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PROVINCE OF QUEBEC
DEPARTMENT OF LANDS AND FORESTS

J. Bourque
Minister

Avila Bédard
Deputy Minister

FOREST PROTECTION SERVICE
Henri Kieffer, Chief

METEOROLOGICAL BUREAU

CLIMATIC CONDITIONS
of the
PROVINCE of QUEBEC
and their RELATIONSHIP *to the*
FORESTS

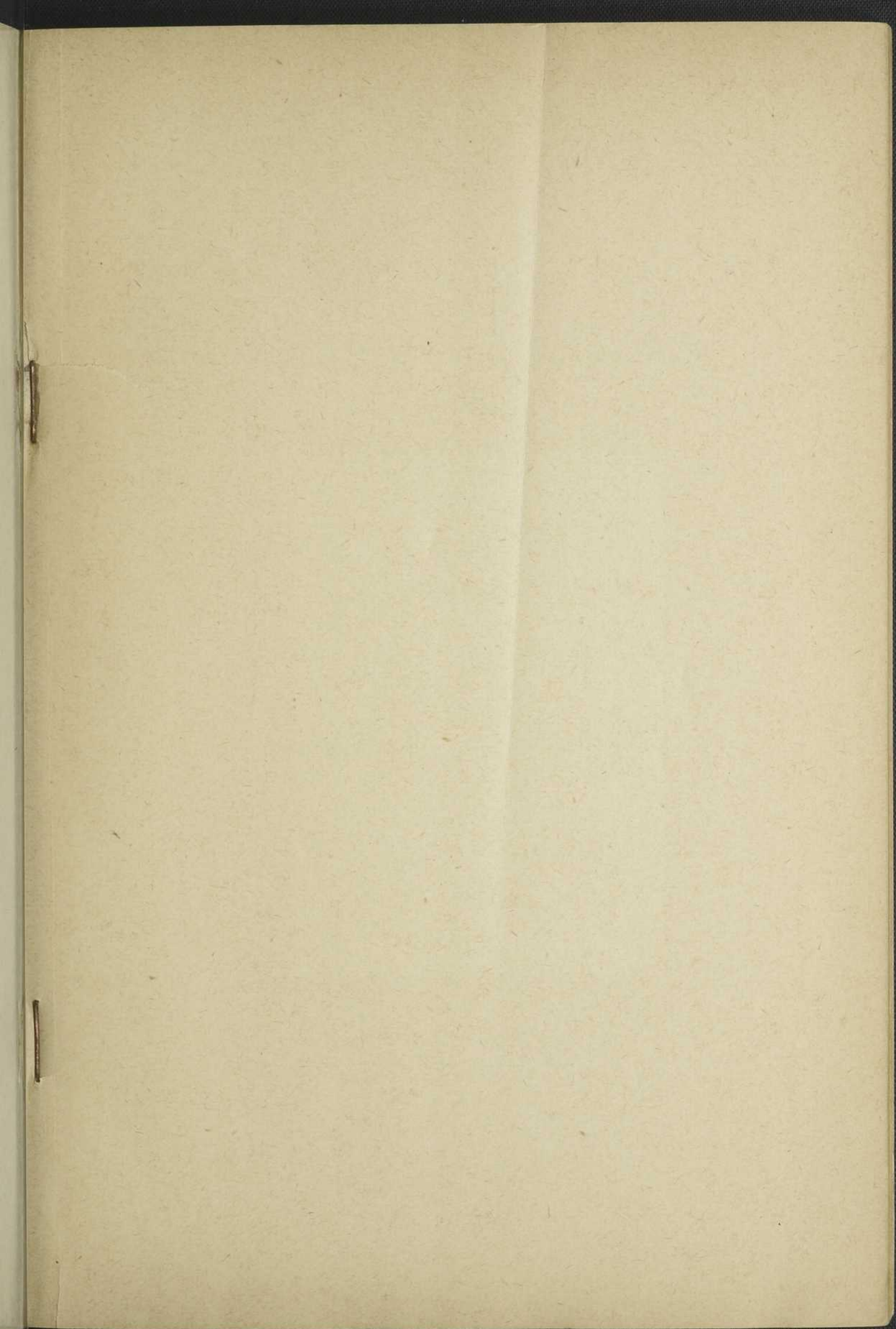
By

G. OSCAR VILLENEUVE, F.E., Q.L.S., M.Sc., Ph.D.

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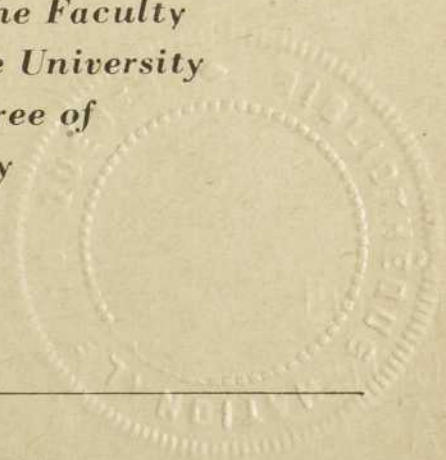
CLIMATIC CONDITIONS
of the
PROVINCE of QUEBEC
and
their RELATIONSHIP to
the FORESTS

by

G. OSCAR VILLENEUVE, Ph.D.

*A Dissertation presented to the Faculty
of the Graduate School of Yale University
in candidacy for the degree of
Doctor of Philosophy*

1946



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DIGEST

The object of this investigation was to analyse the climatological data for the Province of Quebec and to ascertain relationship of these data to the more important features of forest distribution.

