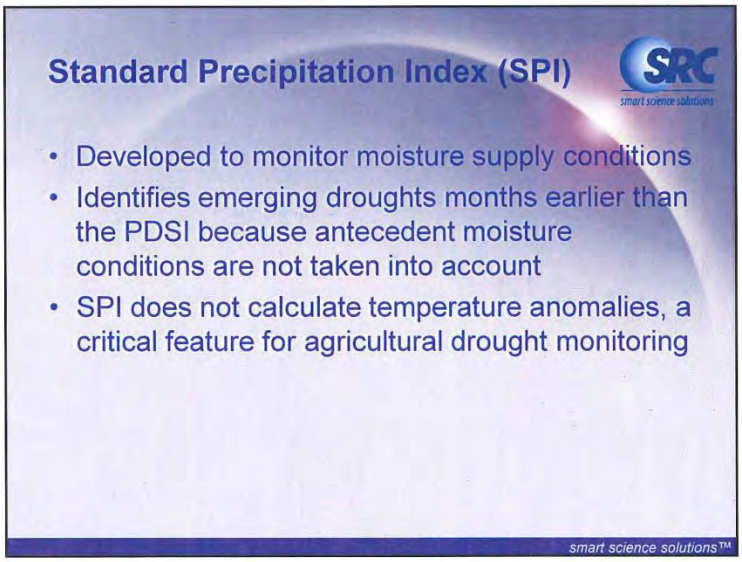
Standard Precipitation Index (SPI)
SRC
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• Developed to monitor moisture supply conditions
• Identifies emerging droughts months earlier than the PDSI because antecedent moisture conditions are not taken into account
• SPI does not calculate temperature anomalies, a critical feature for agricultural drought monitoring
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What do SPI values mean?

Classification		SPI Value
Drought	Exceptional	≤ -2.5
	Extreme	> -2.5 to -2.0
	Severe	> -2.0 to -1.5
	Moderate	> -1.5 to -1.0
	Mild	> -1.0 to -0.5
Near Normal		> -0.5 to 0.5
Wet	Mild	0.5 to < 1.0
	Moderate	1.0 to < 1.5
	Severe	1.5 to < 2.0
	Extreme	2.0 to < 2.5
	Exceptional	≥ 2.5

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Top 10 - 1 Month Extremes Standardized Precipitation Index (1901-2005)

Excessive Moisture			
Year	Month	Value	Change in Wheat Yield*
1975	April	3.2	-28.4
1996	July	3.2	-6.1
1983	July	2.9	-23.1
1995	August	2.9	-15.8
2002	August	2.9	-16.7
1969	Sept	2.9	-10.2
1965	Sept	2.9	-25.1
1909	July	2.8	Not Available
1926	Oct	2.8	Not Available
1970	Oct	2.7	-22.5

Drought			
Year	Month	Value	Change in Wheat Yield*
1971	May	-4.5	-12.3
1980	April	-4.0	-32.5
1961	Aug	-4.0	-80.1
1924	May	-3.9	Not Available
1913	Dec	-3.9	Not Available
1973	Jan	-3.7	-20.8
1992	Mar	-3.5	-24.9
1981	Nov	-3.4	1.5
1925	Dec	-3.4	Not Available
1985	July	-3.2	1.8

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Averaged over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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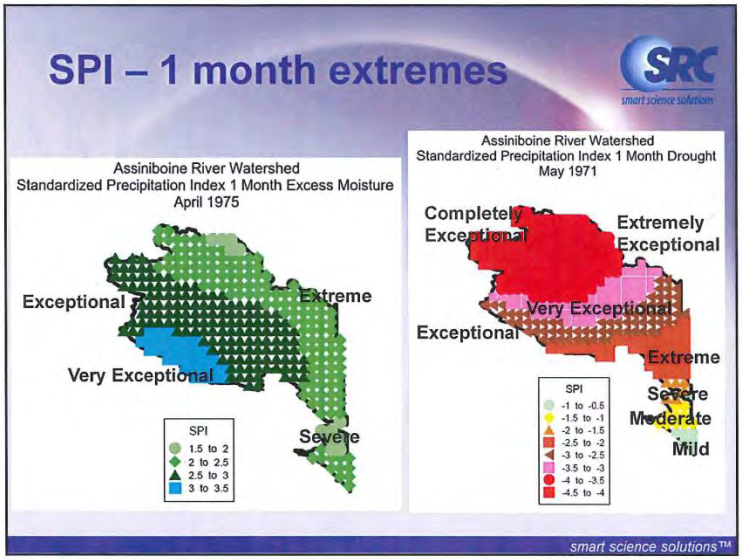
SPI – 1 month extremes
SRC
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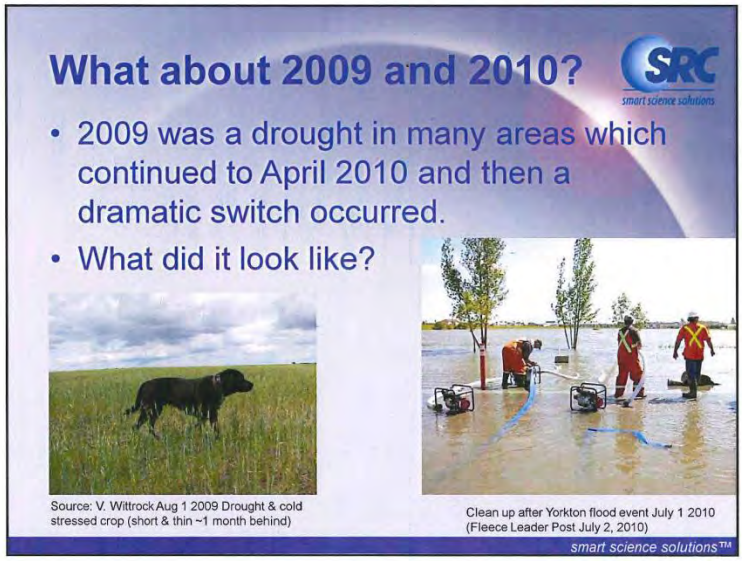
Assiniboine River Watershed
Standardized Precipitation Index 1 Month Excess Moisture
April 1975
Exceptional
Extreme
Very Exceptional
Severe
SPI
1.5 to 2
2 to 2.5
2.5 to 3
3 to 3.5
Assiniboine River Watershed
Standardized Precipitation Index 1 Month Drought
May 1971
Completely Exceptional
Extremely Exceptional
Very Exceptional
Exceptional
Extreme
Severe
Moderate
Mild
SPI
-1 to -0.5
-1.5 to -1
-2 to -1.5
-2.5 to -2
-3 to -2.5
-3.5 to -3
-4 to -3.5
-4.5 to -4
smart science solutions™


What about 2009 and 2010?
SRC
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• 2009 was a drought in many areas which continued to April 2010 and then a dramatic switch occurred.
• What did it look like?
Source: V. Wittrock Aug 1 2009 Drought & cold stressed crop (short & thin ~1 month behind)
Clean up after Yorkton flood event July 1 2010
(Fleece Leader Post July 2, 2010)
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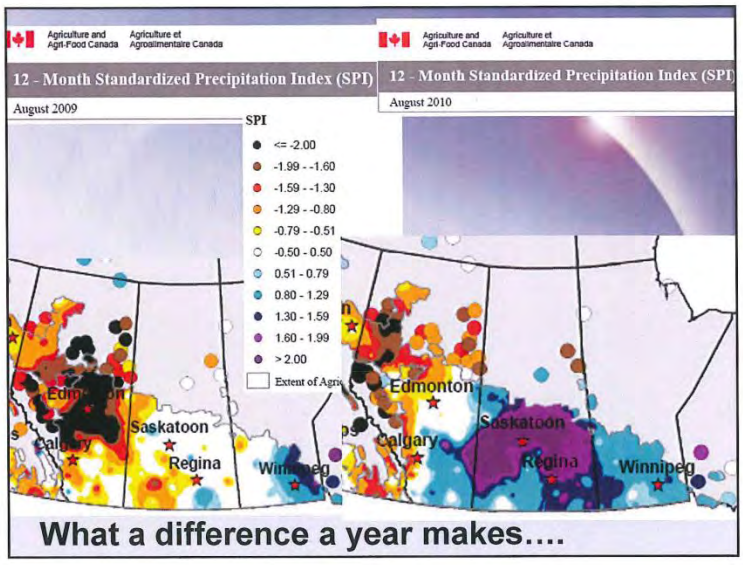
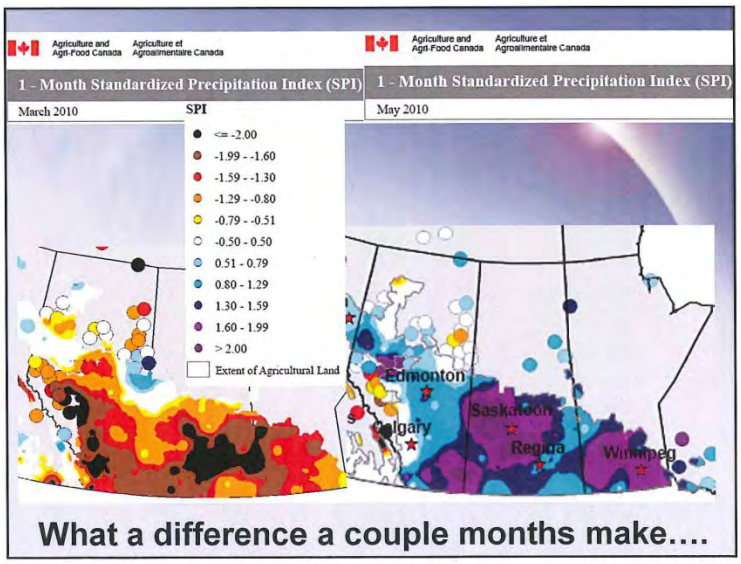

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
12 - Month Standardized Precipitation Index (SPI)
August 2009
SPI
<= -2.00
-1.99 - -1.60
-1.59 - -1.30
-1.29 - -0.80
-0.79 - -0.51
-0.50 - 0.50
0.51 - 0.79
0.80 - 1.29
1.30 - 1.59
1.60 - 1.99
> 2.00
Saskatoon
Regina
12 - Month Standardized Precipitation Index (SPI)
August 2010
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
What a difference a year makes….


Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
1 - Month Standardized Precipitation Index (SPI)
March 2010
SPI
<= -2.00
-1.99 - -1.60
-1.59 - -1.30
-1.29 - -0.80
-0.79 - -0.51
-0.50 - 0.50
0.51 - 0.79
0.80 - 1.29
1.30 - 1.59
1.60 - 1.99
> 2.00
Extent of Agricultural Land
1 - Month Standardized Precipitation Index (SPI)
May 2010
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
What a difference a couple months make….

These Extreme Years have Impacted Everyone and Adaptation Strategies have been Applied

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Impacts from Droughts

- Soil erosion
- Water shortages
- Feed shortages
- Poor yielding crops
- Economic instability
- etc

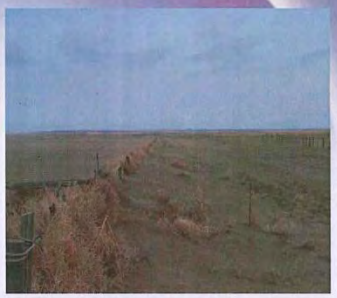

Photo Source: AAFC

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Adaptations to Droughts

- Installation of weirs/dams that allow for more stable water supply(e.g.,Canora Weir, Kamsack Weir)
- Increased irrigation projects
- Drought tolerant crops
- Minimum tillage
- Water conservation
- etc

Photo Source: E. Stratton circa 2002
St. Mary's Irrigation District

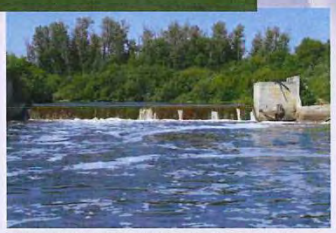

Photo source: Assiniboine Watershed Stewardship Association
Canora Weir

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Impacts from Excessive Moisture

- Soil erosion
- Water quality issues (both surface and ground water
- Degraded crops (crops under water) decreased yield and quality
- Infrastructure problems (e.g., roads, basements)
- etc

Assiniboine River down stream of Kamsack Oct 5, 2010
Source: Assiniboine Watershed Stewardship Association

Whitesand River Flooding Spring 2010
Source: Assiniboine Watershed Stewardship Association

Adaptations to Excessive Moisture

- Installation of dams that allow for flood control (e.g., Yorkton South Project)
- Different crops to adapt to diseases and excess moisture conditions
- Minimum tillage
- Re-establishment of riparian zones
- etc

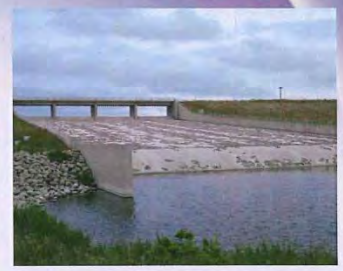

Photo source: Assiniboine Watershed Stewardship Association
Shellmouth Dam

Conclusion and Questions

- Assiniboine River Watershed has always had extreme events and future ones could be worse…
- **But** the trick is to learn from the past to better adapt to our ever evolving future.
- There are still many questions to be asked,
  - What if 2011 is as wet as 2010?
  - Changing infrastructure to accommodate excessive moisture occurrences e.g., Yorkton 2010 rainstorm?
  - What if we have a 10 year drought, how will we be impacted and will we be able to adapt?

