A LIGHTNING CLIMATOLOGY FOR MANITOBA USING CLOUD-TO-GROUND STRIKE DATA FROM A LIGHTNING DETECTION NETWORK

by

Irene Hanuta

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in partial fulfillment of the requirements
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ABSTRACT

While thunderstorm data have been traditionally collected at first order weather stations, this thesis uses lightning detector data with a higher spatial and temporal resolution as a source of thunderstorm information. Cloud-to-ground lightning strike data for Manitoba during 1985 have been analyzed for spatial variability and diurnal/seasonal distribution. Almost 68 000 strikes were detected over a four month period with July recording the most activity. Three areas of the province had the greatest concentration of lightning strikes, indicating some influence by topography and position of large lakes. Comparisons are made between thunderstorm climatologies derived from lightning detectors and those from weather stations. Forest fire and Manitoba Hydro disruption data are compared with lightning distributions. A selection of the most active lightning storms was chosen in order to study associated weather patterns.

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I am very happy to dedicate this thesis to my dad, Nick Hanuta.

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CHAPTER 1
INTRODUCTION

1.1 OBJECTIVES

The objectives of this study include a preliminary presentation of a lightning climatology for Manitoba showing frequency distributions of all lightning strikes in time and space and their variability. Areas will be identified which experience high lightning frequencies. Times when lightning is more common will also be identified for different parts of the province. Recently available information from a lightning detection network will be compared with traditional Atmospheric Environment Service (AES) thunderstorm data to provide an improved thunderstorm climatology for Manitoba. Comparisons will be made between lightning detector data and forest fire occurrences and power disruption locations. A synoptic weather analysis of typical lightning storms will also be presented. Using lightning detector data in conjunction with other weather data to examine synoptic patterns and lightning distributions can provide a better estimate of forest fire and hydro outage hazard areas. This study aims to supplement the present knowledge of lightning and thunderstorm information for Manitoba by identifying lightning strike hazard areas.

1.2 THE STUDY AREA

The centrally located province of Manitoba extends from 49° N to 60° N. It stretches from approximately 95° W (in the south) angling northeastward to about 89° W (in the north) to a western limit ranging from 101° W (in the south) slightly angling northwestward to 102° W at the northern border. Covering 652 000 km^2, Manitoba includes a diverse range of geographic features, both natural and human. A mainly flat surface topography dominates the southern half of Manitoba with a line of remnant hills (rising from 300 m (1000 ft) to 600 m (2000 ft) above the plain) scattered in the western sector of the province marking the transition from a generally higher elevation west of these hills (second prairie level) to the lowland areas of central Manitoba (first prairie level). Elevation increases slightly at the far eastern sector of the province extending into the north following the lee side of Lake Winnipeg. Numerous lakes and rivers dot the province but Lakes Winnipeg, Manitoba and Winnipegosis cover the greatest areas. Rivers flow eastward and northward eventually draining into Hudson Bay (Figure 1.1).

Vegetation zones can also be roughly delimited (Figure 1.2) and are controlled by such factors as climate, topography, drainage and soil types. Boreal forest cover occurs over much of the rocky northern Canadian Shield corresponding with the cooler climate, the forest transitioning to sub-arctic forest further north as conditions are even cooler and drier. In the southern prairie, grassland dominates, diversifying into a mixture of grassland and woods