Meteorological observations obtained during a decade at more than 200 weather stations have been used as a basis for the investigation of climatic conditions. Standard climatic elements were derived from the original data and are presented in both tabular and graphic form.

The Province of Quebec may be divided into two distinct broad regions: a treeless tundra and a forest formation. The forest formation may in turn be subdivided, from North to South, into three different forest regions: a Coniferous Forest Region, a Mixed Forest Region and a Hardwood Forest Region. These regions and their minor subdivisions or sections have been delimited on the basis of forest composition.

The climatic factors having greatest ecological importance were then considered from the standpoint of their significance in accounting for differences in forest conditions in the four regions and twenty-two sections of the Province.

The writer concluded that climatic elements, particularly temperature and precipitation, are the primary causative factors controlling forest distribution in both the Tundra and Hardwood Forest Regions. In the Coniferous Forest Region the vegetation of sections located in relatively northern latitudes or at high altitudes appears to be dependent more on climate than on soils. Soils in turn are regarded as the decisive factors determining forest distribution in four of the coniferous sections. In the Mixed Forest Region, climate and soils have equal importance in controlling the development of the forest vegetation.

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CONTENTS

	Page
Digest	iii
Acknowledgment	v
I. Introduction	1
II. Review of general literature	3
a) Classification of climates	3
b) Forest distribution in relation to climate	5
III. General geographical features of the Province of Quebec	9
a) Situation	9
b) Area	9
c) Physiography	10
IV. Climatic conditions in the Province of Quebec	12
a) Review of previous work	12
b) Source of climatological data employed in the present investigation	14
c) Nature of climatological data	15
d) Analysis of climatological data	17
1 — Mean annual temperature	17
2 — Mean temperature for July	18
3 — Mean temperature for January	19
4 — Annual range of mean monthly temperature	19
5 — Mean maximum temperature in July	20
6 — Mean minimum temperature in January	20
7 — Range of mean extreme temperatures	21
8 — Mean monthly range of temperature for the year	21
9 — Mean monthly range of temperature in July	21
10 — Mean temperature for the four warmest months	22
11 — Average length of the frost free period	23
12 — Mean annual precipitation	24

13 — Mean monthly summer precipitation.....	24
14 — Mean monthly summer evaporation.....	25
15 — Mean maximum evaporation in summer.....	25
16 — Mean monthly relative humidity in summer.....	26
17 — P-E quotient for the summer.....	26
18 — P-E index for the summer.....	27
V. Forest conditions in the Province of Quebec.....	28
a) Review of previous work.....	28
b) Classification of forest regions and sections employed in the present investigation.....	33
THE TUNDRA REGION.....	35
T-1. Ungava Peninsula Section.....	35
T-2. Labrador Coast Section.....	35
THE CONIFEROUS FOREST REGION.....	37
C-1. Central Transition Section.....	38
C-2. Laurentide Park Section.....	39
C-3. South Shore Plateau Section.....	39
C-4. Gaspé Plateau Section.....	39
C-5. Upper St. Maurice Section.....	40
C-6. Northern Clay Section.....	41
C-7. Northern Coniferous Section.....	41
C-8. North Shore Section.....	42
C-9. Hamilton-Ungava Valleys Section.....	42
C-10. Hudsonian Section.....	43
C-11. Coastal Plain Section.....	43
C-12. East James Bay Section.....	44
C-13. Anticosti Section.....	44
THE MIXED FOREST REGION.....	45
M-1. Temiscamingue Section.....	46
M-2. Laurentian Section.....	47
M-3. Lake St. John Section.....	47
M-4. St. Lawrence Estuary Section.....	48
THE HARWOOD FOREST REGION.....	49
H-1. Upper St. Lawrence Section.....	50