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References

- Assiniboine River Watershed Map: Harrison, B., D. Johnson and B. Oegema. 2000. Upper Assiniboine River Basin Study. Appendix A Drainage and Flood Control Committee Report. Saskatchewan Watershed Authority and Manitoba Conservation. 233 pp.
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- Drought Collage: Wheaton, E., with V. Wittrock, S. Kulshreshtha, G. Koshida, C. Grant, A. Chipanshi, B. Bonsal, with the rest of the Canadian Drought Study Steering Committee, P. Adkins, G. Bell, G. Brown, A. Howard and R. MacGregor. 2005. *Lessons Learned from the Canadian Drought Years of 2001 and 2002: Synthesis Report*. Saskatchewan Research Council (SRC) Publication No. 11602-46E03. 30 pp.
- 2010 Excessive Moisture Collage: Created by C. Beaulieu Jan 2011
- PDSI 2001 map: Bonsal, B., E. Wheaton, and E. Siemens. 2010 July. *Characterizing the Surface Dynamics of Canadian Prairie Droughts*. Environment Canada, Saskatchewan Research Council. Water 2010: Hydrology, Hydraulics, and Water Resources in an Uncertain Environment, Quebec City, Quebec, July 5-7, 2010. SRC Publication No. 11602-3D10. 28 slides.
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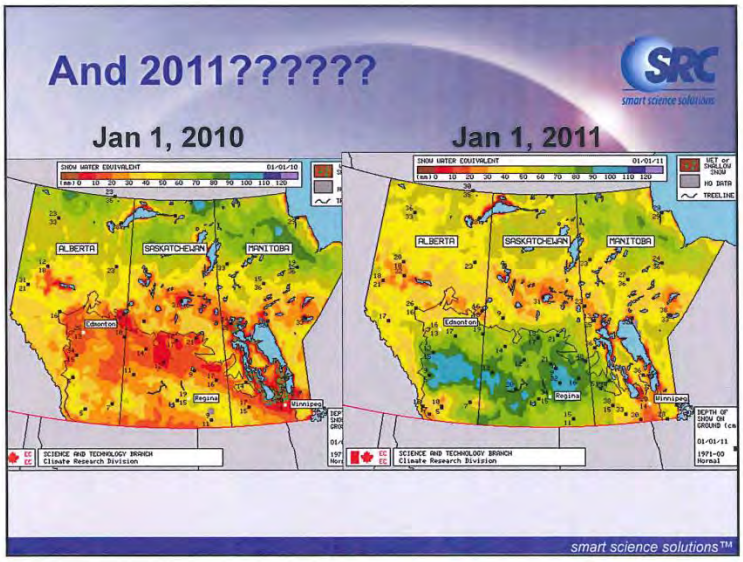
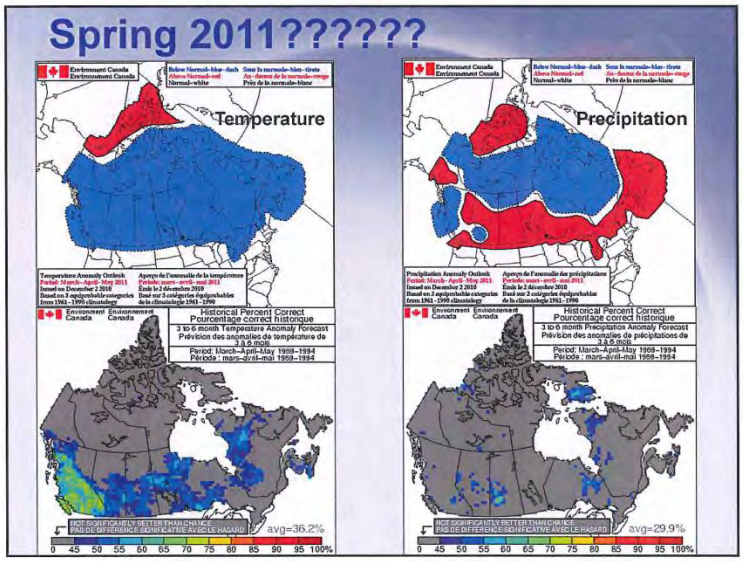
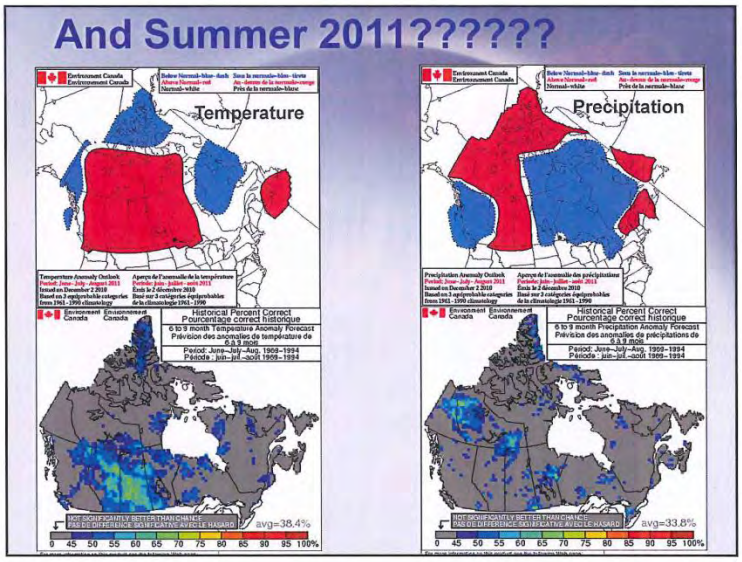
- Temperature and precipitation outlooks: Environment Canada website: http://www.weatheroffice.gc.ca/saisons/index_e.html
- Crop Yields: Ministry of Saskatchewan Agriculture website: http://www.agriculture.gov.sk.ca/rmyields
- Snow Water Equivalent Maps: Environment Canada, Climate Research Division, Science and Technology Branch web site: http://www.ccin.ca/cms/en/socc/currentSnow.aspx
- Photos:
  - Cracked Earth and soil drifts– Agriculture and Agri-Food Canada (AAFC)
  - Tractor stuck: Wucher, L. St. Gregor SK Sept 6 2010
  - Drought and cold stress crop – V. Wittrock Aug 1, 2009 Neidpath
  - Yorkton Flooding – July 1, 2010 Calgary Herald photo
  - Yorkton city workers – T. Fleece July 2 2010 Leader Post http://www.leaderpost.com/news/photos/Yorkton+flooding/3228015/story.html
  - Assiniboine River Photos – Assiniboine Watershed Stewardship Association http://www.assiniboinewatershed.com/index.php?option=com_expose&Itemid=43
  - Rainbow – V. Wittrock May 2009 Martensville


And 2011?????
SRC
smart science solutions
Jan 1, 2010
Jan 1, 2011
ALBERTA
SASKATCHEWAN
MANITOBA
Edmonton
Regina
Winnipeg
SCIENCE AND TECHNOLOGY BRANCH
Climate Research Division
smart science solutions™


Spring 2011??????
Temperature
Precipitation
Historical Percent Correct
Pourcentage correct historique
avg=36.2%
avg=29.9%


And Summer 2011??????
Temperature
Precipitation
Historical Percent Correct
Pourcentage correct historique
Period: June–July–Aug. 1969–1994
Période : juin–juil.–août 1969–1994
avg=38.4%
avg=33.8%


What next?
SRC
smart science solutions
• Study of 2010 for excessive moisture
• Future drought and excessive moisture
• etc
• Still in the develop process
smart science solutions™

Gridded data

- Gridded data sets preferred over station data due to improved spatial/temporal coverage
- Gridding data procedure removes unnecessary noise, resulting in smoother data for mapping
- PDSI and SPI derived from the ANUSPLIN data set
- ANUSPLIN was chosen for ability to capture several significant precipitation events, for better comparability with data and for area covered
- Develop data bases of PDSI and SPII for the watersheds (10 KM grid)

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Top 10 most extreme years
PDSI Z-Value
(1901-2005 Agriculture Year (Sept to Aug))

Excess Moisture		
Year	Value	Change in Wheat Yield*
2002	9.86	-16.7
1995	9.07	-15.8
1942	8.54	-20.8
1985	8.5	1.8
2005	7.75	9.9
1993	6.57	-29.2
1975	6.28	-28.4
1954	5.99	-71.3
1968	5.69	-34.2
1966	5.59	-11.7

Drought		
Year	Value	Change in Wheat Yield*
1961	-6.48	-80.1
1984	-4.86	-18.1
2001	-4.79	-12.6
2003	-4.59	-5.8
1929	-4.54	Not available
1936	-4.34	Not available
1967	-4.04	-49.1
1972	-3.85	-26.0
1930	-3.79	Not available
1960	-3.79	-31.9

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Average over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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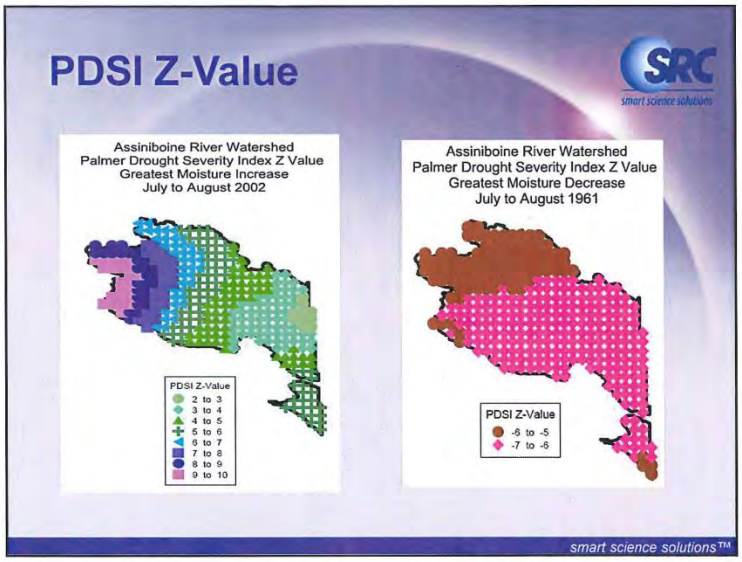

Top 10 most extreme years
SPI – 12 Month (Sept-Aug)(1901-2005)

SRC smart science solutions

Excess Moisture		
Year	Value	Change in Wheat Yield*
1954	2.4	-71.3
1953	2.2	-24.3
1942	2.03	-20.8
1995	2.03	-15.8
1993	2.02	-29.2
1927	1.81	Not Available
1921	1.81	Not Available
1970	1.74	-22.5
2005	1.73	9.9
2004	1.71	-14.3

Drought		
Year	Value	Change in Wheat Yield*
1961	-4.61	-80.1
1929	-2.76	Not Available
1967	-2.54	-49.1
1958	-2.44	-41.8
1914	-2.33	Not Available
1924	-2.3	Not Available
1940	-2.26	-58.5
1936	-2.16	Not Available
1977	-2.06	-17.3
1934	-2.05	Not Available

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Average over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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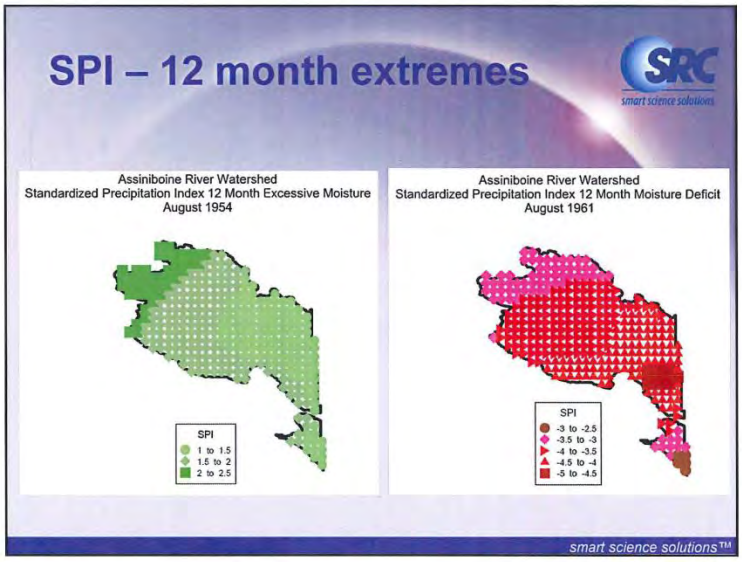
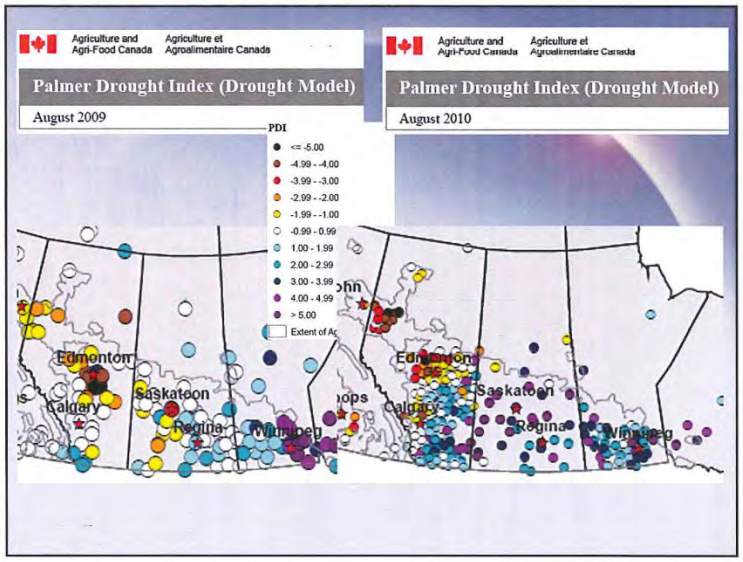
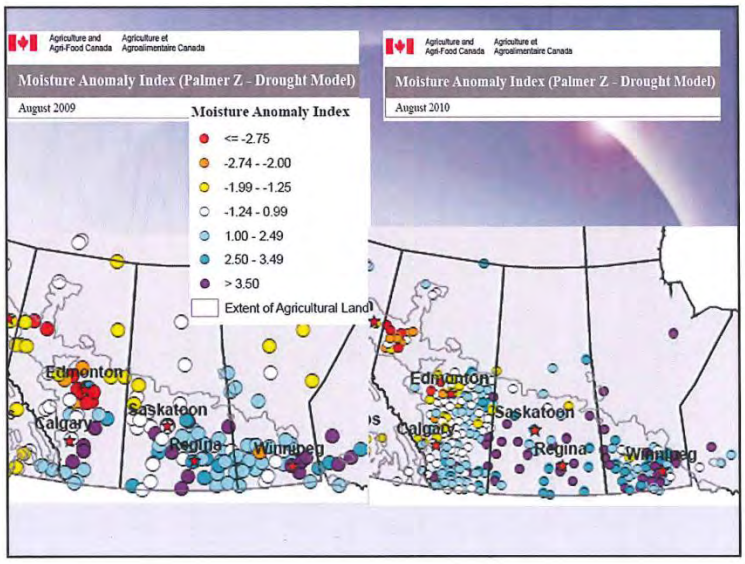
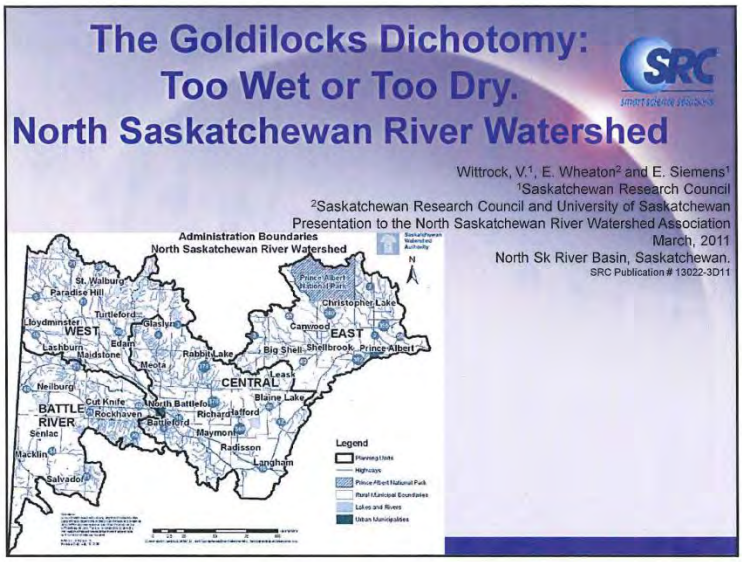

SPI – 12 month extremes
SRC
smart science solutions
Assiniboine River Watershed
Standardized Precipitation Index 12 Month Excessive Moisture
August 1954
SPI
1 to 1.5
1.5 to 2
2 to 2.5
Assiniboine River Watershed
Standardized Precipitation Index 12 Month Moisture Deficit
August 1961
SPI
-3 to -2.5
-3.5 to -3
-4 to -3.5
-4.5 to -4
-5 to -4.5
smart science solutions™


Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Palmer Drought Index (Drought Model)
August 2009
PDI
<= -5.00
-4.99 - -4.00
-3.99 - -3.00
-2.99 - -2.00
-1.99 - -1.00
-0.99 - 0.99
1.00 - 1.99
2.00 - 2.99
3.00 - 3.99
4.00 - 4.99
> 5.00
Edmonton
Saskatoon
Calgary
Regina
Winnipeg
Palmer Drought Index (Drought Model)
August 2010
Edmonton
Saskatoon
Calgary
Regina
Winnipeg


Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Moisture Anomaly Index (Palmer Z - Drought Model)
August 2009
Moisture Anomaly Index
<= -2.75
-2.74 - -2.00
-1.99 - -1.25
-1.24 - 0.99
1.00 - 2.49
2.50 - 3.49
> 3.50
Extent of Agricultural Land
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Moisture Anomaly Index (Palmer Z - Drought Model)
August 2010
Edmonton
Saskatoon
Calgary
Regina
Winnipeg


The Goldilocks Dichotomy:
Too Wet or Too Dry.
North Saskatchewan River Watershed
Wittrock, V.[1], E. Wheaton[2] and E. Siemens[1]
[1]Saskatchewan Research Council
[2]Saskatchewan Research Council and University of Saskatchewan
Presentation to the North Saskatchewan River Watershed Association
March, 2011
North Sk River Basin, Saskatchewan.
SRC Publication # 13022-3D11
Administration Boundaries
North Saskatchewan River Watershed
St. Walburg
Paradise Hill
Turtleford
Loydminster
WEST
Glaslyn
Lashburn
Maidstone
Edam
Meota
Rabbit Lake
Big Shell
Shellbrook
Christopher Lake
Canwood
EAST
Prince Albert
CENTRAL
Blaine Lake
Neilburg
Cut Knife
Rockhaven
North Battleford
Battleford
Richard Telford
BATTLE
RIVER
Senlac
Maymont
Radisson
Langham
Macklin
Salvador
Legend


Outline
• Objectives & benefits
• Methodology
• Background information
• The extreme years
• Impacts and adaptations
• Conclusion
Deluge of rain followed by deluge of aid requests
2010 breaks rain records
Rain washes away fertil
Rain leaves 30 percent of Sask. unseeded
Floods contaminate rural wells
Downpour floods town roads
Drought losses mount in Sask., Alta.
province-wide drought
Drought puts pastures in peril
Hot, dry summer hits areas across Canada
Drought-stressed farmers need help
Farm earnings shrivel
Drought costs economy millions
smart science solutions™


Objectives
SRC
• To characterize drought and excessive moisture events for selected watersheds during the past century.
• Compare and contrast driest and wettest patterns to help determine characteristics for risk assessments and planning.
• Consider the implications for impacts and adaptations directly related to the watershed.
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Benefits of Examining the Past
SRC
• Assist communities, local municipalities, provincial and federal governments with risk management and planning strategies for extreme events.
• Avoid damages and decrease the costs of climate events by learning from the past.
• Help to lower the costs of the impacts of future climatic events.
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What is a Drought?

