Canadian Water Resources Journal / Revue canadienne des ressources hydriques

ISSN: 0701-1784 (Print) 1918-1817 (Online) Journal homepage: http://www.tandfonline.com/loi/tcwr20

The Drought of 1984 in Southern Alberta: Its Severity and Effects

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Abstract:
Many of the seemingly unrelated events of irrigation water-supply problems, grasshopper infestations, and dryland crop failures of the summer of 1984 are related to a sequence of climatic events that began during the previous year. Even before the 1984 growing season began, analysis of precipitation data, overwinter soil moisture measurements, snowpack surveys, river-flow data, and grasshopper survey information indicated that the potential existed for serious agricultural problems in southern Alberta. Examination of historical data indicated that the drought of 1984 was as severe as those encountered during the 1930's. The effects on agriculture, however, were much different.

Résumé:
Plusieurs évènements n'ayant à première vue aucun rapport entre eux comme les problèmes d'approvisionnement en eau d'irrigation, les infestations de sauterelles et la perte des récoltes survenue pendant l'été de 1984 sont en réalité reliés à une série d'évènements climatiques qui ont commencé à se manifester l'année précédente. Avant même que les cultures n'aient commencé à pousser, en 1984, l'analyse de données sur les précipitations, l'humidité du sol pendant l'hiver, l'enneignment, les débits des cours d'eau et les populations de sauterelles montraient déjà que de graves problèmes agricoles se préparaient dans le sud de l'Alberta. En se penchant sur les données historiques disponibles, on a pu se rendre compte que la sécheresse de 1984 a été aussi grave que celles des années trente, bien que ses retombées sur l'agriculture aient été très différentes.

Introduction

The summer of 1984 was marked by a severe drought across southern Alberta and Saskatchewan. Dryland crops dried up before harvesting and producers reported millions of dollars in losses. Farmers who irrigate their crops and are usually less affected by such dry spells, had trouble keeping sufficient water on their fields. Owing to the low spring runoff from the mountains, the stream flows in the Oldman and Bow Rivers were far below normal and some irrigation districts could not supply enough water to meet the demands. Added to these drought problems, there was a severe grasshopper infestation.

When examining the effects of water resources on agriculture, drought situations present special problems. Often the effects of drought or dry spells are many and seemingly unrelated, although the causes are related.

A synthesis of data from various agricultural and environmental monitoring programs is presented here to illustrate the effects and severity of the 1984 drought.

The 1983-84 Crop Year

An examination of weather records indicates that during the spring and summer of 1984, less-than-average precipitation was recorded in most of southern Alberta. For example, Lethbridge received only 94 mm during April, May, and June (Figure 1). More than 30 days passed without rainfall from late June to late July. However, the severe effects on water supply and agriculture cannot be attributed entirely to the dry growing season. The drought actually had its beginnings

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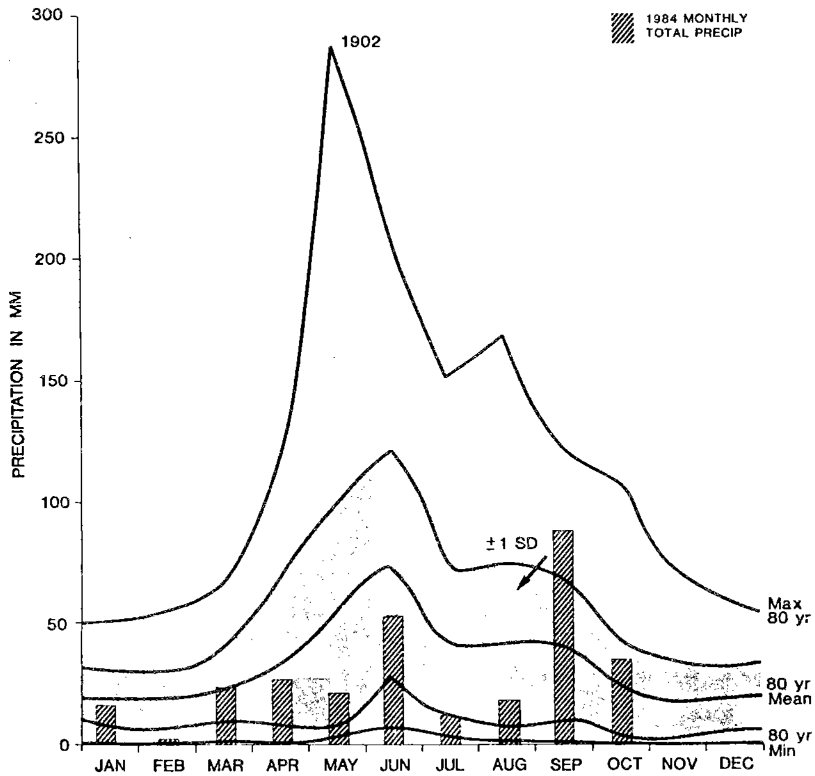
Figure 1: 1984 monthly precipitation and 80-year maximum, minimum, and mean statistics for the Agriculture Canada Research Station at Lethbridge, Alberta. Shaded zone represents one standard deviation.