H-2. Eastern Townships Section	50
H-3. Lower St. Lawrence Section	51
VI. Relationship between climatic and forest conditions in the Province of Quebec	52
THE TUNDRA REGION	53
T-1. Ungava Peninsula Section	54
T-2. Labrador Coast Section	54
THE CONIFEROUS FOREST REGION	55
C-1. Central Transition Section	56
C-2. Laurentide Park Section	57
C-3. South Shore Plateau Section	58
C-4. Gaspé Plateau Section	58
C-5. Upper St. Maurice Section	59
C-6. Northern Clay Section	60
C-7. Northern Coniferous Section	61
C-8. North Shore Section	61
C-9. Hamilton-Ungava Valleys Section	62
C-10. Hudsonian Section	62
C-11. Coastal Plain Section	62
C-12. East James Bay Section	63
C-13. Anticosti Section	63
THE MIXED FOREST REGION	65
M-1. Temiscamingue Section	65
M-2. Laurentian Section	66
M-3. Lake St. John Section	67
M-4. St. Lawrence Estuary Section	68
THE HARDWOOD FOREST REGION	69
H-1. Upper St. Lawrence Section	69
H-2. Eastern Townships Section	70
H-3. Lower St. Lawrence Section	70
VII. Summary and conclusions	72
VIII. Bibliography	76

IX. Appendix	81
TABLE I. Stations; Latitude; Longitude; Altitude	83
TABLE II. Stations; Mean annual temperature; Mean temperature for July; Mean temperature for January; Annual range of mean monthly temperature; Mean maximum temperature in July; Mean minimum temperature in January	91
TABLE III. Stations; Range of mean extreme temperatures; Mean monthly range of temperature for the year; Mean monthly range of temperature in July; Mean temperature for the four warmest months; Average length of the frost free period; Mean annual precipitation	97
TABLE IV. Stations; Mean monthly summer precipitation; Mean monthly summer evaporation; Mean maximum evaporation in summer; Mean monthly relative humidity in summer; P-E quotient for the summer; P-E index for the summer	105
TABLE V. Units used in tables and figures	116
TABLE VI. Climatic records in the four regions of the province of Quebec	117
TABLE VII. Climatic records in the Tundra Sections	118
TABLE VIII. Climatic records in the Coniferous Forest Sections	119
TABLE IX. Climatic records in the Coniferous Forest Sections (Continued)	120
TABLE X. Climatic records in the Coniferous Forest Sections (Continued)	121
TABLE XI. Climatic records in the Mixed Forest Sections	122
TABLE XII. Climatic records in the Hardwood Forest Sections	123
FIGURE M-1. Mean annual temperature	124
FIGURE M-2. Mean temperature for July.	125
FIGURE M-3. Mean temperature for January	126
FIGURE M-4. Annual range of mean monthly temperature.	127

FIGURE M-5. Mean maximum temperature in July	128
FIGURE M-6. Mean minimum temperature in January . .	129
FIGURE M-7. Range of mean extreme temperatures	130
FIGURE M-8. Mean monthly range of temperature for the year	131
FIGURE M-9. Mean monthly range of temperature in July.	132
FIGURE M-10. Mean temperature for the four warmest months	133
FIGURE M-11. Average length of the frost free period . .	134
FIGURE M-12. Mean annual precipitation	135
FIGURE M-13. Mean monthly summer precipitation	136
FIGURE M-14. Mean monthly summer evaporation	137
FIGURE M-15. Mean maximum evaporation in summer . .	138
FIGURE M-16. Mean monthly relative humidity in summer	139
FIGURE M-17. P-E quotient for the summer	140
FIGURE M-18. P-E index for the summer	141
FIGURE M-19. Location of weather stations	142
FIGURE M-20. Forest regions and sections of Quebec . . .	143
FIGURE M-20A. Forest regions and sections of Quebec . .	144

INTRODUCTION

FOR over half a century scientists have been giving increasing attention to the recognition and delimitation of the broad patterns of climate, vegetation and soils of the earth. As knowledge accumulated, it became evident that certain patterns existed and that there was a general coincidence in these patterns; that is, similarities were observed between maps of climatic regions or types, vegetation regions and soil regions. These discoveries quite naturally led to consideration of the interrelationships of climate, vegetation and soil, and to study of the causal factors involved, a field of investigation that has proven highly fruitful.

Climate appears to be a « master factor », for it exercises primary control over vegetation distribution and soil development. The three major types of vegetation: forest, grassland and desert, are clearly determined by climate. It is now equally certain that the great soil groups of the world are determined first by climate and only secondarily by other factors.

It is natural that at the outset it was the general relationships between climate and vegetation that attracted attention and investigation. Although the facts and principles that have been established as a result of studying the broad relationships are themselves of high scientific value, they have, perhaps, been of even greater importance in stimulating inquiry into the relations that exist between climate and vegetation in limited areas. It seems evident that an understanding of the general principles of plant distribution in relation to climate is essential as a background for establishing and interpreting the correlation between local climates and local vegetation areas or types. During the course of time, investigations of climates and vegetation types have, quite logically it would appear, progressed from the general to the specific.