- A deficiency of precipitation from expected or "normal" that, when extended over a season or longer, is insufficient to meet the demands of human activities and the environment
- Four major types of drought including Meteorological, Agricultural, Hydrological and Socio-economic

- Or when it hasn't rained, the fields are dry, the lakes or rivers are really low and it impacts the economy, environment and our way of life

Photo: AAFC

What is Excessive Moisture?

- An excess of precipitation from expected or "normal" that, when extended over a season or longer, is too much to meet the demands of human activities and the environment
- Four major types of excess moisture including Meteorological, Agricultural, Hydrological and Socio-economic

- Or it won't quit raining, the fields are saturated, the lakes or rivers are over flowing their banks and it impacts the economy, environment and our way of life.

Photo: Wucher, L. St. Gregor SK Sept 6, 2010

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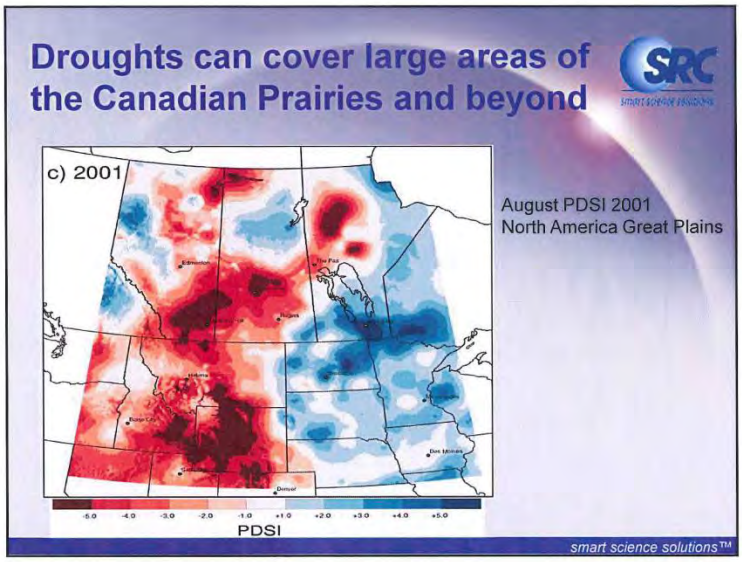
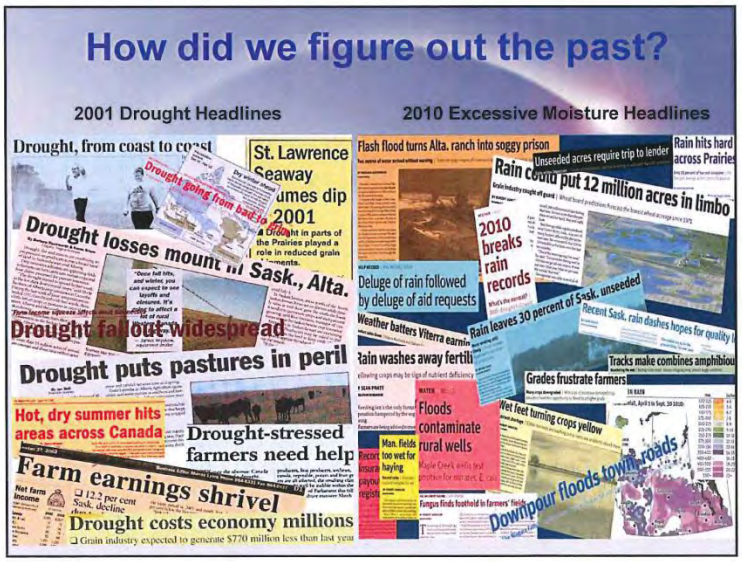
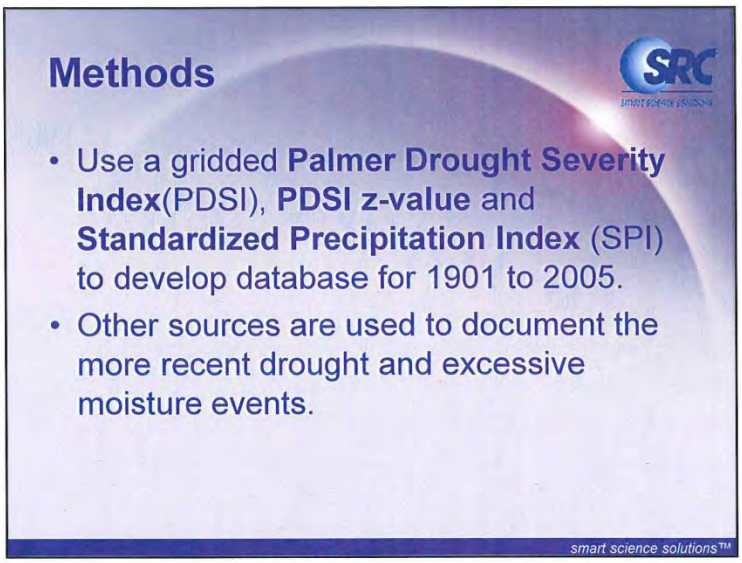

Droughts can cover large areas of the Canadian Prairies and beyond
SRC
c) 2001
August PDSI 2001
North America Great Plains
-5.0 -4.0 -3.0 -2.0 -1.0 +1.0 +2.0 +3.0 +4.0 +5.0
PDSI
smart science solutions™


How did we figure out the past?
2001 Drought Headlines
2010 Excessive Moisture Headlines
Drought, from coast to coast
Drought losses mount in Sask., Alta.
Drought fallout widespread
Drought puts pastures in peril
Hot, dry summer hits areas across Canada
Drought-stressed farmers need help
Farm earnings shrivel
Drought costs economy millions
Flash flood turns Alta. ranch into soggy prison
Rain could put 12 million acres in limbo
2010 breaks rain records
Deluge of rain followed by deluge of aid requests
Rain leaves 30 percent of Sask. unseeded
Rain washes away fertili
Floods contaminate rural wells
Wet feet turning crops yellow
Downpour floods town roads
Tracks make combines amphibious
Grades frustrate farmers


Methods
SRC
• Use a gridded **Palmer Drought Severity Index**(PDSI), **PDSI z-value** and **Standardized Precipitation Index** (SPI) to develop database for 1901 to 2005.
• Other sources are used to document the more recent drought and excessive moisture events.
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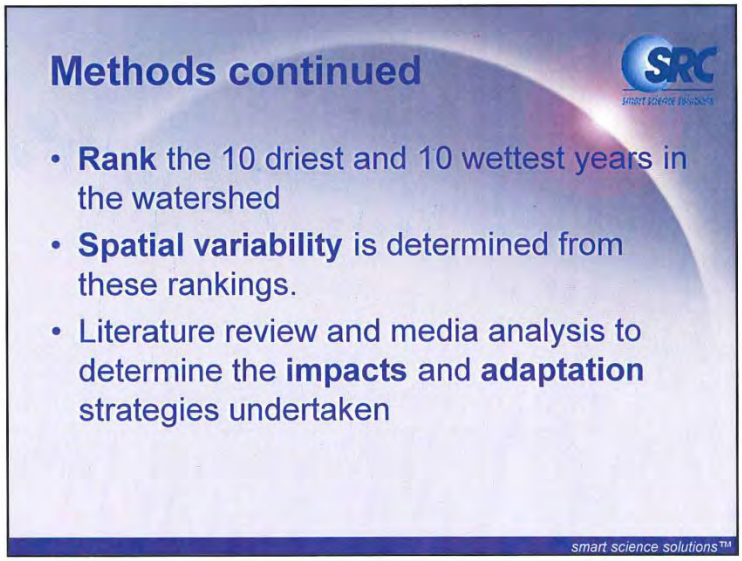
Methods continued
SRC
• **Rank** the 10 driest and 10 wettest years in the watershed
• **Spatial variability** is determined from these rankings.
• Literature review and media analysis to determine the **impacts** and **adaptation** strategies undertaken
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How do we classify severe drought, excessive moisture or average conditions?

Source: V. Wittrock Aug 1 2009
Drought & cold stressed crop (short & thin) (SouthWest Sask)

Source: Booth Leader Post
July 22, 2010 Rain/Hail Event over City of North Battleford

Palmer Drought Severity Index (PDSI)

- One of the most widely used drought and excessive moisture indices
- Primarily a hydrological drought index
- Derived using a soil moisture/water balance model which requires information on the available soil water content along with daily/monthly precipitation and temperature data
- Value contain a long term memory of the previous moisture conditions because the calculated value.

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What do PDSI values mean?

Classification		PDSI Value
Drought	Exceptional	≤ -5
	Extreme	> -5.0 to -4.0
	Severe	> -4.0 to -3.0
	Moderate	> -3.0 to -2.0
	Mild	> -2.0 to -1.0
Near Normal		> -1.0 to 1.0
Wet	Mild	1.0 to < 2.0
	Moderate	2.0 to < 3.0
	Severe	3.0 to < 4.0
	Extreme	4.0 to < 5.0
	Exceptional	≥ 5.0

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Top 10 Extreme Years and Wheat Yields

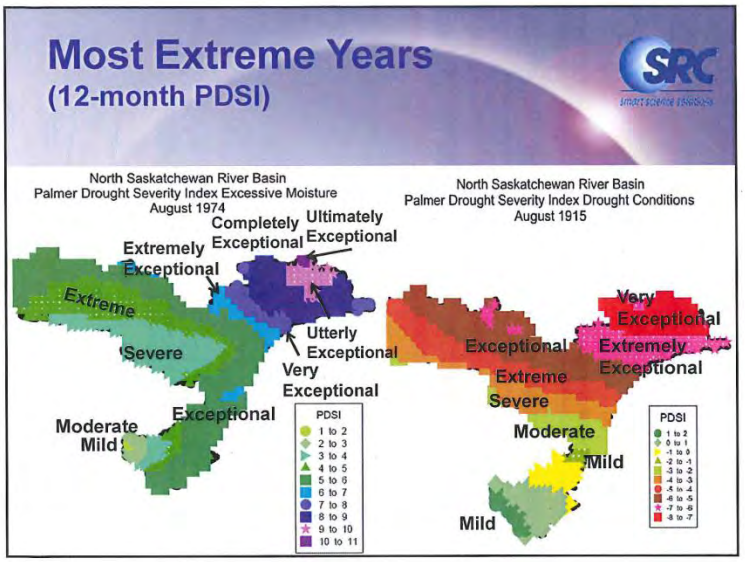
Palmer Drought Severity Index for the Assiniboine River Watershed
(1901-2005 Agriculture Year(Sept to Aug))

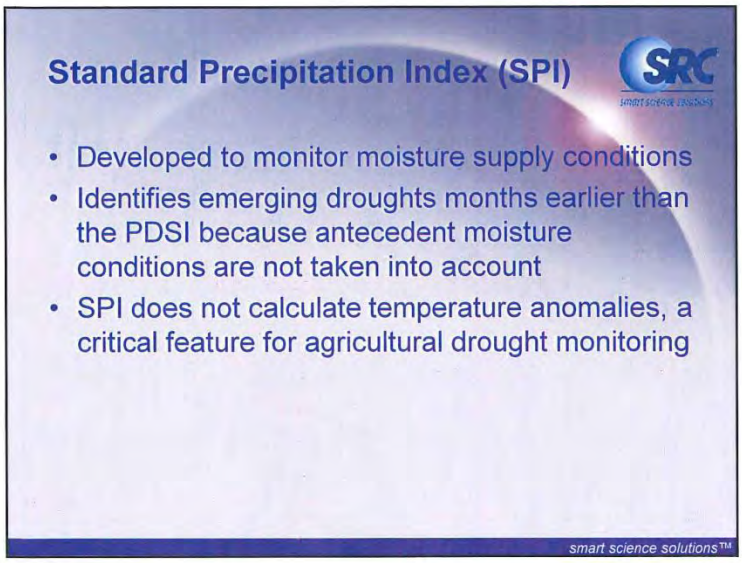
Excessive Moisture		
Year	Value	% Change in Wheat Yield*
1974	10.1	-23.7
1916	7.3	Not Available
1973	7.3	-19.0
1954	7.1	-72.6
1975	7.0	-14.1
1965	6.5	-31.7
1907	6.4	Not Available
1927	6.3	Not Available
1960	6.2	-35.4
2005	5.9	26.1

Drought		
Year	Value	% Change in Wheat Yield*
1915	-7.5	Not Available
1919	-7.3	Not Available
1929	-6.8	Not Available
2002	-6.3	-70.3
1972	-6.0	-28.9
2003	-5.7	-23.6
1973	-5.6	-19.0
1937	-5.5	Not Available
1988	-5.5	-38.5
2001	-5.5	-17.5

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Averaged over entire watershed

Wheat Yield data:
SK Ministry of Agriculture


Most Extreme Years
(12-month PDSI)
North Saskatchewan River Basin
Palmer Drought Severity Index Excessive Moisture
August 1974
Completely Exceptional
Ultimately Exceptional
Extremely Exceptional
Extreme
Severe
Utterly Exceptional
Very Exceptional
Exceptional
Moderate
Mild
PDSI
1 to 2
2 to 3
3 to 4
4 to 5
5 to 6
6 to 7
7 to 8
8 to 9
9 to 10
10 to 11
North Saskatchewan River Basin
Palmer Drought Severity Index Drought Conditions
August 1915
Exceptional
Very Exceptional
Extremely Exceptional
Extreme
Severe
Moderate
Mild
Mild
PDSI


Standard Precipitation Index (SPI)
• Developed to monitor moisture supply conditions
• Identifies emerging droughts months earlier than the PDSI because antecedent moisture conditions are not taken into account
• SPI does not calculate temperature anomalies, a critical feature for agricultural drought monitoring
smart science solutions™

What do SPI values mean?