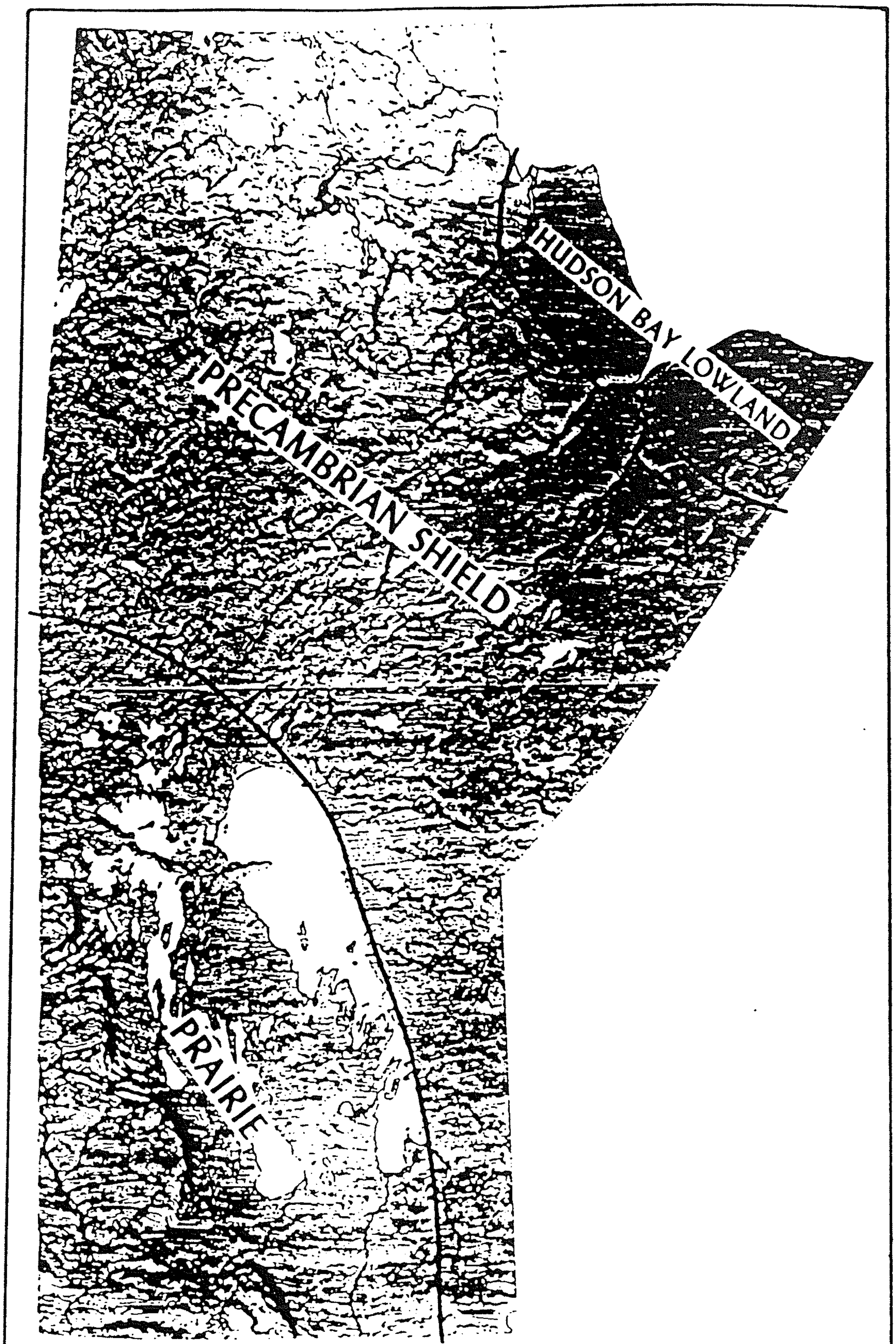

Figure 1.1: Physiographic Regions and Topographic Features of Manitoba. (From LaDochy, 1985)