Foresters are becoming increasingly aware of the importance of climate, and individual climatic elements, in determining, or at least influencing, forest composition and growth, forest fire danger, and damage by insect pests and fungi. Within comparatively recent years attention has been focused on the influence which climate plays in the development of local races of our important timber trees and it has now become common practice for users of forest tree seed to insist

on information as to the climate of the region of origin. These are only some of the reasons why climatological investigations now receive consideration at practically every forest experiment station in both the United States and Canada.

Within the Province of Quebec, Canada, marked contrasts exist in the climatic and vegetation conditions. In the southernmost part the climate can be designated in a very general way as cool and humid; the forest vegetation consists principally of hardwoods. In the northernmost part, on the other hand, the climate is distinctly arctic, the only vegetation present consisting of lichens, mosses and certain herbaceous and shrubby plants, characteristic of tundra. Between these extremes are two broad zones, each of which is characterized by differences in both climate and vegetation.

A considerable body of climatological data has been collected, particularly during the last decade, at weather stations located throughout most of the Province. Information concerning forest conditions has also been obtained and has been summarized in the form of a regional classification. The object of the present investigation is to analyse the climatological data for the Province of Quebec and to relate these data to the more important features of forest distribution.

REVIEW OF GENERAL LITERATURE

a) Classification of climates

CLASSIFICATIONS of the earth's climates have been attempted since very early times. The beginnings of this study are to be found in the work of the ancients, among whom may be mentioned Parmenide, Hippocrates, Aristotle, Polybius, Posidonius, and Strabo. Supan, Gebelin, Davis and Woeikof have also been considered as authors of importance for their contributions in the field of climatology (Ward, 1918).

Out of the considerable number of classifications of world climates that have been devised, those of Köppen (1918) and Thornthwaite (1931) are particularly noteworthy because they have pointed out the climatic factors which seem most influential in governing plant distribution. These classifications are quantitative systems which use numerical values for defining the boundaries of climatic groups and types.

Köppen started by first accepting the plant classification proposed by A. de Candolle in 1874, which was a division of the earth's vegetation into five principal biological groups under the control of temperature and moisture. Köppen determined the characteristics of the climate of each division by critical values for the coldest and the warmest month, the four warmest months of the year, the driest and the wettest month, the difference between extreme months and also the quotient obtained by dividing the amount of rainfall in the wettest month by the maximum vapor-tension at the mean temperature of the same month. Utilizing these same data, the five climatic divisions of Köppen, corresponding to the five vegetation divisions of de Candolle, were subdivided into thirteen major types of climate. Secondary subdivisions of each major type have also been drawn to bring out the conditions of minor types or sub-climatic regions.

Köppen's classification has been applied by Ackerman (1941) to North America, but with new climatic data and different criteria. The result has been a much more detailed classification of climates than Köppen's first classification.

Instead of employing only temperature and precipitation values for delimiting regional boundaries, Thornthwaite introduced two new

concepts: temperature efficiency and precipitation effectiveness. Temperature efficiency was obtained by dividing mean monthly temperatures by evaporation and precipitation effectiveness was determined by the ratio of rainfall to evaporation.

Thornthwaite adopted the view that in the tropical rain forest where vegetation is dense and growth rapid, the climate must be the most favorable of all. Indeed, temperatures are continually high and rainfall constantly abundant. Therefore, the temperature efficiency and the precipitation effectiveness must be at a maximum. On the other hand, precipitation effectiveness must be at a minimum approaching zero in the tropical desert and temperature efficiency also at a minimum in the climate of perpetual frost. Between these maxima and minima the author defined transitional regions according to the precipitation effectiveness and temperature efficiency. The transitional regions were classified and five rainfall types and six temperature efficiency types were recognized as follows:

<i>Rainfall types</i>	<i>Temperature types</i>
1 — Rain forest	1 — Tropical
2 — Forest	2 — Mesothermal
3 — Grassland	3 — Microthermal
4 — Steppe	4 — Taiga
5 — Desert	5 — Tundra
	6 — Perpetual frost

In addition Thornthwaite recognized four types of seasonal distribution of rainfall:

- 1 — Abundant at all seasons
- 2 — Scanty in summer (abundant in winter)
- 3 — Scanty in winter (abundant in summer)
- 4 — Scanty at all seasons

On the basis of the above rainfall types, temperature types and types of seasonal distribution of rainfall, thirty-two climatic types were recognized and designated by combinations of letters. Thornthwaite applied his classification to the continent of North America in 1931, and in 1933 he classified the climates of the world.

Thornthwaite's treatment of precipitation and temperature data is less empirical than Köppen's and his climatic regions show better agreement with vegetation distribution than did those of Köppen.

Köppen and Thornthwaite excepted, most of the other climatologists have used only small regions or countries as areas of application for their studies (Gorczynski, 1942; Knoche, 1942).