Classification		SPI Value
Drought	Exceptional	≤ -2.5
	Extreme	> -2.5 to -2.0
	Severe	> -2.0 to -1.5
	Moderate	> -1.5 to -1.0
	Mild	> -1.0 to -0.5
Near Normal		> -0.5 to 0.5
Wet	Mild	0.5 to < 1.0
	Moderate	1.0 to < 1.5
	Severe	1.5 to < 2.0
	Extreme	2.0 to < 2.5
	Exceptional	≥ 2.5

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Top 10 - 1 Month Extremes Standardized Precipitation Index (1901-2005)

Excessive Moisture			
Year	Month	Value	% Change in Wheat Yield*
1977	May	3.4	-14.3
1965	Feb	3.2	-31.7
1942	Jan	3.1	-21.0
1955	April	3.1	-27.7
2000	July	3.1	5.5
1991	April	3.1	4.4
1986	July	3.1	0.6
1985	April	3.0	-7.2
1954	August	3.0	-72.6
1916	July	3.0	Not Available

Drought			
Year	Month	Value	% Change in Wheat Yield
1961	August	-3.7	-58.4
1967	May	-3.7	-21.9
1952	Dec	-3.7	-10.9
1995	Sept	-3.4	-21.6
1964	June	-3.3	-57.7
1974	Nov	-3.2	-23.7
1980	April	-3.2	-13.4
2002	May	-3.2	-70.3
1988	April	-3.2	-38.5
1928	January	-3.2	Not Available

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Averaged over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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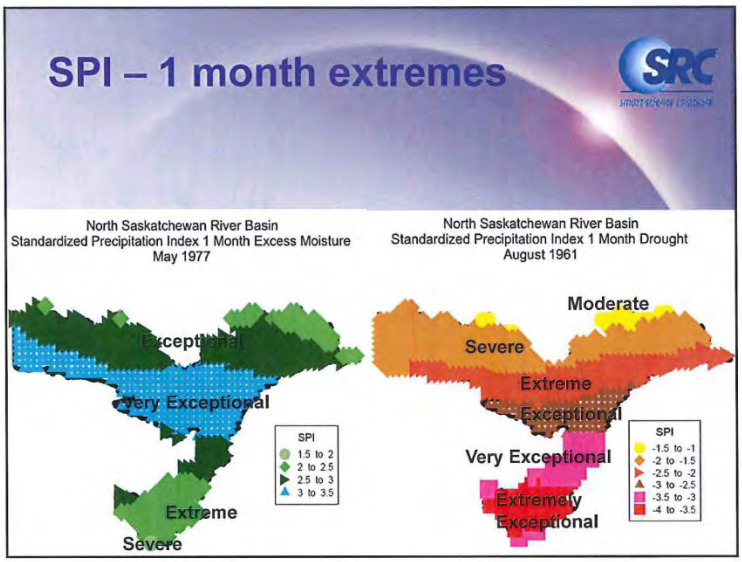
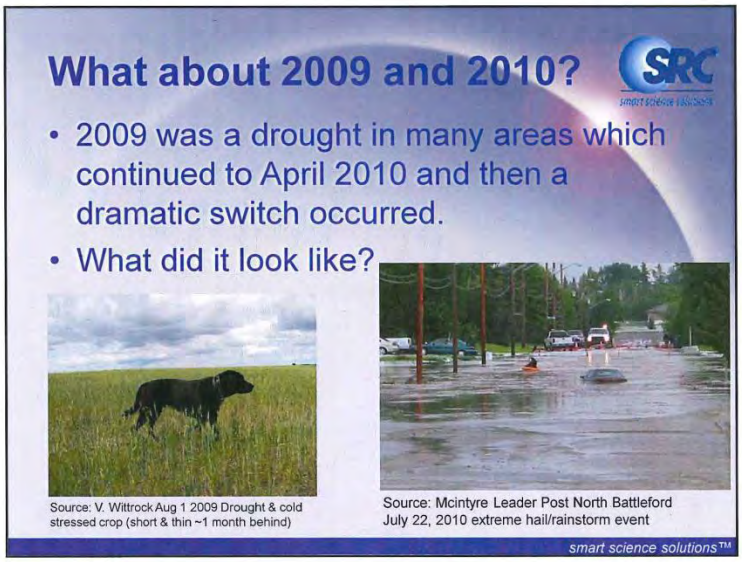

SPI – 1 month extremes
North Saskatchewan River Basin
Standardized Precipitation Index 1 Month Excess Moisture
May 1977
Exceptional
Very Exceptional
Extreme
Severe
SPI
1.5 to 2
2 to 2.5
2.5 to 3
3 to 3.5
North Saskatchewan River Basin
Standardized Precipitation Index 1 Month Drought
August 1961
Moderate
Severe
Extreme
Exceptional
Very Exceptional
Extremely Exceptional
SPI
-1.5 to -1
-2 to -1.5
-2.5 to -2
-3 to -2.5
-3.5 to -3
-4 to -3.5


What about 2009 and 2010?
• 2009 was a drought in many areas which continued to April 2010 and then a dramatic switch occurred.
• What did it look like?
Source: V. Wittrock Aug 1 2009 Drought & cold stressed crop (short & thin ~1 month behind)
Source: Mcintyre Leader Post North Battleford July 22, 2010 extreme hail/rainstorm event
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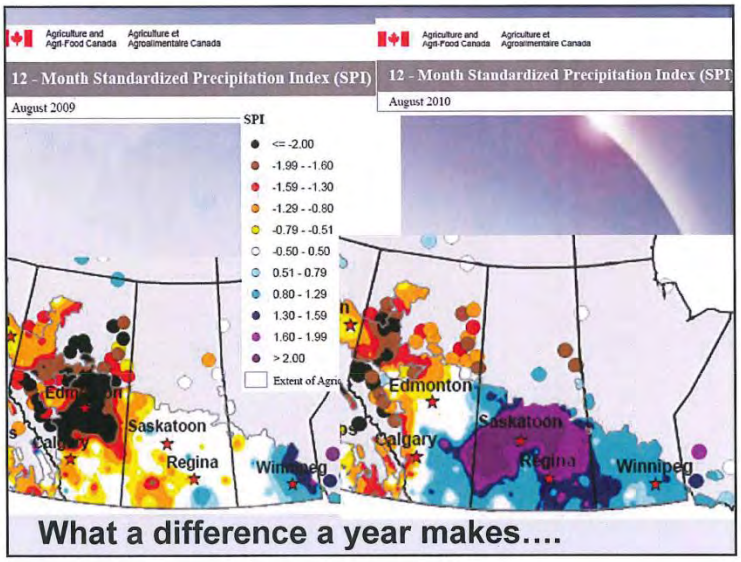
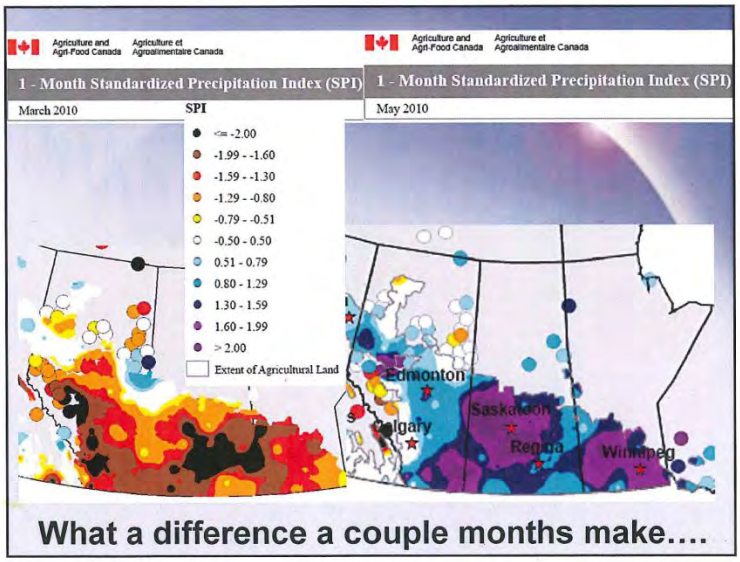

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
12 - Month Standardized Precipitation Index (SPI)
August 2009
SPI
<= -2.00
-1.99 - -1.60
-1.59 - -1.30
-1.29 - -0.80
-0.79 - -0.51
-0.50 - 0.50
0.51 - 0.79
0.80 - 1.29
1.30 - 1.59
1.60 - 1.99
> 2.00
Extent of Agri
Saskatoon
Regina
Winnipeg
12 - Month Standardized Precipitation Index (SPI)
August 2010
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
What a difference a year makes....


Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
1 - Month Standardized Precipitation Index (SPI)
March 2010
SPI
<= -2.00
-1.99 - -1.60
-1.59 - -1.30
-1.29 - -0.80
-0.79 - -0.51
-0.50 - 0.50
0.51 - 0.79
0.80 - 1.29
1.30 - 1.59
1.60 - 1.99
> 2.00
Extent of Agricultural Land
1 - Month Standardized Precipitation Index (SPI)
May 2010
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
What a difference a couple months make....

These Extreme Years have Impacted Everyone and Adaptation Strategies have been Applied

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Impacts from Droughts

- Soil erosion
- Water shortages
- Feed shortages
- Poor yielding crops
- Economic instability
- etc

Photo Source: AAFC

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Adaptations to Droughts

- Installation of weirs/dams that allow for more stable water supply (e.g., Jackfish, Anglin Lakes)
- Increased irrigation projects
- Drought tolerant crops
- Minimum tillage
- Water conservation
- etc

Photo Source: E. Stratton circa 2002
St. Mary's Irrigation District

Photo Source: V. Wittrock Oct 2010
SW Saskatchewan

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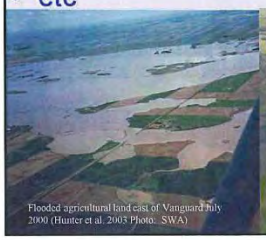
Impacts from Excessive Moisture

- Soil erosion
- Water quality issues (both surface and ground water
- Degraded crops (crops under water) decreased yield and quality
- Infrastructure problems (e.g., roads, basements)
- etc



Flooded agricultural land east of Vanguard July 2000 (Hunter et al. 2003 Photo: SWA)

Assiniboine River down stream of Kamsack Oct 5, 2010
Source: Assiniboine Watershed Stewardship Association

Photo Source: Leader Post June 2010
Highway #1 by Maple Creek

Adaptations to Excessive Moisture

- Installation of dams that allow for flood control (e.g., Jackfish Lake Flood Control Project)
- Different crops to adapt to diseases and excess moisture conditions
- Minimum tillage
- Re-establishment of riparian zones
- etc

Conclusion and Questions

- North Saskatchewan River Watershed has always had extreme events and future ones could be worse…
- **But** the trick is to learn from the past to better adapt to our ever evolving future.
- There are still many questions to be asked,
  - What if 2011 is as wet as 2010?
  - Changing infrastructure to accommodate excessive moisture occurrences (e.g., 2010 hail / rainstorm event)
  - What if we have a 10 year drought, how will we be impacted and will we be able to adapt?

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References

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- Drought Collage: Wheaton, E., with V. Wittrock, S. Kulshreshtha, G. Koshida, C. Grant, A. Chipanshi, B. Bonsal, with the rest of the Canadian Drought Study Steering Committee, P. Adkins, G. Bell, G. Brown, A. Howard and R. MacGregor. 2005. *Lessons Learned from the Canadian Drought Years of 2001 and 2002: Synthesis Report.* Saskatchewan Research Council (SRC) Publication No. 11602-46E03. 30 pp.
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- PDSI 2001 map: Bonsal, B., E. Wheaton, and E. Siemens. 2010 July. *Characterizing the Surface Dynamics of Canadian Prairie Droughts.* Environment Canada, Saskatchewan Research Council. Water 2010: Hydrology, Hydraulics, and Water Resources in an Uncertain Environment, Quebec City, Quebec, July 5-7, 2010. SRC Publication No. 11602-3D10. 28 slides.
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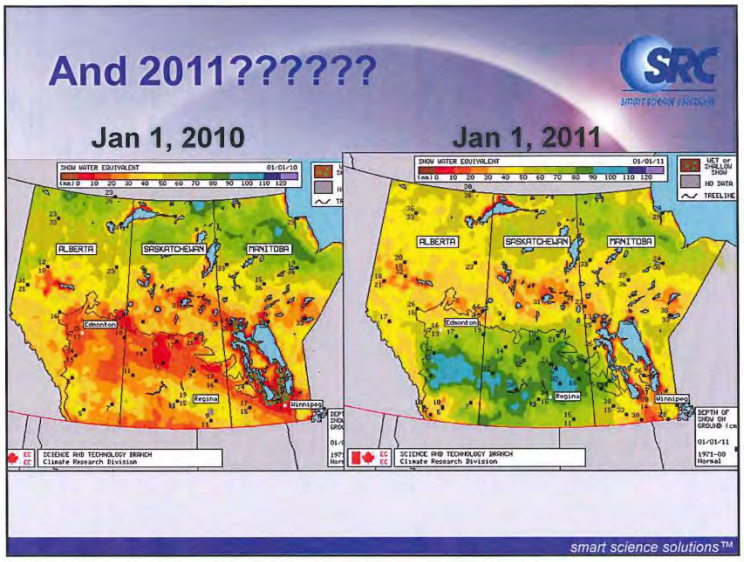
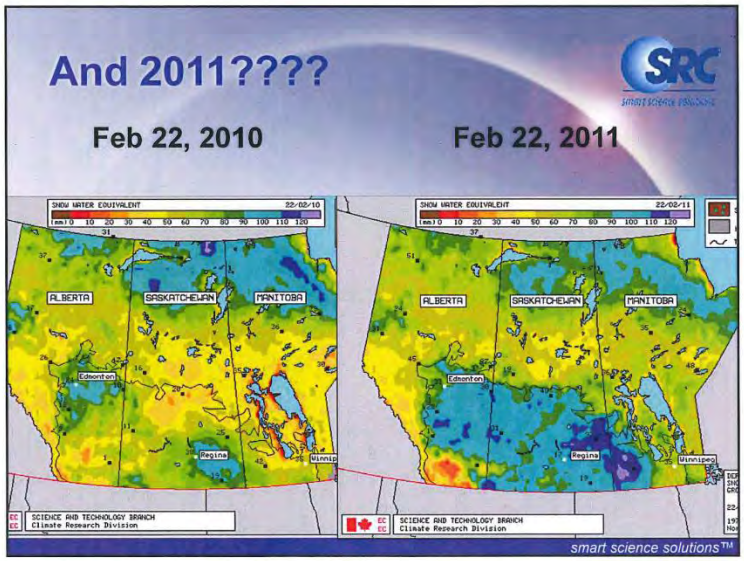
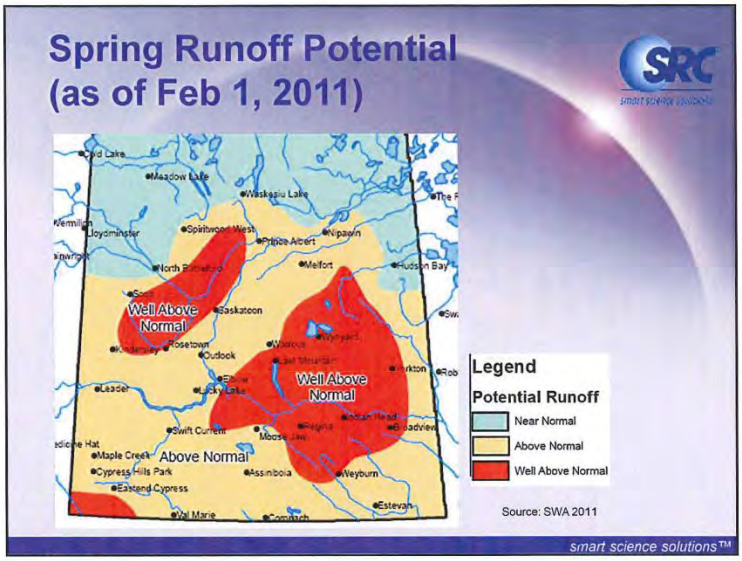
- Crop Yields: Ministry of Saskatchewan Agriculture website: http://www.agriculture.gov.sk.ca/rmyields
- Snow Water Equivalent Maps: Environment Canada, Climate Research Division, Science and Technology Branch web site: http://www.ccin.ca/cms/en/socc/currentSnow.aspx
- Spring Runoff Potential: Saskatchewan Watershed Authority. 2011. Precipitation, Streamflow and Lake Level conditions for Saskatchewan. Based on conditions as of February 1, 2011. Saskatchewan Watershed Authority, Moose Jaw, SK. Web site: http://www.swa.ca/WaterManagement/MonthlyForecast/ProvincialForecast.pdf Accessed Feb. 23, 2011.
- Photos:
  - Cracked Earth and soil drifts– Agriculture and Agri-Food Canada (AAFC)
  - Tractor stuck: Wucher, L. St. Gregor SK Sept 6 2010
  - Drought and cold stress crop – V. Wittrock Aug 1, 2009 Neidpath
  - Rain/Hail Event over City of North Battleford – Booth, Leader Post July 22, 2010
  - Extreme Hail/Rain Event North Battleford – McIntyre Leader Post July 22, 2010
  - St. Mary's Irrigation District – E. Stratton circa 2002
  - Combines in field – V. Wittrock Oct 2010 SW Saskatchewan
  - Vanguard Flood – SWA – July 2000
  - Assiniboine River – Assiniboine Watershed Stewardship Association – Oct 5, 2010
  - Highway #1 by Maple Creek – Leader Post – June 2010
  - Frontal Cloud – S. Wittrock July 2, 2010, Swift Current, SK
  - Rainbow – V. Wittrock May 2009 Martensville, SK