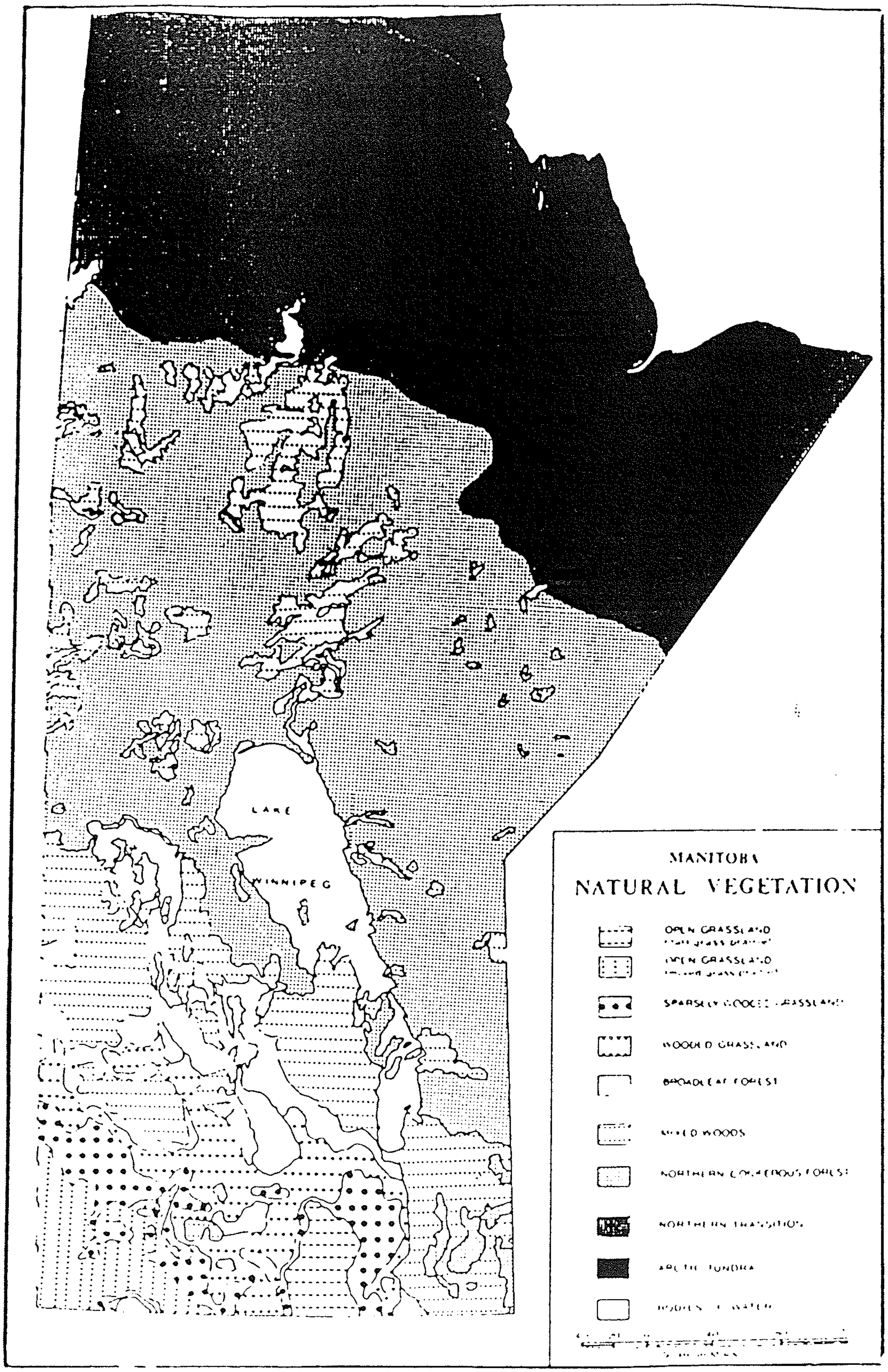

Figure 1.2: Vegetation Coverage in Manitoba. (Atlas of Manitoba, 1983)

between the prairie and forest as a result of the longer, warmer and relatively moister summer season. Most human settlement and development is concentrated in the southern sector of the province with more than 99% of the population found in the southernmost third of Manitoba (south of 53° N) and 55% in Winnipeg alone thus leaving large areas of the north mostly uninhabited.