It may be concluded from this review that Köppen and Thornthwaite have based their classification of world climates on temperature and moisture relations with vegetation, and that Thornthwaite seems to have succeeded better than Köppen as a result of having utilized evaporation data in his classification. The classification systems of these two authors still remain the best devices to date because of their basis, temperature and moisture relations, and their worldwide application.

b) Forest distribution in relation to climate

A brief review of the literature will show that climatic elements have been considered as most important in classifying vegetation distribution.

The first comprehensive report on the distribution of forests in the United States was prepared by Sargent (1884). The author ignored political boundaries and divided the United States into ten regions on the basis of the flora. Each floristic region was considered as a « vegetational group » on account of the floristic elements, topography, soil and climate. Indeed, individual species were subordinated to the floristic group, and the floristic group was considered as a product of the physiographic features and climatic elements. The climatic elements mentioned by the author as being causally related to the floristic regions were mean annual temperature, and both annual and seasonal rainfall. Temperature and rainfall, as well as topography and soil, were correlated with the forest vegetation in each of Sargent's ten regions.

Merriam (1894) investigated the geographical distribution of native plants and animals, and divided the North American continent into seven life zones; the flora and fauna of each, although not homogeneous, had distinctive features. In delimiting his zones, Merriam adopted the view that temperature was the most important factor and stated that the northern boundary of any group of plants and animals is governed by the sum of the positive temperatures during the growth and reproduction period. The southern boundary is governed by the mean temperature of the six hottest weeks of the year. For

the computation of the sum of the positive temperatures, the author considered 43 degrees F. as the temperature marking the inception of both physiological activity of plants and reproductive activity of animals. He believed that these two considerations cover the fundamental facts of distribution and he proposed as a project the completion of the boundary surveys of the several zones, the subdivision of the zones on the basis of minor faunas and floras, the tabulation of the distinctive species of each zone and its subdivisions, and the formulation of the subordinate laws governing the restriction of species to particular areas within the principal zones.

Later, another author, Mayr (1925) attempted to correlate forest vegetational areas with certain site factors. Stating that air temperature and humidity govern the distribution of forests, he based his classification on the following climatic elements:

- 1 — Mean annual temperature.
- 2 — Mean temperature for the four warmest months (50 degrees F. being the critical temperature below which no forest exists).
- 3 — The lowest recorded temperature.
- 4 — Last frost in the spring and first frost in the autumn.
- 5 — Average relative humidity from May to September.
- 6 — Amount of rainfall from May to September.

Mayr recognized in North America five forest zones which he subdivided into Atlantic, Central and Pacific regions. He mentioned a tropical forest zone but said that it was left out of consideration because no parallel existed in Europe

Mayr saw evidence that vegetation conditions could not be related to individual climatic factors but that all climatic elements had to be analysed. Among the climatic factors studied he attached much importance to the length of the period of physiological activity, which he called the vegetative period. He used the expression « vegetation therm » to mean the average minimum temperature required by a forest species for growth irrespective of the duration beyond the minimum of one month and half. He found for Alpine larch a vegetation therm of 14 degrees C. but he did not apply this criterion in the delimitation of his forest zones.

Clements (1916) also developed a classification of vegetation. On the basis of growth-forms and climates, he divided the United States into nine forest regions. This author did not study individual climatic factors. Rather he recognized different formations or cli-

maxes which he affirmed to be the product of climate. He stated that the various climaxes are characterized by different climates on account of the dissimilar requirements in temperature, moisture and period of growth.

The last noteworthy classification of the North American vegetation in relation to climate is that of Livingston and Shreve (1921). These authors devised certain methods to correlate climatic elements with forest distribution. They have developed and applied indices of various kinds in order to express in a single formula the effect of several climatic factors. Livingston and Shreve devoted much attention to certain critical values such as the maximum and minimum of temperature and precipitation. They related the vegetational areas to the climatic data; they also discussed the position of isoclimatic lines with respect to areas of similar vegetation or similar groups of plants. In their conclusion Livingston and Shreve stated, as others have, that although individual climatic elements are important in the distribution of plants, all climatic elements have to be considered as a whole because a change in the value of one climatic element alters the influence of the others. In other words, all climatic elements contribute to produce a type of vegetation and their effect is both collective and interdependent.

From this brief review of literature it is possible to summarize the climatic elements that various investigators have considered to be of chief importance in controlling forest distribution. These climatic elements are:

a) *Temperature data*

- 1 — The mean annual temperature.
- 2 — The sum of positive temperatures (above 43 degrees F.) for the growth and reproduction period.
- 3 — The mean temperature for the four warmest months.
- 4 — The mean temperature for the six hottest weeks.
- 5 — The lowest recorded temperature.
- 6 — The length of the frost free period.
- 7 — The maximum, minimum and critical temperatures.

b) *Moisture data*

- 8 — The annual and seasonal rainfall.
- 9 — The average summer relative humidity.

c) *Indices derived from moisture or temperature data*

such as:

- 10 — P-E (Ratio of precipitation to evaporation).