And 2011?????
Jan 1, 2010
Jan 1, 2011
ALBERTA
SASKATCHEWAN
MANITOBA
Edmonton
Regina
Winnipeg
SCIENCE AND TECHNOLOGY BRANCH
Climate Research Division
smart science solutions™


And 2011????
Feb 22, 2010
Feb 22, 2011
ALBERTA
SASKATCHEWAN
MANITOBA
Edmonton
Regina
SCIENCE AND TECHNOLOGY BRANCH
Climate Research Division
smart science solutions™


Spring Runoff Potential
(as of Feb 1, 2011)
SRC
Meadow Lake
Waskesiu Lake
Spiritwood West
Prince Albert
Nipawin
Melfort
Saskatoon
Well Above Normal
Rosetown
Outlook
Leader
Swift Current
Maple Creek
Above Normal
Cypress Hills Park
Eastend Cypress
Assiniboia
Weyburn
Estevan
Legend
Potential Runoff
Near Normal
Above Normal
Well Above Normal
Source: SWA 2011
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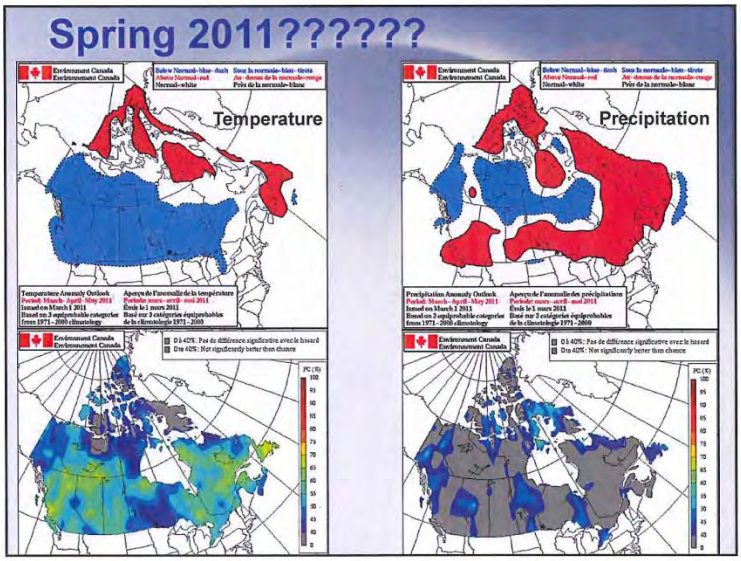
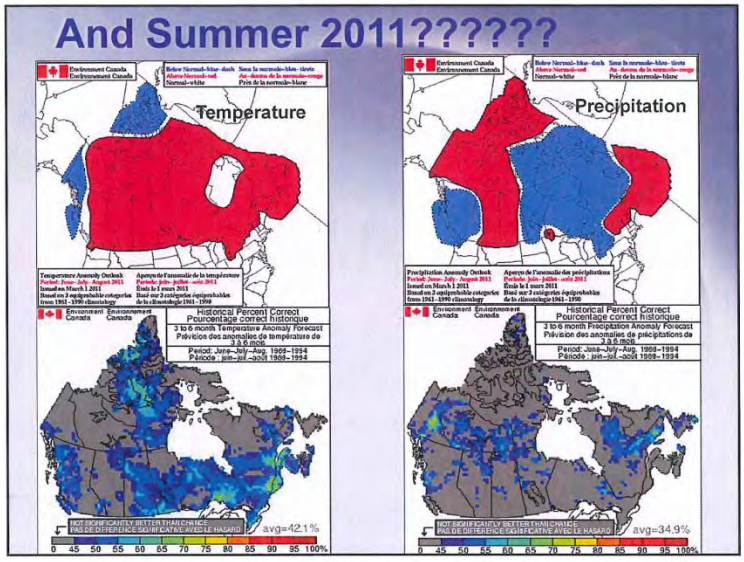

Spring 2011?????
Temperature
Precipitation


And Summer 2011??????
Temperature
Precipitation
Historical Percent Correct
Pourcentage correct historique
3 to 6 month Temperature Anomaly Forecast
Prévision des anomalies de température de 3 à 6 mois
Period: June–July–Aug. 1969–1994
Période : juin–jil.–août 1969–1994
avg=42.1%
3 to 6 month Precipitation Anomaly Forecast
Prévision des anomalies de précipitations de 3 à 6 mois
avg=34.9%


What next?
• Study of 2010 for excessive moisture
• Future drought and excessive moisture
• etc
• Still in the develop process
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Gridded data

- Gridded data sets preferred over station data due to improved spatial/temporal coverage
- Gridding data procedure removes unnecessary noise, resulting in smoother data for mapping
- PDSI and SPI derived from the ANUSPLIN data set
- ANUSPLIN was chosen for ability to capture several significant precipitation events, for better comparability with data and for area covered
- Develop data bases of PDSI and SPII for the watersheds (10 KM grid)

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Top 10 most extreme years
PDSI Z-Value
(1901-2005 Agriculture Year (Sept to Aug))

Excessive Moisture		
Year	Value	% Change in Wheat Yield*
1954	11.9	-72.6
1988	8.7	-38.5
1982	8.3	4.5
1951	8.3	-27.5
1974	7.4	-23.7
2005	7.3	26.1
1959	6.7	-58.1
1907	6.6	Not Available
1995	6.3	-21.6
1993	6.2	7.7

Drought		
Year	Value	% Change in Wheat Yield
1961	-5.7	-58.4
1915	-5.5	Not Available
2001	-5.4	-17.5
1929	-4.7	Not Available
1981	-4.5	-12.1
1939	-4.3	-47.0
1958	-4.2	-50.6
2003	-4.1	-23.6
1984	-4.0	-16.0
1998	-4.0	-7.6

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Average over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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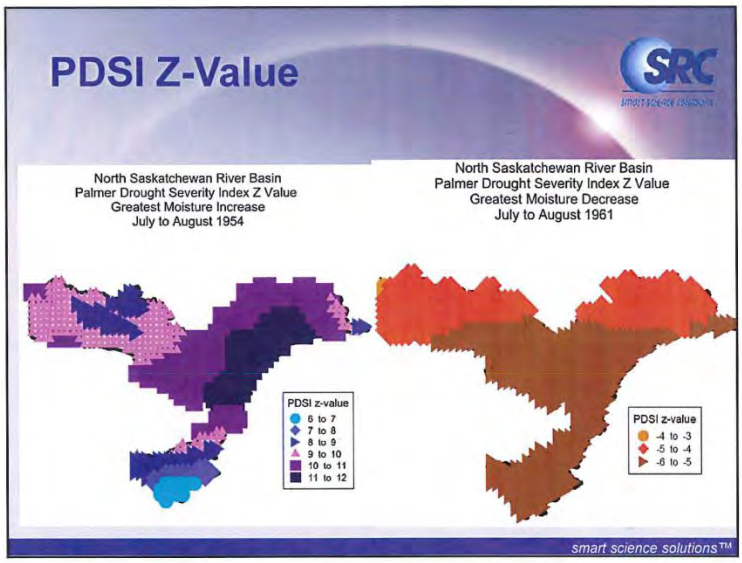

Top 10 most extreme years
SPI – 12 Month (Sept-Aug)(1901-2005)

August Excessive Moisture		
Year	Value	% Change in Wheat Yield*
1974	3.0	-23.7
1973	2.6	-19.0
1965	2.5	-31.7
1916	2.5	Not Available
1954	2.3	-72.6
1932	2.3	Not Available
1993	2.2	7.7
1960	2.2	-35.4
2005	2.0	26.1
1985	2.0	-7.2

August Drought		
Year	Value	% Change in Wheat Yield*
1929	-3.2	Not Available
1917	-2.8	Not Available
1961	-2.8	-58.4
2001	-2.6	-17.5
1924	-2.6	Not Available
1972	-2.4	-28.9
1918	-2.3	Not Available
2002	-2.3	-70.3
1936	-2.3	Not Available
1973	-2.1	-19.0

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Average over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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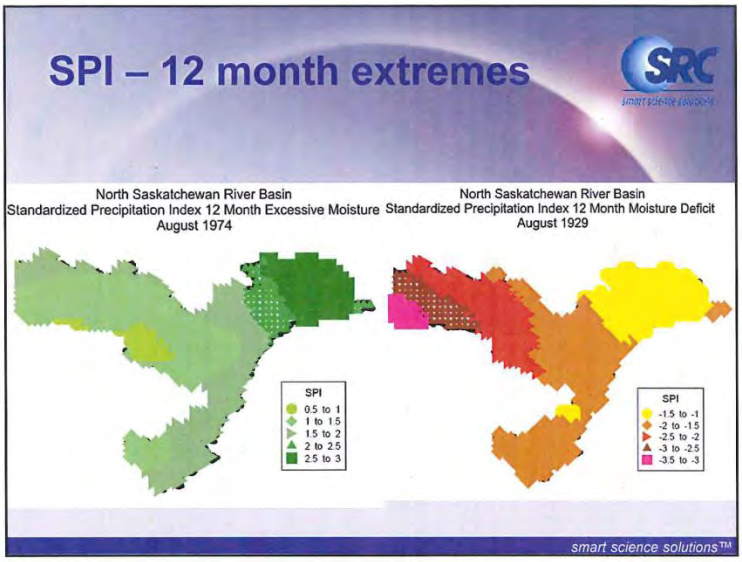
SPI – 12 month extremes
North Saskatchewan River Basin
Standardized Precipitation Index 12 Month Excessive Moisture
August 1974
SPI
0.5 to 1
1 to 1.5
1.5 to 2
2 to 2.5
2.5 to 3
North Saskatchewan River Basin
Standardized Precipitation Index 12 Month Moisture Deficit
August 1929
SPI
-1.5 to -1
-2 to -1.5
-2.5 to -2
-3 to -2.5
-3.5 to -3
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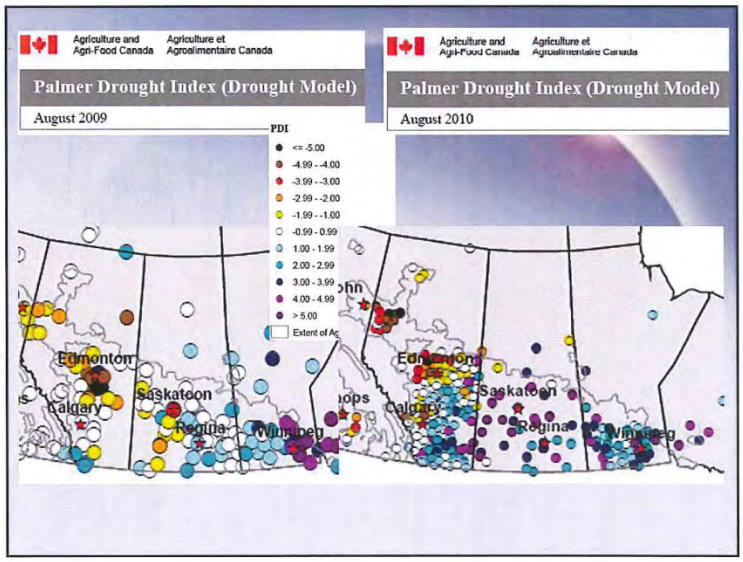
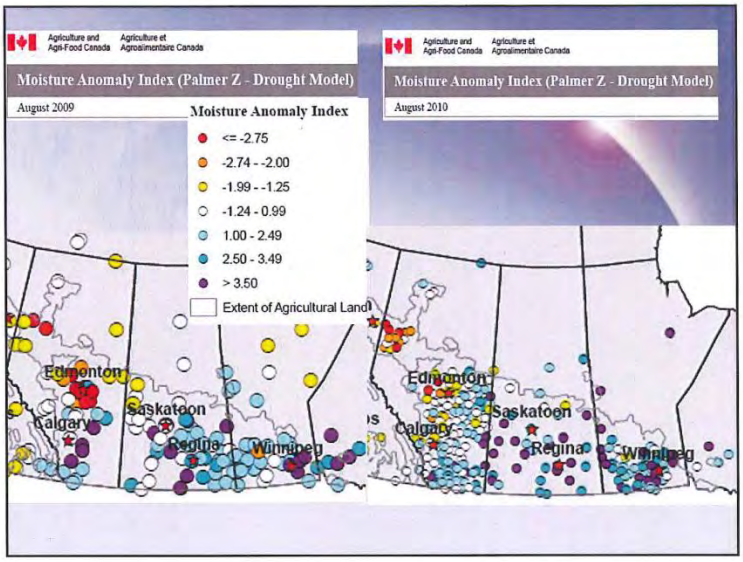
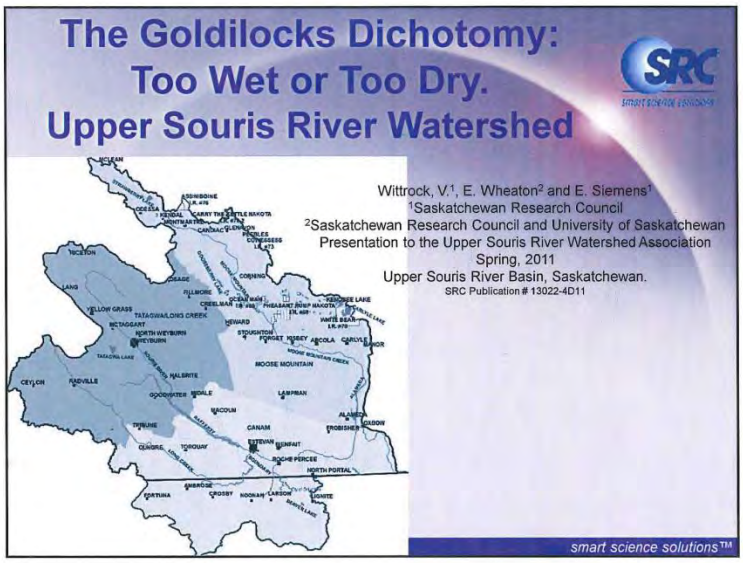