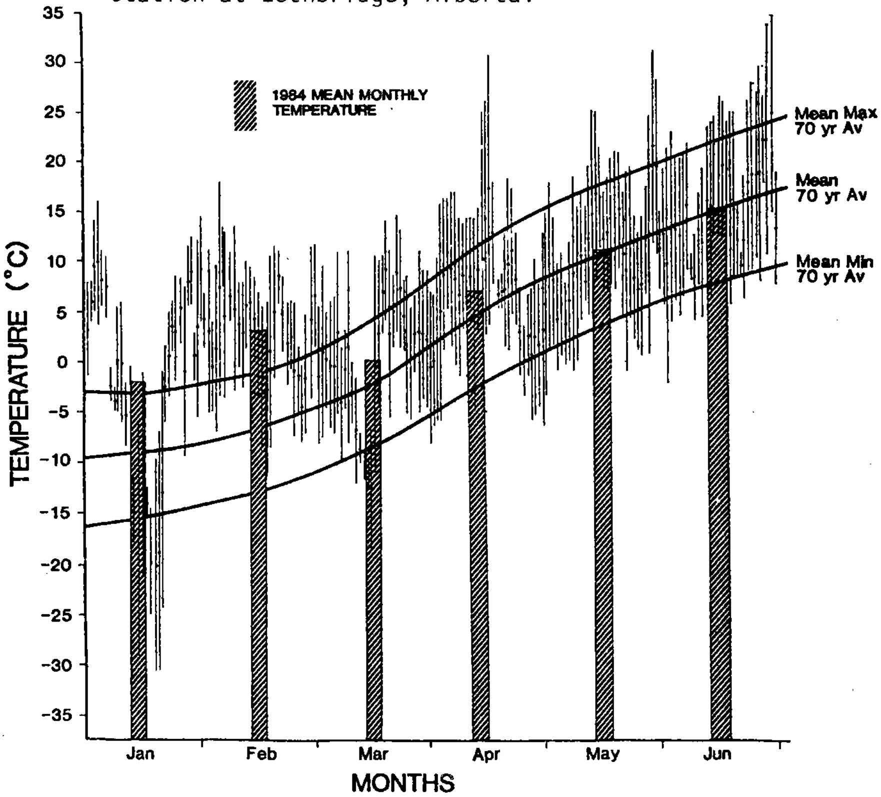
during the fall and winter of 1983.

Fall and Winter
Since crop growth normally removes all available moisture from the soil during each growing season, dryland farming operations depend on precipitation during the fall and winter to ensure adequate soil moisture reserves at planting time. Irrigation practices also rely on overwinter moisture accumulation, although to a lesser extent. Most irrigation systems in western Canada have insufficient capacity to sustain maximum crop growth when precipitation is well below normal. More importantly for irrigation, adequate fall and winter precipitation is required to replenish reservoirs and build snowpack in the mountains to ensure sufficient stream flow during the spring and summer months.

Although Lethbridge is not representative of all of southern Alberta, data from this location do indicate the trends of the 1984 drought. The Agriculture Canada Research Station at Lethbridge, which monitors climatic variables, reported that the 1983-84 fall and winter period was one of the driest on record (Grace, 1984a, 1985b). Only 89 mm of precipitation fell from August 1983 to March 1984, compared with the 82-year mean of 178 mm for this period. Such a dry winter occurred only 4 times in the 82 years of weather records at the Research Station. The greatly reduced precipitation resulted in little moisture stored in the soil.