1.2.1 MANITOBA WEATHER AND CLIMATE

Manitoba's interior position, distant from any ocean gives rise to a continental climate meaning that a great range of temperature occurs between winter and summer but precipitation occurs year round in some form. Manitoba receives most of its precipitation during the summer months with much of the precipitation coming from convective thunderstorms, especially in the southern part of the province where moisture content of the air and temperatures can become sufficiently high to induce instability. Table 1.1 displays long-term average maximum and minimum temperatures at Winnipeg and Thompson (representing southern and northern Manitoba) as well as extremes for the summer months.

Month	Average Maximum Wpg	Average Maximum Tho	Average Minimum Wpg	Average Minimum Tho	Extreme Maximum Wpg	Extreme Maximum Tho	Extreme Minimum Wpg	Extreme Minimum Tho
MAY	18.0	11.9	4.0	0.0	38.0	31.0	-12.0	-26.0
JUNE	23.0	19.2	10.0	5.1	38.0	31.0	-6.0	-11.0
JULY	26.0	22.6	13.0	8.7	42.0	36.0	2.0	-6.0
AUG	24.0	20.8	11.0	6.9	39.0	32.0	1.0	-4.0
SEPT	18.0	12.2	6.0	1.6	37.0	29.0	-8.0	-9.0

Wpg=Winnipeg (south) **Tho=Thompson (north)**

Table 1.1: Average Summer Maximum, Minimum and Extreme Temperatures (°C) (1951-80) for Northern and Southern Manitoba. (World Weather Guide, 1984)

South of 54° N average summer temperatures are 18° C or greater decreasing in a generally northeasterly direction. Between 54° N and about 58° N, average temperatures are around 15° C, falling to 10° C in the far northern sector of Manitoba (Figure 1.3). Summer precipitation varies from the southeast to the northwest with the southeast receiving an average of 305 mm (12 in) or more. North of the lakes extending northwestward amounts range from 254 mm (10 in) to 305 mm and less than 254 mm falls in the far northeast (Figure 1.4). Averages for temperature and precipitation, however, in a continental climate are less meaningful than for other regions because great variability can occur from day to day and from year to year.

The growing season in the southern third of the province, ranging from 80 to 120 days also varies following a south to north