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Palmer Drought Index (Drought Model)
August 2009
PDI
<= -5.00
-4.99 - -4.00
-3.99 - -3.00
-2.99 - -2.00
-1.99 - -1.00
-0.99 - 0.99
1.00 - 1.99
2.00 - 2.99
3.00 - 3.99
4.00 - 4.99
> 5.00
Edmonton
Saskatoon
Calgary
Regina
Palmer Drought Index (Drought Model)
August 2010
Saskatoon
Calgary
Regina


Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Moisture Anomaly Index (Palmer Z - Drought Model)
August 2009
Moisture Anomaly Index
<= -2.75
-2.74 - -2.00
-1.99 - -1.25
-1.24 - 0.99
1.00 - 2.49
2.50 - 3.49
> 3.50
Extent of Agricultural Land
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Moisture Anomaly Index (Palmer Z - Drought Model)
August 2010
Edmonton
Saskatoon
Calgary
Regina
Winnipeg


The Goldilocks Dichotomy:
Too Wet or Too Dry.
Upper Souris River Watershed
SRC
Wittrock, V.[1], E. Wheaton[2] and E. Siemens[1]
[1]Saskatchewan Research Council
[2]Saskatchewan Research Council and University of Saskatchewan
Presentation to the Upper Souris River Watershed Association
Spring, 2011
Upper Souris River Basin, Saskatchewan.
SRC Publication # 13022-4D11
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Outline
• Objectives & benefits
• Methodology
• Background information
• The extreme years
• Impacts and adaptations
• Conclusion
Deluge of rain followed by deluge of aid requests
2010 breaks rain records
Rain leaves 30 percent of Sask. unseeded
Floods contaminate rural wells
Downpour floods town roads
Drought losses mount in Sask., Alta.
Drought puts pastures in peril
Drought-stressed farmers need help
Farm earnings shrivel
Drought costs economy millions
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Objectives
SRC
• To characterize drought and excessive moisture events for selected watersheds during the past century.
• Compare and contrast driest and wettest patterns to help determine characteristics for risk assessments and planning.
• Consider the implications for impacts and adaptations directly related to the watershed.
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Benefits of Examining the Past
SRC
• Assist communities, local municipalities, provincial and federal governments with risk management and planning strategies for extreme events.
• Avoid damages and decrease the costs of climate events by learning from the past.
• Help to lower the costs of the impacts of future climatic events.
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What is a Drought?

- A deficiency of precipitation from expected or "normal" that, when extended over a season or longer, is insufficient to meet the demands of human activities and the environment
- Four major types of drought including Meteorological, Agricultural, Hydrological and Socio-economic

• Or when it hasn't rained, the fields are dry, the lakes or rivers are really low and it impacts the economy, environment and our way of life

Photo: AAFC

What is Excessive Moisture?

- An excess of precipitation from expected or "normal" that, when extended over a season or longer, is too much to meet the demands of human activities and the environment
- Four major types of excess moisture including Meteorological, Agricultural, Hydrological and Socio-economic

• Or it won't quit raining, the fields are saturated, the lakes or rivers are over flowing their banks and it impacts the economy, environment and our way of life.

Photo: Wucher, L. St. Gregor SK Sept 6, 2010

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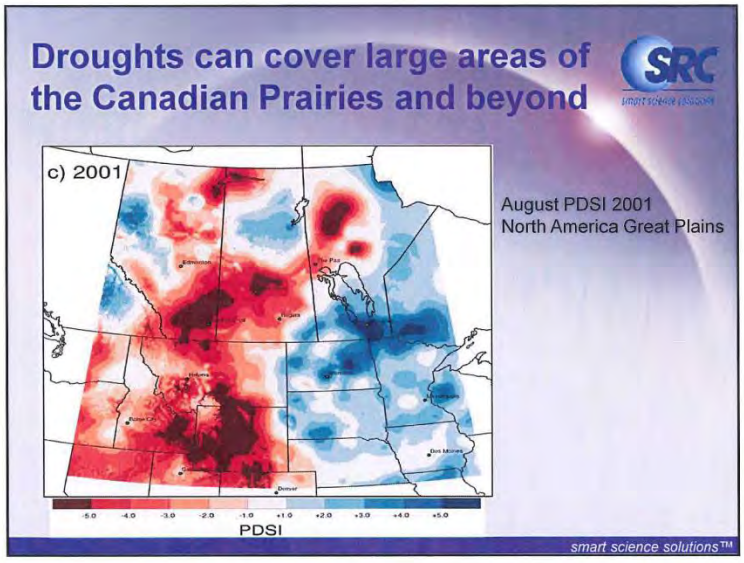
Droughts can cover large areas of the Canadian Prairies and beyond
SRC
c) 2001
August PDSI 2001
North America Great Plains
-5.0 -4.0 -3.0 -2.0 -1.0 +1.0 +2.0 +3.0 +4.0 +5.0
PDSI
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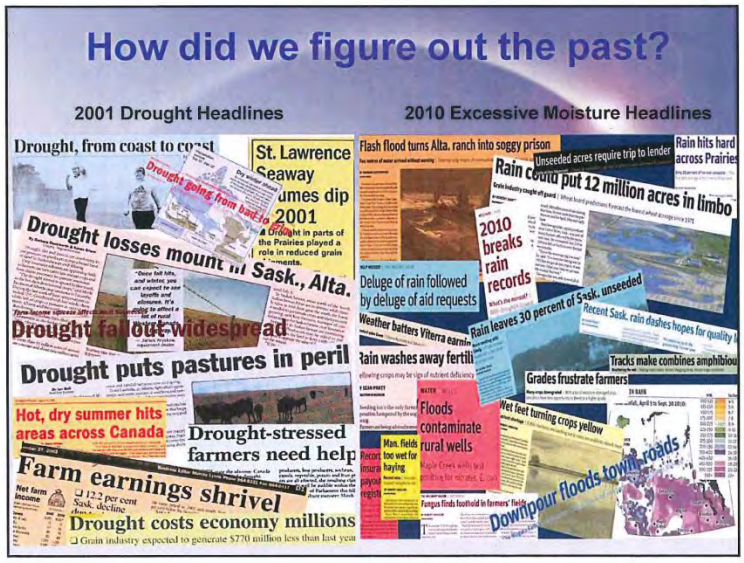
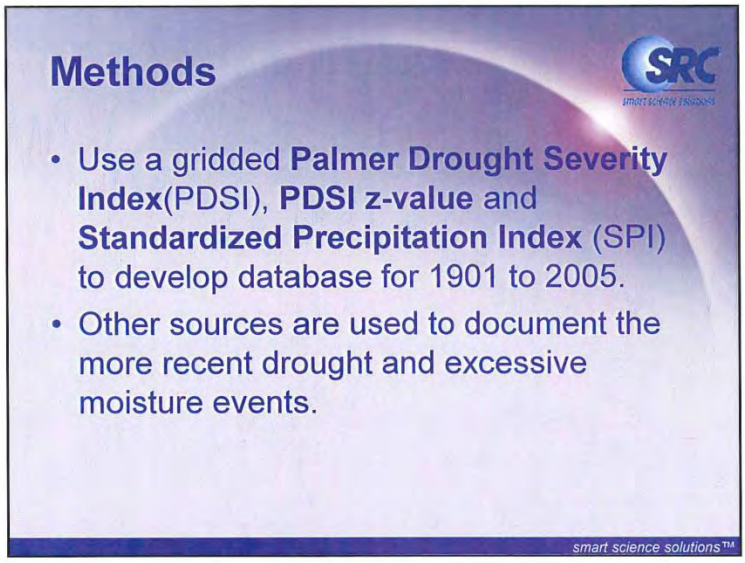

How did we figure out the past?
2001 Drought Headlines
2010 Excessive Moisture Headlines
Drought, from coast to coast
St. Lawrence Seaway
2001
Drought losses mount in Sask., Alta.
Drought fallout widespread
Drought puts pastures in peril
Hot, dry summer hits areas across Canada
Drought-stressed farmers need help
Farm earnings shrivel
Drought costs economy millions
Flash flood turns Alta. ranch into soggy prison
Rain could put 12 million acres in limbo
Rain hits hard across Prairies
2010 breaks rain records
Deluge of rain followed by deluge of aid requests
Rain leaves 30 percent of Sask. unseeded
Recent Sask. rain dashes hopes for quality
Tracks make combines amphibious
Grades frustrate farmers
Floods contaminate rural wells
Wet feet turning crops yellow
Downpour floods town roads


Methods
SRC
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• Use a gridded **Palmer Drought Severity Index**(PDSI), **PDSI z-value** and **Standardized Precipitation Index** (SPI) to develop database for 1901 to 2005.
• Other sources are used to document the more recent drought and excessive moisture events.
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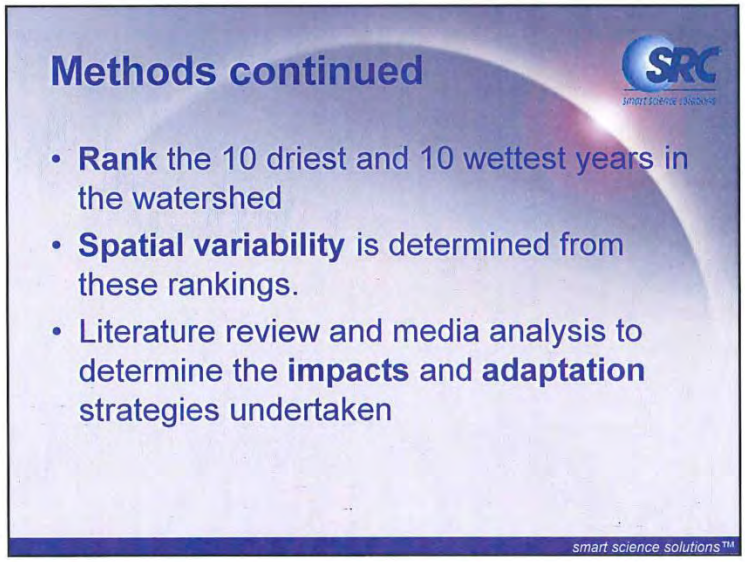
Methods continued
SRC
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• **Rank** the 10 driest and 10 wettest years in the watershed
• **Spatial variability** is determined from these rankings.
• Literature review and media analysis to determine the **impacts** and **adaptation** strategies undertaken
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How do we classify severe drought, excessive moisture or average conditions?

Source: V. Wittrock Aug 1 2009
Drought & cold stressed crop (short & thin)
(SouthWest Sask)

Source: Upper Souris Watershed Association
Rafferty Dam releasing water from riparian structure

Palmer Drought Severity Index (PDSI)

- One of the most widely used drought and excessive moisture indices
- Primarily a hydrological drought index
- Derived using a soil moisture/water balance model which requires information on the available soil water content along with daily/monthly precipitation and temperature data
- Value contain a long term memory of the previous moisture conditions because the calculated value.

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What do PDSI values mean?

Classification		PDSI Value
Drought	Exceptional	≤ -5
	Extreme	> -5.0 to -4.0
	Severe	> -4.0 to -3.0
	Moderate	> -3.0 to -2.0
	Mild	> -2.0 to -1.0
Near Normal		> -1.0 to 1.0
Wet	Mild	1.0 to < 2.0
	Moderate	2.0 to < 3.0
	Severe	3.0 to < 4.0
	Extreme	4.0 to < 5.0
	Exceptional	≥ 5.0

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Top 10 Extreme Years and Wheat Yields

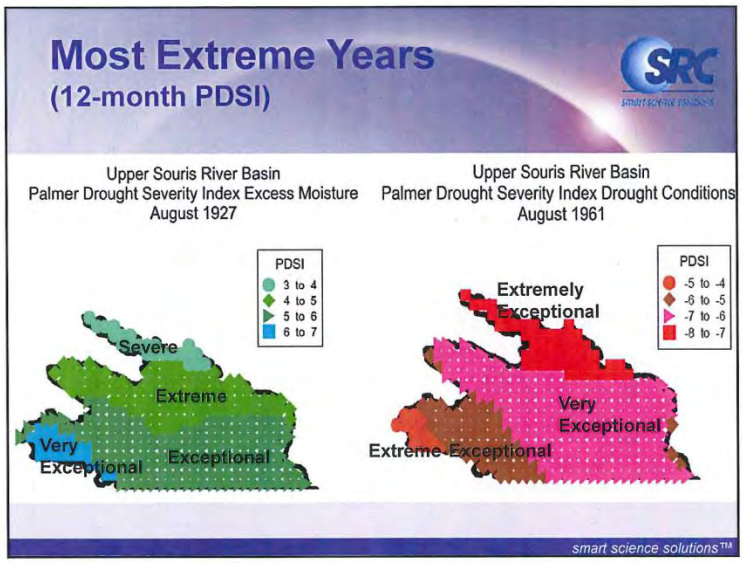
Palmer Drought Severity Index for the Upper Souris River Watershed
(1901-2005 Agriculture Year(Sept to Aug))

Excessive Moisture		
Year	Value	% Change in Wheat Yield *
1927	6.4	Not Available
1902	6.3	Not Available
1991	6.0	-7.6
1909	5.8	Not Available
1928	5.6	Not Available
1923	5.5	Not Available
1954	5.5	-73.1
1955	5.5	-25.7
1999	5.3	-5.6
1947	5.2	-44.6

Drought		
Year	Value	% Change in Wheat Yield *
1961	-8.0	-79.9
1988	-6.8	-54.8
1958	-6.7	-64.9
1959	-6.6	-53.6
1984	-6.5	-39.3
1977	-6.1	4.2
1989	-6.0	-42.7
1937	-5.9	Not Available
1931	-5.2	Not Available
1915	-5.0	Not Available

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Averaged over entire watershed

Wheat Yield data:
SK Ministry of Agriculture


Most Extreme Years
(12-month PDSI)
Upper Souris River Basin
Palmer Drought Severity Index Excess Moisture
August 1927
PDSI
3 to 4
4 to 5
5 to 6
6 to 7
Severe
Extreme
Very Exceptional
Exceptional
Upper Souris River Basin
Palmer Drought Severity Index Drought Conditions
August 1961
PDSI
-5 to -4
-6 to -5
-7 to -6
-8 to -7
Extremely Exceptional
Very Exceptional
Extreme-Exceptional
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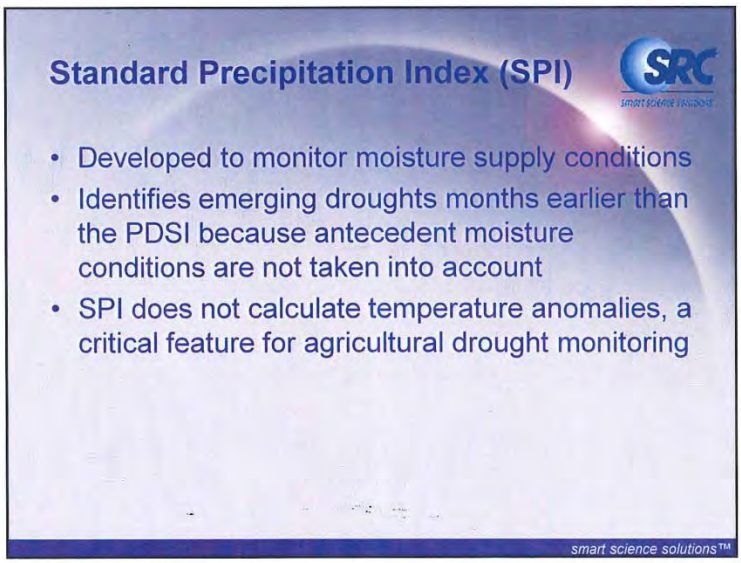
Standard Precipitation Index (SPI)
• Developed to monitor moisture supply conditions
• Identifies emerging droughts months earlier than the PDSI because antecedent moisture conditions are not taken into account
• SPI does not calculate temperature anomalies, a critical feature for agricultural drought monitoring
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What do SPI values mean?