In addition to the lack of moisture, above-normal temperatures were recorded in southern Alberta for January, February, and March (Figure 2). This area traditionally has the highest frequency and intensity of chinooks in western North America (Longley, 1966), and the 1984 winter was even milder

Figure 2: 1984 daily temperature range and monthly mean temperatures for the months of January to June and the 70-year monthly mean, maximum and minimum termperature data for the Agriculture Canada Research Station at Lethbridge, Alberta.



than usual. For example, mean daily soil temperatures to a depth of 3 meters for half the month of January and all of February and March were above 0°C at Lethbridge. The combination of above-freezing temperatures, high winds, and low humidity depleted any soil moisture reserves that had accumulated.

During the same period, poor snow pack conditions in the mountains were reported by the Alberta River Forecast Centre, Alberta Environment (Anon., 1984b). Alberta Environment monitors snowpack conditions at 37 mountain locations in Alberta from February to May and issues river flow forecasts. Representative snow-course data (Table 1) for three sampling locations in the headwater areas of the Oldman River Basin indicate that snow pack ranged from 48 to 61 percent of normal. Therefore, low stream flows were anticipated in the Oldman River during the spring and summer runoff period. The potential problem for irrigation water supply was apparent.

Spring

Above-average precipitation for the spring months was required to ensure normal crop development for dryland crops and to provide adequate stream flow for irrigation systems. Unfortunately, precipitation was below normal for the months of April, May, and June, with May rainfall less than half the 80-year average. Precipitation from May 1 to mid-July ~~(Table 2)~~ ranged from 40 to 60 percent of normal across southern Alberta. Only in central and northern Alberta did rainfall approach or exceed normal levels.

Summer

The limited soil moisture reserves of early spring were largely depleted by early

Table 1: Snow pack in the headwaters of the Oldman River Basin (March 27, 1984).

Sampling location	1984	21-year mean	Percent of normal
Wilkinson Summit	99	189	52
West Castle	226	474*	48
Allison Pass	307	504	61

*Mean of 18 years of data. Amounts given in mm-water equivalent.

Alberta River Forecast Center, Alberta Environment.

Table 2: Growing season precipitation (from May 1 to July 23, 1984).

Location	Actual (mm)	Normal (mm)	Percent of normal
Lethbridge	72.7	169.0	43
Vauxhall	70.2	123.8	57
Manyberries	65.2	129.8	50
Foremost	84.0	139.2	60
Medicine Hat	86.8	136.1	64
Calgary	157.5	185.9	85
Edmonton	170.3	180.5	94
Beaverlodge	169.5	159.4	106
Grande Prairie	211.3	149.5	141
Peace River	261.6	131.3	199

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summer, a time when cereal crops require high amounts of moisture for reproductive growth and grain development. However, instead of receiving the needed rain, the southern parts of Alberta entered a dry period. A total of 36 days without precipitation was recorded at Lethbridge from June 23 to July 28 (Table 3).

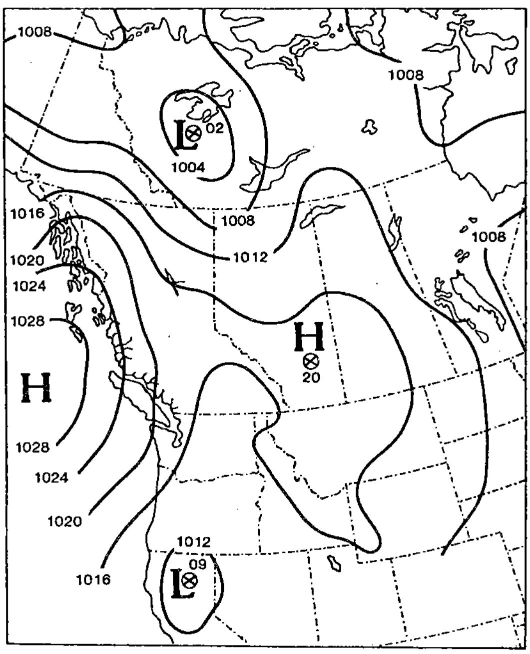
The kind of pattern that generally prevents moisture from entering southern Alberta is illustrated in Figure 3. This is a surface pattern for July 17, 1984, a warm, dry day during the June-July dry period. Major features of this map are the extension into southern Alberta of the Pacific high-pressure ridge and the location of a low-pressure system well to the north,