- 11 — P-E multiplied by Ts (Ratio of precipitation to evaporation, multiplied by a temperature summation with 49 degrees F. as unity).
 - 12 — P-S (Total rainfall for average frostless season divided by the number of days in that period).
 - 13 — π -s (Total precipitation for period of average frostless season plus preceding 30 days, divided by the number of days in the average frostless season).
 - 14 — Number of days with critical temperatures or rainfall.
-

GENERAL GEOGRAPHICAL FEATURES OF THE PROVINCE OF QUEBEC

a) *Situation*

QUEBEC, the most easterly of the provinces of Canada, is bounded on the North by Ungava Bay and Hudson Straits, on the West by Hudson Bay, James Bay, the Ottawa River and the Province of Ontario. It is bounded on the South by the States of New York, Vermont, New Hampshire, Maine and the Province of New Brunswick, and on the East by the Labrador coast and the Gulf of the St. Lawrence. The Province of Quebec lies approximately between 45 and 63 degrees latitude North, and 56 and 79 degrees longitude West.

b) *Area*

In 1912, the area of Quebec was exactly doubled, and extended to 703,653 square miles through annexation of the Territory of Ungava. However, in 1927, a decision of the Privy Council gave back to the colony of Newfoundland 102,000 of the 351,780 square miles thus added in 1912. With an actual present area of 594,534 square miles, Quebec is still the largest of the Canadian provinces. The combined area of France, Germany and Spain exceeds only by 2,600 square miles that of Quebec.

The total area of the Province may be divided into two parts: a section north of 52 degrees latitude covering 310,234 square miles considered as inaccessible at present, and a section south of 52 degrees latitude including 284,300 square miles.

The portion of the Province north of 52 degrees latitude comprises the following basins:

Ungava Bay.....	142,025 square miles
Hudson Bay.....	89,907 " "
James Bay.....	64,366 " "
North of St. Lawrence.....	13,604 " "
Saguenay.....	332 " "

310,234 square miles

This area may be classified as follows:

Water.....	15 per cent
Denuded and essentially non-productive	40 " "
Productive of commercial forest.....	30 " "
Productive of non-commercial forest...	15 " "

Thus, the productive and commercial area of the region amounts to approximately 93,000 square miles.

Of the total 284,300 square miles south of 52 degrees latitude, the non-forested area includes the following:

Farm lands.....	9,000 square miles
Pasture.....	4,000 " "
Natural prairies.....	2,200 " "
Various cleared lands.....	9,400 " "
	24,600 square miles

Subtraction of this non-forested area from the total leaves a gross forest area of 259,700 square miles. From this, however, must be subtracted:

Unproductive land.....	20,000 square miles
Water.....	25,000 " "
	45,000 square miles

After allowance is made for the above it is found that the net forest area in Quebec south of 52 degrees latitude is approximately 214,700 square miles.

c) *Physiography*

More than ninety per cent of the Province of Quebec is made up of the vast Precambrian or Canadian Shield, which is considered the most ancient geological formation in the world (Blanchard, 1935). The mountains may be classified in three groups:

- 1 — The Laurentians
- 2 — The Appalachians
- 3 — The Montereigians

The Laurentians skirt the St. Lawrence from Labrador to a point not far from the city of Quebec and then recede, leaving a widening lowland between them and the St. Lawrence river as far as the Ottawa river.

The Appalachians form a mountainous chain which extends in Canada from the frontier in the neighbourhood of Lake Champlain to the city of Quebec, and thence to the gulf, down the St. Lawrence valley and through the Gaspé peninsula.

The Monteregians are situated in the western portion of the St. Lawrence lowlands.

In the Laurentians, along the gulf and the St. Lawrence river, the elevations vary from less than 1,000 to over 3,000 feet. Some peaks of the Appalachians rise to 3,000 feet in the Eastern townships, and somewhat higher than 4,000 in the Gaspé peninsula. The Monteregians are considerably lower. Their elevation rarely exceeds 1,700 feet.

CLIMATIC CONDITIONS IN THE PROVINCE OF QUEBEC

a) Review of previous work

THE climatic conditions of the Province of Quebec have been a subject of speculation until recently, and even now the number of records is not sufficient to give a completely satisfactory representation of the regional climates within the Province. However, since Köppen's and Thornthwaite's classifications of climates are particularly noteworthy, it is of interest to know how they have classified the Province of Quebec.

According to Köppen's classification the Province of Quebec may be divided into three climatic belts:

1 — The southern part, which is a temperate belt with at least a four month period with temperatures between 50 and 68 degrees F. Here summers are cool and winters cold.

2 — The northern part (the tundra region), which has a polar climate. All months are cold.

3 — A belt between these two, called a cold belt by Köppen, where one to four months have moderate temperatures and the rest are cold.

The above divisions determined by Köppen, represent a broad classification based on very few recorded data.