Classification		SPI Value
Drought	Exceptional	≤ -2.5
	Extreme	> -2.5 to -2.0
	Severe	> -2.0 to -1.5
	Moderate	> -1.5 to -1.0
	Mild	> -1.0 to -0.5
Near Normal		> -0.5 to 0.5
Wet	Mild	0.5 to < 1.0
	Moderate	1.0 to < 1.5
	Severe	1.5 to < 2.0
	Extreme	2.0 to < 2.5
	Exceptional	≥ 2.5

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Top 10 - 1 Month Extremes
Standardized Precipitation Index (1901-2005)

Excessive Moisture			
Year	Month	Value	% Change in Wheat Yield *
1993	July	3.5	2.6
1998	Feb	3.4	-10.8
2000	Nov	3.3	-0.4
1975	Apr	3.1	-19.0
1968	Aug	3.0	-47.8
1970	Apr	3.0	-17.0
1902	Feb	2.9	Not Available
1999	Feb	2.9	-5.6
1965	May	2.9	-11.5
2003	Apr	2.7	-23.2

Drought			
Year	Month	Value	% Change in Wheat Yield *
1961	Aug	-3.7	-79.9
1997	Dec	-3.5	-25.5
1980	May	-3.5	-31.7
1973	Jan	-3.4	-10.2
1968	Apr	-3.4	-47.8
1985	July	-3.4	-33.8
2001	Aug	-3.3	-8.9
1934	Apr	-3.1	Not Available
1969	Oct	-3.1	11.9
1965	Oct	-3.1	-11.5

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Averaged over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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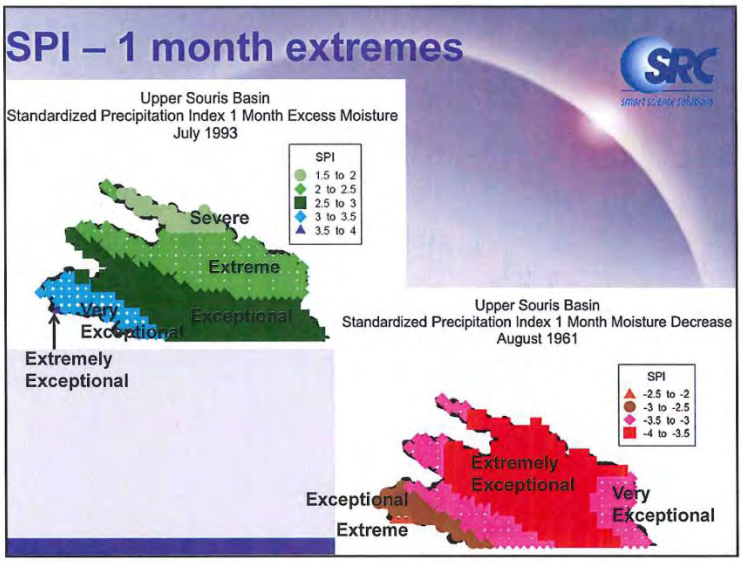
SPI – 1 month extremes
SRC
smart science solutions
Upper Souris Basin
Standardized Precipitation Index 1 Month Excess Moisture
July 1993
SPI
1.5 to 2
2 to 2.5
2.5 to 3
3 to 3.5
3.5 to 4
Severe
Extreme
Very Exceptional
Exceptional
Extremely Exceptional
Upper Souris Basin
Standardized Precipitation Index 1 Month Moisture Decrease
August 1961
SPI
-2.5 to -2
-3 to -2.5
-3.5 to -3
-4 to -3.5
Extremely Exceptional
Very Exceptional
Exceptional
Extreme


What about 2009 and 2010?
SRC
smart science solutions
• 2009 was a drought in many areas which continued to April 2010 and then a dramatic switch occurred.
• What did it look like?
Source: V. Wittrock Aug 1 2009 Drought & cold stressed crop (short & thin ~1 month behind)
Source: Sandquist, J. June 25, 2007 Alameda Reservoir / Alameda Dam
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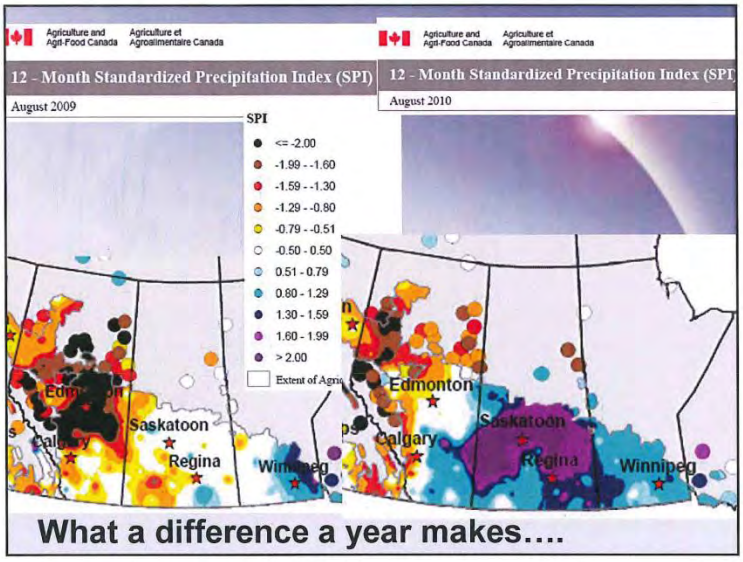
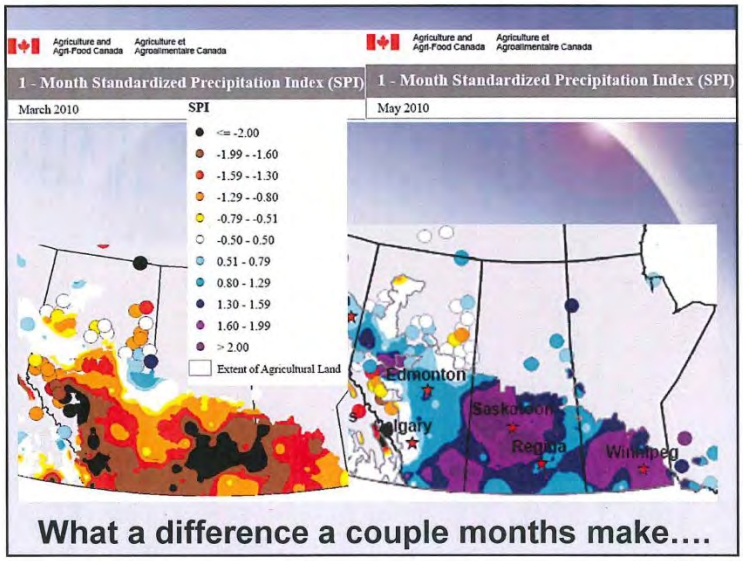

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
12 - Month Standardized Precipitation Index (SPI)
August 2009
SPI
<= -2.00
-1.99 - -1.60
-1.59 - -1.30
-1.29 - -0.80
-0.79 - -0.51
-0.50 - 0.50
0.51 - 0.79
0.80 - 1.29
1.30 - 1.59
1.60 - 1.99
> 2.00
Saskatoon
Regina
Winnipeg
12 - Month Standardized Precipitation Index (SPI)
August 2010
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
What a difference a year makes....


Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
1 - Month Standardized Precipitation Index (SPI)
March 2010
SPI
<= -2.00
-1.99 - -1.60
-1.59 - -1.30
-1.29 - -0.80
-0.79 - -0.51
-0.50 - 0.50
0.51 - 0.79
0.80 - 1.29
1.30 - 1.59
1.60 - 1.99
> 2.00
Extent of Agricultural Land
1 - Month Standardized Precipitation Index (SPI)
May 2010
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
What a difference a couple months make....

These Extreme Years have Impacted Everyone and Adaptation Strategies have been Applied

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Impacts from Droughts

- Soil erosion
- Water shortages
- Feed shortages
- Poor yielding crops
- Economic instability
- etc

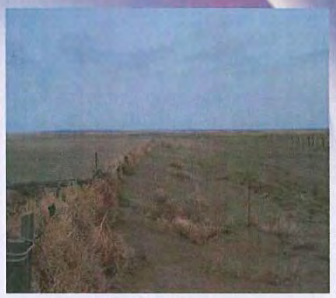

Photo Source: AAFC

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Adaptations to Droughts

- Installation of weirs/dams that allow for more stable water supply(e.g.,Rafferty and Alameda Dams)
- Increased irrigation projects
- Drought tolerant crops
- Minimum tillage
- Water conservation
- etc

Photo Source: E. Stratton circa 2002
St. Mary's Irrigation District

Source: Saskatchewan Watershed Authority
Rafferty Dam

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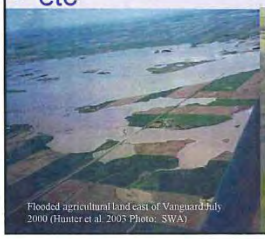
Impacts from Excessive Moisture

- Soil erosion
- Water quality issues (both surface and ground water
- Degraded crops (crops under water) decreased yield and quality
- Infrastructure problems (e.g., roads, basements)
- etc



Flooded agricultural land east of Vangnard July 2000 (Hunter et al. 2003 Photo: SWA)

Assiniboine River down stream of Kamsack Oct 5, 2010
Source: Assiniboine Watershed Stewardship Association

Photo Source: Leader Post June 2010
Highway #1 by Maple Creek

Adaptations to Excessive Moisture

- Installation of dams that allow for flood control (e.g., Rafferty and Alameda Dams)
- Different crops to adapt to diseases and excess moisture conditions
- Minimum tillage
- Re-establishment of riparian zones
- etc

Source: Saskatchewan Watershed Authority
Alameda Dam

Conclusion and Questions

- Assiniboine River Watershed has always had extreme events and future ones could be worse…
- **But** the trick is to learn from the past to better adapt to our ever evolving future.
- There are still many questions to be asked,
  - What if 2011 is as wet as 2010?
  - Changing infrastructure to accommodate excessive moisture occurrences
  - What if we have a 10 year drought, how will we be impacted and will we be able to adapt?

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References

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- Drought Collage: Wheaton, E., with V. Wittrock, S. Kulshreshtha, G. Koshida, C. Grant, A. Chipanshi, B. Bonsal, with the rest of the Canadian Drought Study Steering Committee, P. Adkins, G. Bell, G. Brown, A. Howard and R. MacGregor. 2005. *Lessons Learned from the Canadian Drought Years of 2001 and 2002: Synthesis Report.* Saskatchewan Research Council (SRC) Publication No. 11602-46E03. 30 pp.
- 2010 Excessive Moisture Collage: Created by C. Beaulieu Jan 2011
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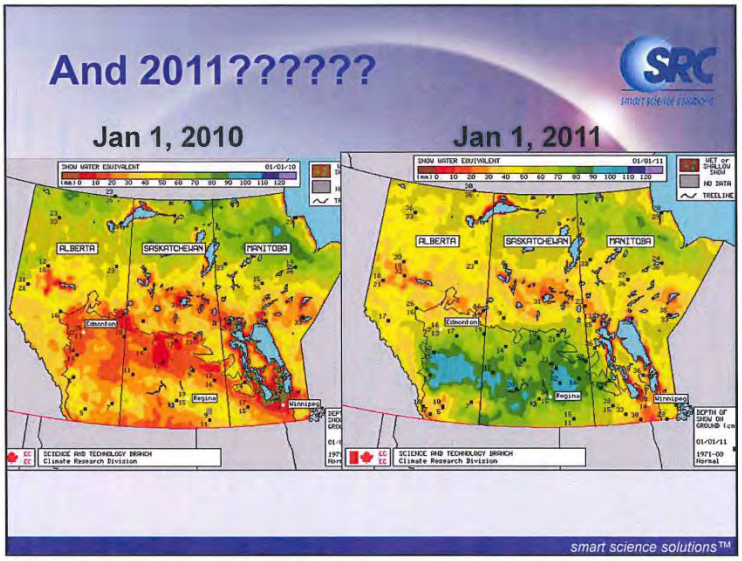
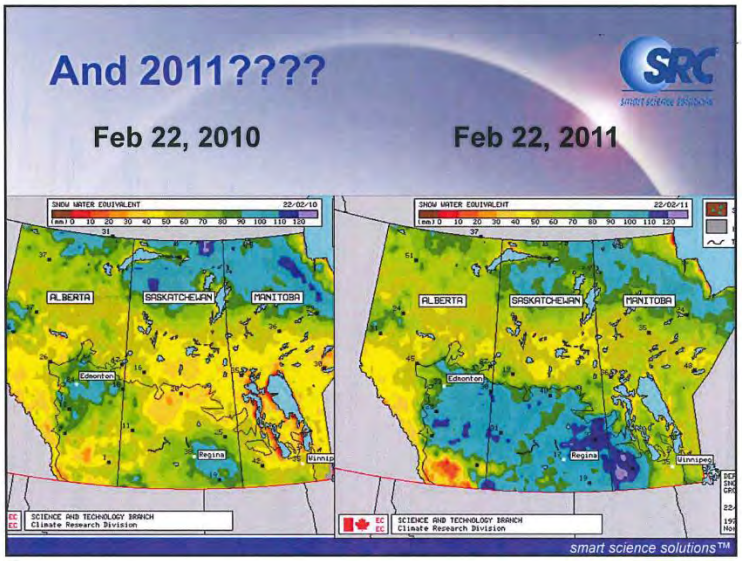
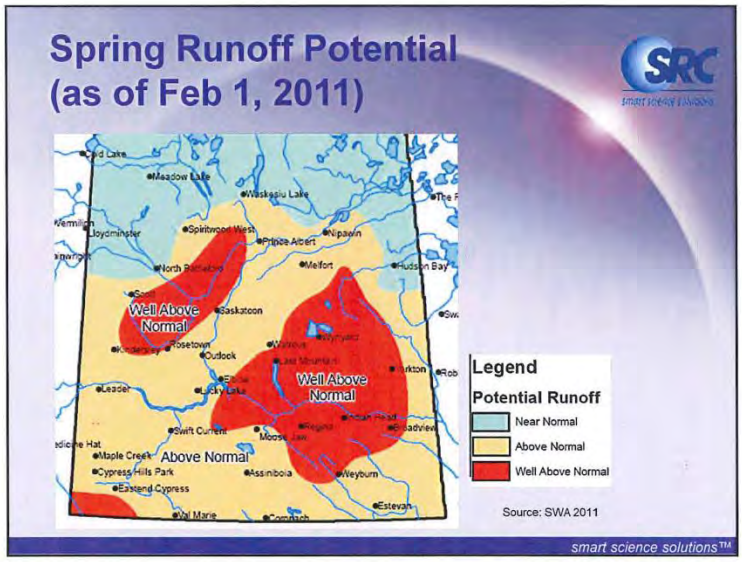
- PDI and SPI maps Aug 2009 & 2010: Agriculture and Agri-Food Canada Web site: http://www4.agr.gc.ca/DW-GS/historical-historiques.jspx?lang=eng&isEnabled=true
- Temperature and precipitation outlooks: Environment Canada website: http://www.weatheroffice.gc.ca/saisons/index_e.html
- Crop Yields: Ministry of Saskatchewan Agriculture website: http://www.agriculture.gov.sk.ca/rmyields
- Snow Water Equivalent Maps: Environment Canada, Climate Research Division, Science and Technology Branch web site: http://www.ccin.ca/cms/en/socc/currentSnow.aspx
- Photos:
  - Cracked Earth and soil drifts– Agriculture and Agri-Food Canada (AAFC)
  - Tractor stuck: Wucher, L. St. Gregor SK Sept 6 2010
  - Drought and cold stress crop – V. Wittrock Aug 1, 2009 Neidpath
  - Rafferty Dam releasing water from riparian structure – Upper Souris Watershed Association
  - Alameda Reservoir / Alameda Dam – J. Sandquist June 25, 2007
  - St. Mary's Irrigation District – E. Stratton circa 2002
  - Rafferty Dam – Saskatchewan Watershed Authority
  - Vanguard Flood – SWA – July 2000
  - Assiniboine River – Assiniboine Watershed Stewardship Association – Oct 5, 2010
  - Highway #1 by Maple Creek – Leader Post – June 2010
  - Alameda Dam – Saskatchewan Watershed Authority
  - Rainbow – V. Wittrock May 2009 Martensville