Table 3: Longest durations of dry conditions (<0.1 mm precipitation) at Lethbridge in the June and July growing period (1936-1984)

Year	Period	Duration
1979	Jul 14 to Jul 24	10 days
1977	Jun 17 to Jun 27	10 days
1957	Jul 17 to Jul 29	12 days
1947	Jul 4 to Jul 23	17 days
1960	Jul 4 to Aug 1	28 days
1984	Jun 23 to Jul 28	36 days

Data courtesy of the Atmospheric Environment Service, Environment Canada.

Figure 3: Surface pattern for western Canada, at 0000 hours, GMT, on July 17, 1984.



just south of Great Bear Lake.

On a crop-year basis, i.e., August to August, only 234 mm of precipitation was recorded in Lethbridge in 1983-84 (Figure 4). Normally, the area received 405 mm during that time. Owing to the reduced snow-pack conditions, stream flow in the Oldman River was reported at 52 percent of normal in June and 50 percent in July (Anon., 1984b). As a result of reduced supply and increased demand, the Lethbridge Northern Irrigation District required four general system shutdowns during the summer of 1984, the most in one year since it began service in 1924 (F.A. Ross, pers. comm.).

Soil Moisture

When considering the effects of drought on agriculture it is important to remember that it is not just the lack of rain that causes a drought, but also the timing of precipitation events. Certainly, any one year may have above-normal percipitation, but if it occurs at a time when crops cannot utilize the moisture then the rainfall is of little use and a drought situation can be defined to exist. If a precipitation event is followed by very hot, dry and windy weather, then the water is of little benefit to crop growth because of high evaporation losses. Such was the case during June of 1984. Twenty-four millimeters of rain fell in Lethbridge on June 21. This was followed by a week of clear, hot (27 to 35°C), dry (21 to 34 percent RH), and windy (30 to >70 km/h) weather. Within a few days, much of the moisture provided by the rain was lost to the atmosphere and did little to avert crop damage. For the crops, the rainfall had little significance.

Soil moisture, therefore, is the key in assessing drought conditions for crops. For example, the 1974 growing season (May to July) in Lethbridge was dry with only 52 percent of normal rainfall recorded, yet average and above-average crop yield were reported for this year from historical experimental plots on the Research Station in Lethbridge (unpublished data). Soil moisture reserves were adequate during the dry growing season owing to above-normal precipitation in late winter.

In contrast, soil moisture at the Lethbridge Research Station research plots in mid-July 1984 was low (Table 4). Under a winter wheat crop, soil moisture contents to a depth of 150 cm were near the wilting point, or a soil

Figure 4: Accumulation of precipitation during the 1983-84 crop year at the Agriculture Canada Research Station at Lethbridge, Alberta.

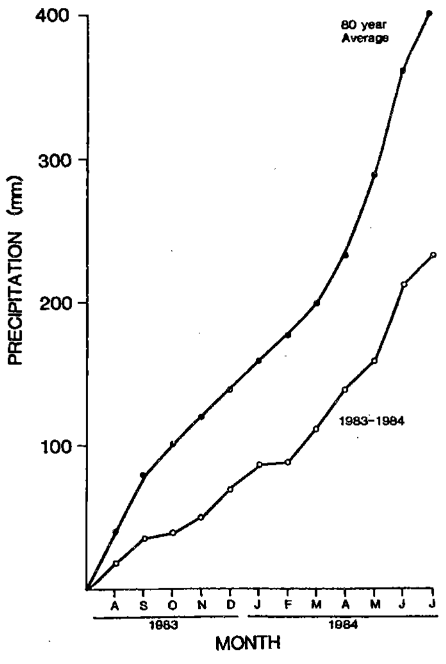


Table 4: Soil moisture (percent of dry weight) on July 26, 1984.