With new data, Ackerman (1941) classified North America according to the Köppen classification and divided the Province of Quebec more precisely. He recognized the following divisions:

1 — A cold region, roughly north of 58 degrees latitude, (ET).

2 — A region of moderate temperature, south of a line approximately marked by 48 degrees of latitude, (Dfb).

3 — A moderately cold region between the preceding regions, (Dfc).

The symbolic letters have the following significance:

E: Polar climate: average temperature of the warmest month below 50 degrees F.

- ET: Brief growing season. Tundra climate: average temperature of the warmest month below 50 degrees F. but above 32 degrees F.
- D: Cold, snowy, forest climate: average temperature of coldest month below 26.6 degrees F.; average temperature of warmest month above 50 degrees F.
- Df: Cold climate with humid winters.
- Dfb: Cool summer: average temperature of warmest month under 71.6 degrees F.
- Dfc: Cool short summer: less than four months over 50 degrees F.

Thornthwaite (1931) also recognized three broad climatic regions in the Province of Quebec: the tundra, the taiga and the humid region. He considered as tundra all the territory north of a line between Hudson Bay and Belle-Isle Strait, while Köppen and Ackerman included only the Ungava and Labrador peninsulas.

Ellis (1937), of the Soils Division of the University of Manitoba, has computed climatic data for Canada by Thornthwaite's formulae. But « due to the relatively small number of stations available, particularly those with any duration of recording, and their general massing along the southern portion of Canada » it was found difficult to make a satisfactory separation of climatic provinces. Based on the data available, the following five climatic provinces were recognized by Ellis in the Province of Quebec:

<i>Descriptive terms</i>	<i>Temperature Efficiency index</i>	<i>Descriptive terms</i>	<i>Precipitation Effectiveness index</i>
1 — Cool Temperate plus	24 — 31	Humid plus	96 — 127
2 — Cool Temperate plus	24 — 31	Humid	64 — 95
3 — Temperate	32 — 47	Humid plus	96 — 127
4 — Temperate	32 — 47	Wet	128 — 191
5 — Temperate	32 — 47	Humid	64 — 95

In the above outline, the descriptive terms used to designate the provinces are those of Halliday (1937). They are only very slightly different from those used by Ellis.

None of these climatic provinces are situated in the coldest region delimited by Köppen's or Thornthwaite's classification. The first and second provinces mentioned above may be located in either Köppen's or Thornthwaite's Middle region of Quebec. The third and fourth seem to agree with the Southern region of these authors and the last one with Thornthwaite's Southern portion of Quebec although not

exactly as far as the actual boundaries are concerned. The delimitation of Köppen's, Ackerman's and Thornthwaite's climatic provinces of Quebec is too general and drawn on too small-scale a map to be compared exactly and advantageously with Ellis and Halliday's classification of climatic provinces.

*b) Source of climatological data employed
in the present investigation*

Meteorological observations have been made in Canada for more than a century (Patterson, 1939), but it is chiefly during the past twenty-five years that, as a result of gradually increasing records, an understanding of the climate of Quebec has been reached. In the northernmost part of the Province there is still much of uncertainty on account of the small number of weather records.

Based on the few records available to him, Connor (1931) published weather data which gave a fair idea of the general climate of the Province of Quebec. Brooks and Connor (1936) in drawing the climatic isoclines of North America, have used for the Province of Quebec the data of a very small weather-station network. Although these maps give the best general representation of the climates of North America, they do not show the local climates which may be recognized on the basis of an extensive series of weather records.

In 1936, the Quebec Meteorological Bureau extended the network of its weather stations (Villeneuve, 1943) and started to collect weather data regularly at more than 125 observation stations. Many other organizations had even earlier started to collect data. Consequently it is now possible to compute the main climatic elements observed over a period of nearly ten years. These data supply a good understanding of the regional or local climatic conditions in the Province of Quebec.

For the present investigation, climatological data from more than 200 weather stations have been computed. These weather stations are the property of the Meteorological Service of Canada, the Quebec Meteorological Bureau, various associations for the protection of forests, the Quebec Stream Commission, certain private enterprises, notably the pulp and paper companies, and many biological, agricultural and forest experiment stations.