And 2011?????
Jan 1, 2010
Jan 1, 2011
ALBERTA
SASKATCHEWAN
MANITOBA
Edmonton
Regina
Winnipeg
SCIENCE AND TECHNOLOGY BRANCH
Climate Research Division
smart science solutions™


And 2011????
Feb 22, 2010
Feb 22, 2011
ALBERTA
SASKATCHEWAN
MANITOBA
Edmonton
Regina
SCIENCE AND TECHNOLOGY BRANCH
Climate Research Division
smart science solutions™


Spring Runoff Potential
(as of Feb 1, 2011)
Meadow Lake
Waskesiu Lake
Spiritwood West
Prince Albert
Nipawin
Melfort
Hudson Bay
North Battleford
Saskatoon
Well Above Normal
Rosetown
Outlook
Leader
Lucky Lake
Well Above Normal
Swift Current
Moose Jaw
Maple Creek
Above Normal
Cypress Hills Park
Assiniboia
Weyburn
Eastend Cypress
Estevan
Val Marie
Legend
Potential Runoff
Near Normal
Above Normal
Well Above Normal
Source: SWA 2011
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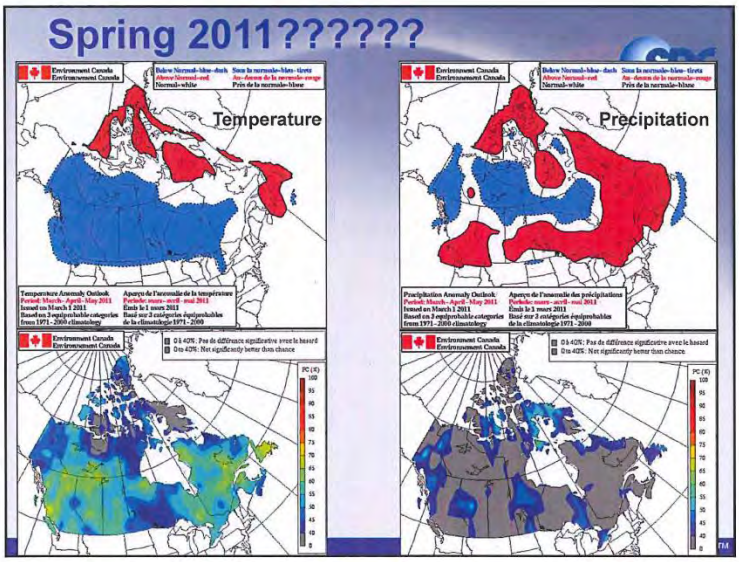
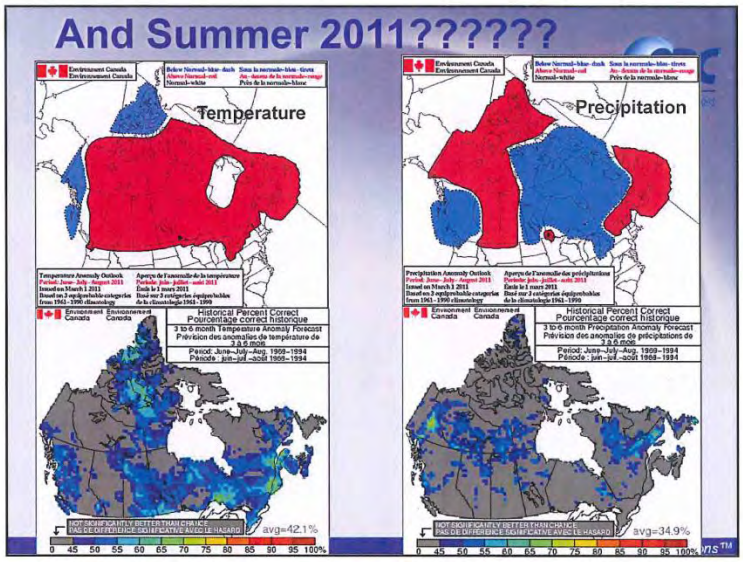

Spring 2011??????
Temperature
Precipitation


And Summer 2011??????
Temperature
Precipitation
Historical Percent Correct
Pourcentage correct historique
avg=42.1%
avg=34.9%
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What next?
• Study of 2010 for excessive moisture
• Future drought and excessive moisture
• etc
• Still in the develop process
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Gridded data

- Gridded data sets preferred over station data due to improved spatial/temporal coverage
- Gridding data procedure removes unnecessary noise, resulting in smoother data for mapping
- PDSI and SPI derived from the ANUSPLIN data set
- ANUSPLIN was chosen for ability to capture several significant precipitation events, for better comparability with data and for area covered
- Develop data bases of PDSI and SPII for the watersheds (10 KM grid)

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Top 10 most extreme years
PDSI Z-Value

(1901-2005 Agriculture Year (Sept to Aug))

Excessive Moisture		
Year	Value	% Change in Wheat Yield *
1968	9.6	-47.8
1985	8.3	-33.8
1942	7.8	-16.0
1903	7.3	Not Available
1974	6.7	-27.3
2002	6.3	-6.6
1975	5.9	-19.0
1954	5.8	-73.1
1963	5.6	-5.6
1980	5.6	-31.7

Drought		
Year	Value	% Change in Wheat Yield *
1961	-6.0	-79.9
1984	-5.2	-39.3
2001	-4.7	-8.9
1929	-4.7	Not Available
1971	-4.7	-0.8
2003	-4.7	-23.2
1958	-4.3	-64.9
1936	-3.9	Not Available
1967	-3.9	-43.1
1937	-3.8	Not Available

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Average over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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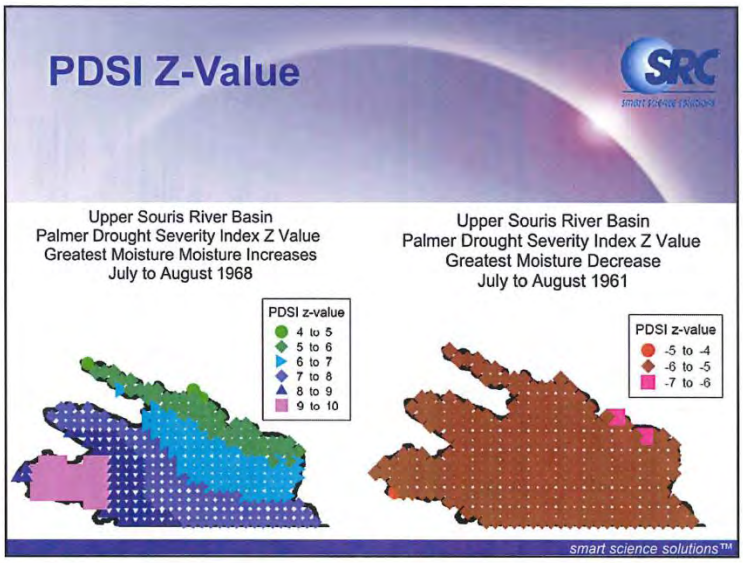

Top 10 most extreme years
SPI – 12 Month (Sept-Aug)(1901-2005)

Excessive Moisture		
Year	Value	% Change in Wheat Yield *
1999	2.4	-5.6
1927	2.1	Not Available
1902	2.1	Not Available
1974	2.0	-27.3
1972	2.0	-17.9
1991	1.9	-7.6
1963	1.8	-5.6
1923	1.7	Not Available
1976	1.7	0.2
1947	1.6	-44.6

Drought		
Year	Value	% Change in Wheat Yield *
1961	-4.2	-79.9
1958	-3.1	-64.9
1967	-2.7	-43.1
1977	-2.7	4.2
1929	-2.7	Not Available
1936	-2.3	Not Available
1937	-2.3	Not Available
1984	-2.2	-39.3
1959	-1.9	-53.6
1989	-1.8	-42.7

*Spring Wheat Percent from 2000 to 2009 10 yr Average
Average over entire watershed

Wheat Yield data:
SK Ministry of Agriculture

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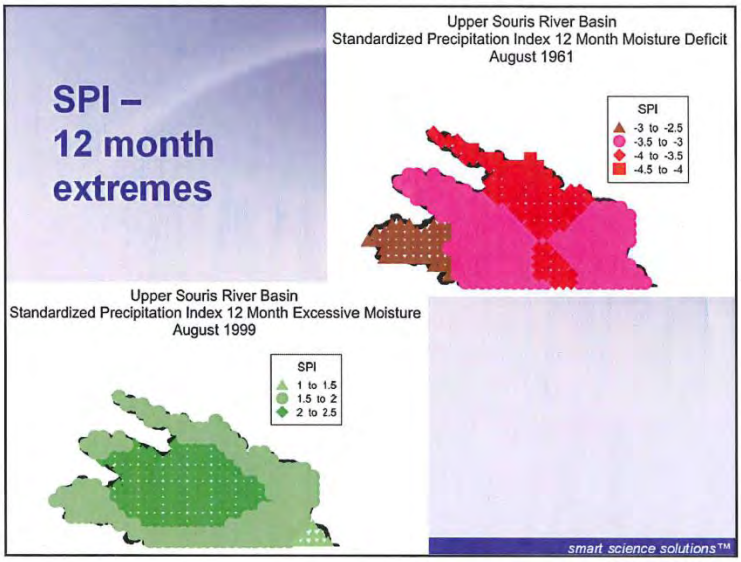
SPI –
12 month
extremes
Upper Souris River Basin
Standardized Precipitation Index 12 Month Moisture Deficit
August 1961
SPI
-3 to -2.5
-3.5 to -3
-4 to -3.5
-4.5 to -4
Upper Souris River Basin
Standardized Precipitation Index 12 Month Excessive Moisture
August 1999
SPI
1 to 1.5
1.5 to 2
2 to 2.5
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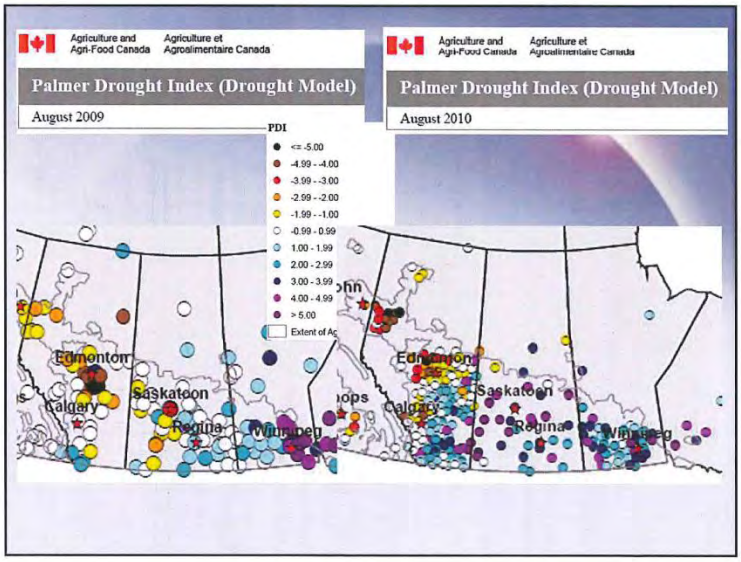
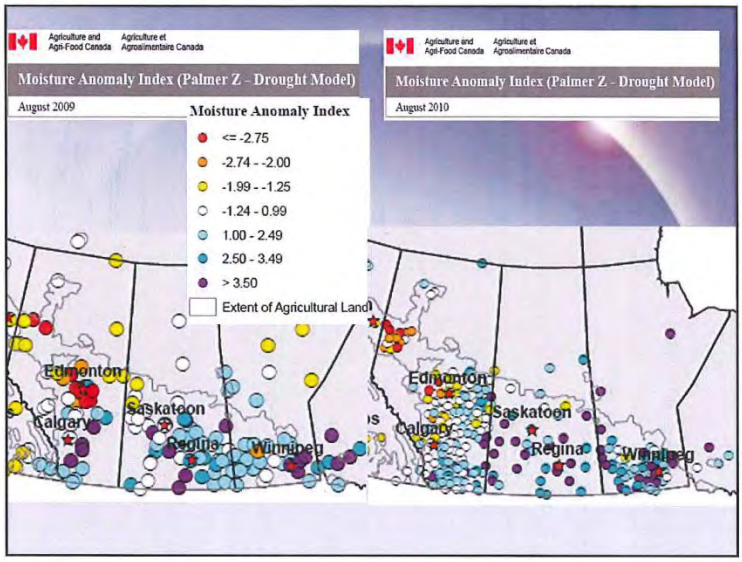

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Palmer Drought Index (Drought Model)
August 2009
PDI
<= -5.00
-4.99 - -4.00
-3.99 - -3.00
-2.99 - -2.00
-1.99 - -1.00
-0.99 - 0.99
1.00 - 1.99
2.00 - 2.99
3.00 - 3.99
4.00 - 4.99
> 5.00
Edmonton
Saskatoon
Calgary
Regina
Winnipeg
Palmer Drought Index (Drought Model)
August 2010
Edmonton
Saskatoon
Calgary
Regina


Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Moisture Anomaly Index (Palmer Z - Drought Model)
August 2009
Moisture Anomaly Index
<= -2.75
-2.74 - -2.00
-1.99 - -1.25
-1.24 - 0.99
1.00 - 2.49
2.50 - 3.49
> 3.50
Extent of Agricultural Land
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Moisture Anomaly Index (Palmer Z - Drought Model)
August 2010
Edmonton
Calgary
Saskatoon
Regina
Winnipeg