	Plots		
Depth (cm)	Winter wheat	Blade fallow	Chemical fallow
0- 30	6.6	12.0	13.9
30- 60	6.7	8.5	11.9
60- 90	6.5	7.5	8.0
90-120	7.3	8.2	9.4
120-150	8.6	9.9	10.5

Based on data collected at the Agriculture Canada Research Station, Lethbridge, Alberta.

moisture content of approximately 8.5 percent (wt/wt) for this soil. Plots in fallow, which normally have 17 to 20 percent moisture at 30 to 150 cm depths, were all dry with average values ranging from 7.5 to 11.9 percent at these depths. (Field capacity for these soils is approximately 19 to 20 percent.)

Unfortunately, data on the rate of soil drying do not exist. However, class 'A' pan evaporation can be used as an indication of the potential for evaporation. During the 1984 growing season at the Lethbridge Research Station, pan evaporation rates averaged 20 percent higher than the 17-year mean.

Crop Losses

Across southern Alberta and Saskatchewan, crop losses and reduced yields were reported during the summer of 1984. The magnitude of damage caused by the drought conditions is difficult to assess. The Alberta Wheat Pool monitors and regularly reports crop development and production. In 1984 they reported that an estimated one million acres of land were taken out of production in southern Alberta alone (D.B. McIntyre, pers. comm.).

Although the acreage of wheat planted in southern Alberta was slightly higher than the 5-year average (Table 5), both yields and total production were low relative to previous years. Total production of all wheats was reduced by almost one million tonnes in the southern crop districts. In the Lethbridge Crop District, yields for all of the major cereal crops, even those traditionally grown on irrigated land, were below the 1983 levels. The most dramatic decrease in yields occurred on dryland crops such as Hard Red Spring wheat (HRSW), which was reduced by 46 percent (Table 6). Actual losses are much higher since these values do not include yields that were too low to warrant harvesting. For example, the total acreage of HRSW harvested in 1984 was only 50 percent of the 1983 total. Some crops had such poor yields that they were left standing in the fields or used for forage.

Grasshoppers

Climatic conditions that resulted in drought and crop losses in 1984 also contributed to the severe grasshopper outbreaks experienced across the prairies from June to September, 1984. Annual surveys of breeding populations at the beginning of August indicate that the grasshopper population had been on the increase in Alberta since 1978, and increased dramatically in 1983 and 1984 (Johnson, 1984).

The sunny, dry weather of August, 1983

Table 5: Six southern Alberta crop districts - 5-year averages vs. 1984.

	Yield (kg/ha)		Area (x1000 ha)		Production*	
	Average	1984	Average	1984	Average	1984
All wheats	2203	1544	1,451.5	1,579.5	3.2	2.4
Barley	2707	1670	688.5	526.5	1.9	0.9

*Production data in millions of tonnes per hectare. Data courtesy of the Alberta Wheat Pool.

Table 6: Lethbridge-Brooks crop district - 1983 vs. 1984.

	Yield (kg/ha)		Harvested area (ha)	
	1983	1984	1983	1984
Soft white spring wheat†	4435*	3515	N/A	22,275
Hard red spring wheat	2601	1405	293,220	149,445
Durum wheat	2205	1351	66,825	71,685
Winter wheat	2030	1855	32,805	59,130
Barley	2973	2355	106,110	72,900

†Grown only under irrigation.

*Approximate value.

Data courtesy of the Alberta Wheat Pool.

provided excellent conditions for grasshopper breeding and egg-laying. The eggs are laid in pods 2- to 5-cm deep in the soil and hatch the following spring. Temperatures below -20°C at this depth will kill the eggs, especially if the cold remains over extended periods. However, the effects of air temperatures below -20°C for 19 days in December, 1983 were ameliorated by an insulating layer of snow. Soil temperatures at the Lethbridge Research Station, for example, never fell below -11°C at a depth of 5 cm. Temperatures in January and February were above normal (Figure 2) and, consequently, the rate of mortality of overwintering grasshopper eggs was low. Eggs collected in February, 1984 showed nearly 90 percent survival, compared with values as low as 12 percent recorded in past years (R.M. White, unpublished data).

Reduced mobility and growth rates, as well as increased risk of fungal infections and nymph mortality, occur during cool, wet spring weather. A wet spring can result in the virtual disappearance of a large population of young grasshoppers, such as occurred in 1951-52. However, the warm and dry spring weather in 1984 produced dramatic population increases due to rapid growth and high survival of the nymphs (see MacCarthy, 1956; Gage and Mukerji, 1977; Smith and Holmes, 1977).