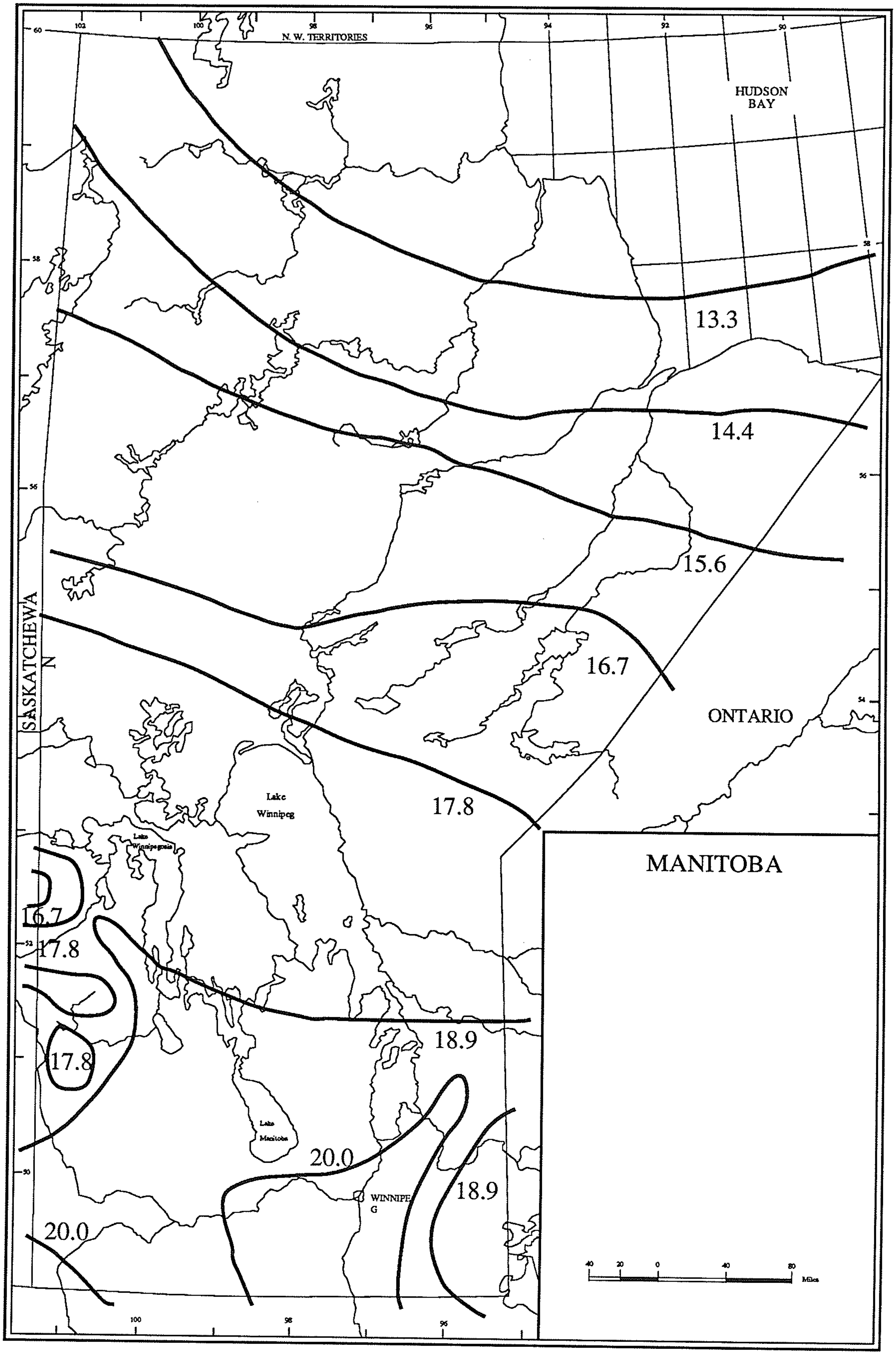

Figure 1.3: July Mean Daily Temperature (°C), 1951-80. (Source: Atlas of Manitoba, 1983)