As a result of the sequence of climatic conditions we have described, grasshopper populations in 1984 exhibited increases (Figure 5) around loci established in 1983. The area rated severe to very severe increased from 4,250 km^2 in 1982 to 4,970 km^2 in 1983 and 15,250 km^2 in 1984. The increase in the grasshopper population was even more significant when geography was considered. The entire outbreak was confined to the more southerly counties, with approximately 40 percent of the area south of 52° north latitude rated moderate to very severe for the 1985 crop year.

It is difficult to separate the damage caused by grasshoppers during 1984 and that which is attributed to the drought. Direct losses to crop producers from grasshoppers were estimated to exceed $4 million in Alberta in 1984. This does not include losses in forage on rangeland, hayfields, and pastures. These losses can be considerable. For example, the USDA Rangeland Insect Laboratory estimates that in the western United States, 23 percent of the forage suitable for grazing livestock is destroyed by grasshoppers, causing an annual loss of nearly $400 million (Hewitt and Onsager, 1983). In southern Alberta, there are approximately one million hectares of forage and pasture land, where grasshopper damage is likely of the same magnitude as in the western United States.

The Dirty Thirties

Although the media made many references during the summer of 1984 to the drought conditions of the 1930's, there are few grounds on which to compare the drought of the 1930's and the drought of 1984. The major problems during the 1930's were caused by poor soil management, improper tillage practices, major infestations of grasshoppers and other insects, and a poor economy. With modern techniques of trash cover, minimum tillage, and strip farming, wind erosion is less of a problem. Pest management programs today include extensive monitoring and control procedures. Government programs and crop insurance have alleviated some of the worst of the economic problems faced by producers during the 1930's.

From a climatic point of view, the minimum precipitation at Lethbridge during the 1930's, 287 mm, occurred in the 1930-31 crop year. The total for 1983-84 was only 213 . The dry years of 1930-31 and 1935-36 would probably have resulted in reduced yields even with the use of modern agricultural practices. However, when assessing the effects of drought, absolute differences in precipitation amounts can be misleading. Crop failures may occur during one year and not in another even though both years have the same total precipitation. Timing of precipitation events and their effect on soil moisture are the critical elements in assessing droughts.

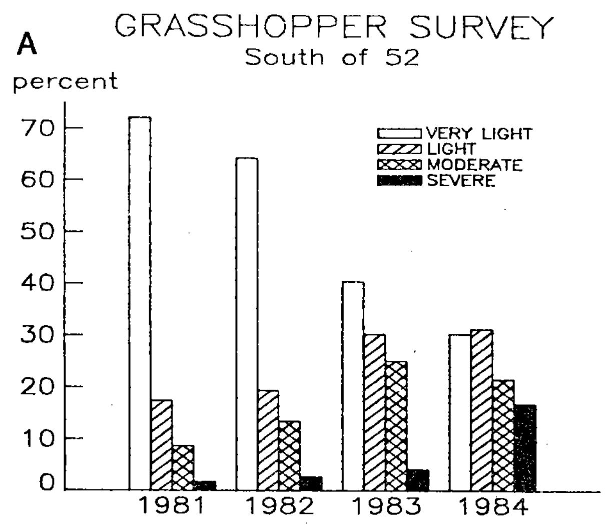
Recently, Dr. K.D. Hage at the University of Alberta developed a dry-year or drought index for southern Alberta (Hage, in press). The index is derived from averaged climatic data and from community histories that encompass most of the settled areas of southern Alberta. According to this index (Table 7), 1984 was the fourth worst drought year since 1888, the first year for which Hage attempted to estimate a value. According to his index, the drought of 1984 was more severe than those

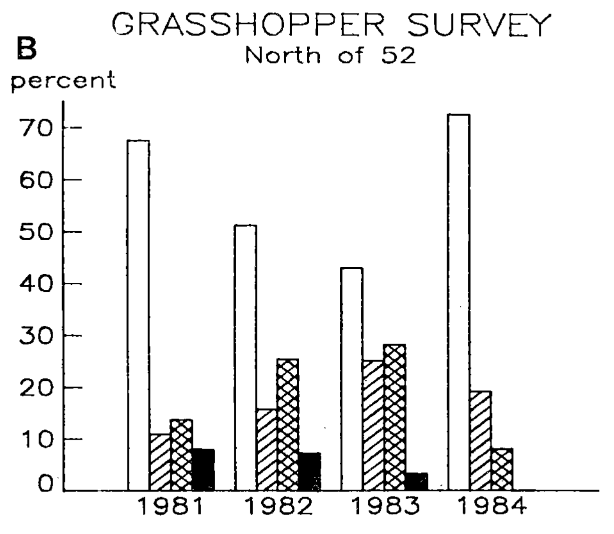
Table 7: Drought index

Year	Index
1910	.60
1919	.54
1918	.47
1984	.39
1930	.34
1936	.33
1922	.33
1961	.32

Courtesy of K. D. Hage, pers. comm.

Figure 5: Percentage of land infested with grasshoppers from 1981 to 1984 in (a) southern Alberta, south of 52° north latitude and (b) northern Alberta, north of 52° latitude. Categories are based on densities of breeding adults in late summer. Areas rated moderate require monitoring and possibly control measures; severe areas require control measures.





in the 1930's and the worst in 65 years.

A drought index based on soil moisture measurements would provide a more accurate assessment of the severity of drought. However, such data do not exist for extended periods.

Summary and Conclusions

Many of the seemingly unrelated events of irrigation water-supply problems, grasshopper infestations, and dryland crop failures of the summer of 1984 are related to a sequence of climatic events that began during the previous year. Even before the 1984 growing season began, analysis of precipitation data, overwinter soil moisture measurements, snowpack surveys, river flow data, and grasshopper survey information indicated that the potential existed for serious agricultural problems in southern Alberta. Continued reporting of data obtained by agricultural and environmental monitoring programs allows producers to make more informed cropping and management decisions.

Acknowledgements

The authors wish to acknowledge F.A. Ross, Lethbridge Northern Irrigation District; D.B. McIntyre, Alberta Wheat Pool; G.H. Hewitt, USDA Rangeland Insect Laboratory; W.D. Hume, Atmospheric Environment Service, Environment Canada; and K.D. Hage, Geography Department, University of Alberta who provided information necessary for the preparation of this paper. A special debt of gratitude is owed L.J.L. Sears for editorial assistance.

References

Anon. 1984a. *Agricultural Weather.* AgWx. Vol. VII, No. 5. Alberta Agriculture.

Anon. 1984b. "Water Supply Outlook and Snow Survey Bulletin". *Alberta River Forecast Centre and Survey Branch Monthly Reports.* Alberta Environment.

Gage, S.H. and M.K. Mukerji. 1977. "A Perspective of Grasshopper Population Distribution in Saskatchewan and Interrelationship with Weather". *Environmental Entomology.* 6:469-479.

Grace, B. 1984a. "Precipitation in Southern Alberta: Can You Trust the Average?" *Mimeo report to the Foremost Producers.* Agriculture Canada, Lethbridge Research Station. 11 pp.

Grace, B. 1984b. "Odds Against Getting Enough Rain". *News Release*, April 1984. Lethbridge Research Station, Lethbridge, Alberta.

Hage, K.D. (in press) "Weather Extremes in Alberta: 1880 to 1960". *Climatology Bulletin.*

Hewitt, G.B. and J.A. Onsager. 1983. "Control of Grasshoppers on Rangeland in the United States–a Perspective". *Journal of Range Management.* 36:202-207.

Johnson, D.L. 1984. "The 1984 Alberta Grasshopper Forecast". In Sears, L.J.L. and D.B. Wilson (eds.), *Research Highlights–1983.* Agriculture Canada Research Station, Lethbridge, Alberta.

Longley, R.W. 1966. "The Frequency of Chinooks in Alberta". *The Albertan Geographer.* 3:20-22.

MacCarthy, H.R. 1956. "A Ten-year Study of the Climatology of *Melanoplus mexicanus mexicanus* (Sauss.) (Orthoptra: Acrididae) in Saskatchewan". *Canadian Journal of Agricultural Science.* 36:455-462.

Smith, D.S. and N.D. Holmes. 1977. "The Distribution and Abundance of Adult Grasshoppers (Acrididae) in Crops in Alberta, 1919-1975". *The Canadian Entmologist.* 109:575-592.