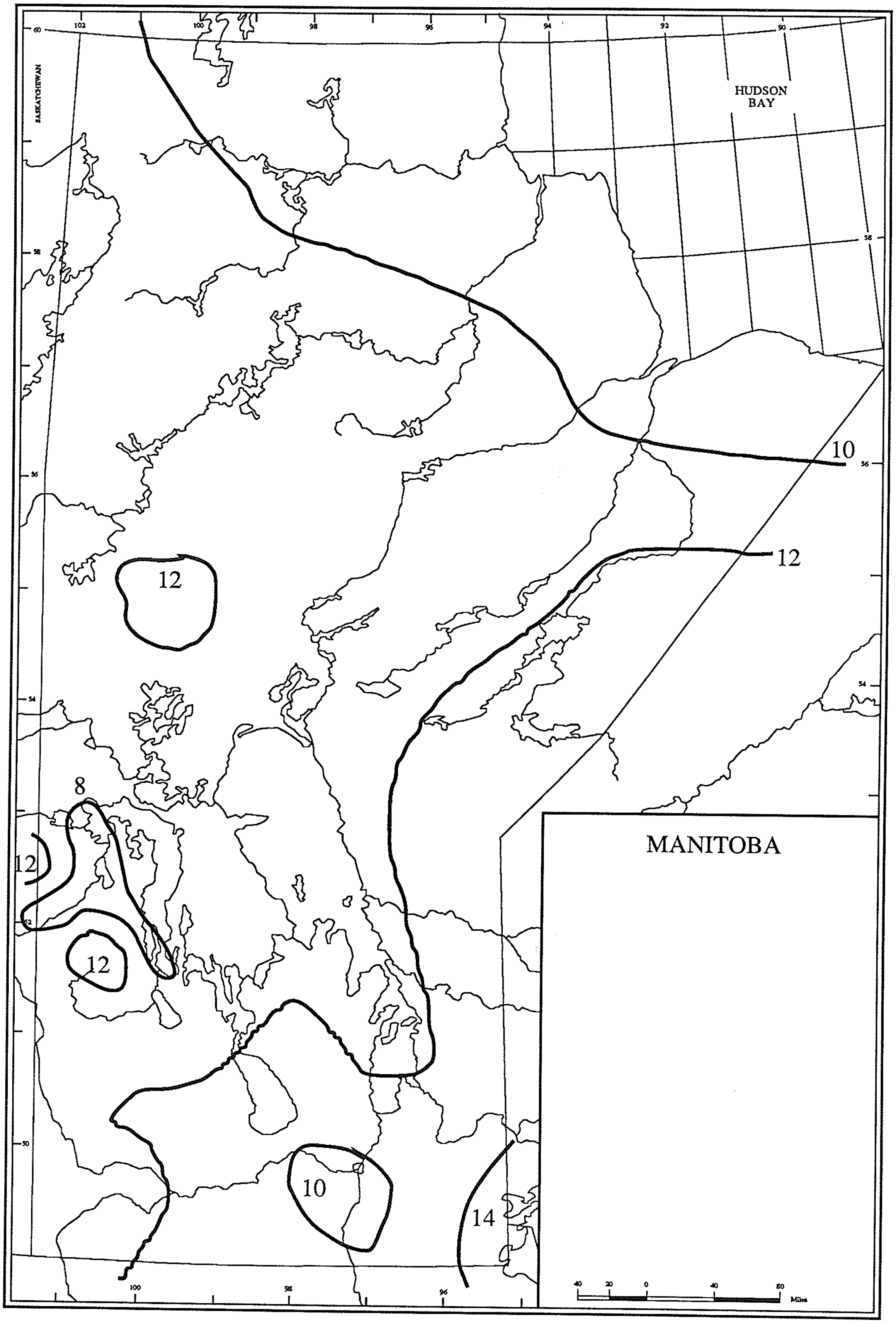

Figure 1.4: Mean Summer Precipitation (May to September) (inches), 1951-80.
(Atlas of Manitoba, 1983)

gradient, with the more southerly locations experiencing the longest season and growing time decreasing as latitude increases (Figure 1.5). Thunderstorm frequency usually increases as the summer progresses, following the seasonal heating increase with peak activity occurring late in June and early July. The southern part of Manitoba receives more thunderstorms than the north (Figure 1.6). Hail and tornadoes can occur during thunderstorms, both being more frequent during mid-June to Mid-August although other months have recorded significant hail or tornadic damage. However, since weather is so variable from year to year, the actual number of thunderstorms can vary significantly from year to year. Lightning, one component that always accompanies thunderstorms also varies from year to year and from thunderstorm to thunderstorm, as some storms can produce a great deal of flashes while others pass with hardly any activity.

1.3 THUNDERSTORM DEVELOPMENT

One definition of a thunderstorm is: "A local storm invariably produced by a cumulonimbus cloud, and always accompanied by lightning and thunder, usually with strong gusts of wind, heavy rain and sometimes with hail. It is usually of short duration, seldom over two hours for any one storm" (Huschke, 1959). In order for a thunderstorm to develop, three conditions must exist: air must be moisture-laden; some triggering agent must be present that will force the moist air to ascend (frontal or orographic lift or insolation heating, for example) and the atmosphere must be unstable so that