The Canadian Meteorological Service operates 38 weather stations in the Province of Quebec, Ungava and Labrador coast. These weather stations send daily telegraphic reports to Toronto, the weather forecasting office of the Federal Meteorological Service. The Quebec Meteorological Bureau controls about 175 weather stations from which weekly reports are sent to Quebec city where the data are computed and analysed for various purposes. Every association for the protection of forests in the Province operates a number of weather stations. These stations, numbering 61 in 1944, are operated only during the season of forest fire protection, that is, from April to November. The Quebec Stream Commission also obtains monthly rainfall and temperature reports from about a hundred meteorological stations with the object of using the data in hydrological studies. Figure M-19 shows the location of the weather stations in operation in the Province of Quebec and Table I gives the exact geographic location of these stations.

c) *Nature of climatological data*

The climatological elements that have been computed for the present investigation, are derived from temperature, precipitation, evaporation, and relative humidity data. Facilities and instruments in use for observing these elements are as follows:

INSTRUMENT SHELTER

The instrument shelter used by the Meteorological Bureau is the Stevenson screen, the size of which varies depending on the number and character of instruments to be accommodated. Shelter walls are louvered and there is a double roof with an air space between. The bottom is constructed so as to permit free circulation of air. Screens are always painted white inside and outside in order to reduce absorption of radiation to a minimum. The shelter with its base 45 inches above ground is placed in an exposed situation. Although offering protection from radiation, rain, and snow, the construction is such as to provide for free movement of air around the instruments.

TEMPERATURE

A mercurial maximum thermometer is used for recording the highest daily temperature, and the lowest daily temperature is read from an alcohol minimum thermometer. Very often a Six-type ther-

mometer is added to the previously mentioned instruments so that in case of breakage the observations will not be interrupted while awaiting replacements. Temperature units are Fahrenheit. Minimum thermometers are read at 8 a.m. and maximum thermometers at 6 p.m. Both types of thermometers are housed in an instrument shelter.

PRECIPITATION

In addition to the instrument shelter, and at two or three feet above ground, is fixed, usually on a wooden pillar, a rain-gauge for precipitation measurements. Precipitation is measured in hundredths of an inch twice daily, that is, at 8 a.m. and 6 p.m. The time of the start and the time of the end of each precipitation is also reported so that it is possible to determine each day the total amount and duration of precipitation. Rain-gauges used for this observation are cylindrical receptacles of five inches diameter. For precipitation in the form of snow, the usual receiver is a square wooden board 12 inches square which is placed on the ground to receive each snowfall. The depth of snowfall is measured in tenths of an inch. Although it is realized that the density of snow, and consequently its water equivalent, is variable, the present stage of meteorological observations in Quebec is such that it has been necessary to assume, for conversion purposes that one inch of snow is equivalent to one tenth of an inch of water.

EVAPORATION

Evaporation from Wright pan-evaporimeters is measured at 6 p.m. daily in cubic centimeters and reduced to Livingston units (one L.U.: 0.45 c.c.) to be comparable to data obtained from Livingston white bulb atmometers. The Wright pan-evaporimeter is fixed on a wooden post at a height of 45 inches above ground (Villeneuve, 1943).

RELATIVE HUMIDITY

Relative humidity data computed from tables are derived from the dry and wet bulb thermometer readings which are taken at 8 a.m., 2 p.m., 4 p.m., and 6 p.m., that is, four times daily.

OTHER OBSERVATIONS

Of course many observations other than those indicated above are made at a regular weather station. Phenomena observed, besides those mentioned are wind speed and direction, insolation, cloudiness,

visibility, snow conditions, and others of phenological importance. Since these data have not been utilized in the present investigation they will not be considered further.

d) Analysis of climatological data

The following atmospheric factors, derived from the primary climatic elements observed at weather stations, have been considered as those having the greatest influence upon vegetation distribution. Consequently they are the factors that have received principal attention in the pages that follow.

- 1 — Mean annual temperature.
- 2 — Mean temperature for July.
- 3 — Mean temperature for January.
- 4 — Annual range of mean monthly temperature.
- 5 — Mean maximum temperature in July.
- 6 — Mean minimum temperature in January.
- 7 — Range of mean extreme temperatures.
- 8 — Mean monthly range of temperature for the year.
- 9 — Mean monthly range of temperature in July.
- 10 — Mean temperature for the four warmest months.
- 11 — Average length of the frost free period.
- 12 — Mean annual precipitation.
- 13 — Mean monthly summer precipitation.
- 14 — Mean monthly summer evaporation.
- 15 — Mean maximum evaporation in summer.
- 16 — Mean monthly relative humidity in summer.
- 17 — P-E quotient for the summer.
- 18 — P-E index for the summer.

The computation of the climatic elements has been summarized in tables and added at the end of this paper. For missing values, a method suggested by Landsberg (1943) has been applied and is considered close enough for most statistical purposes.

1. Mean annual temperature

The daily mean temperature is found by averaging the highest and lowest temperatures. The sum of these mean temperatures for a month divided by the number of days of the month gives the monthly mean temperature. In this way the monthly mean temperature has been computed for the last decade, and from the monthly values an average or mean annual temperature has been computed.

The mean annual temperature data are based on records from one hundred observation stations which are listed in Table II of the Appendix. The lowest mean annual temperature shown by the records is 18.0 degrees F. at Port Harrison and the highest is 43.7 degrees F at Montreal.

Figure M-1 shows the isothermal lines of the mean annual temperature. A region having a relatively high mean annual temperature is indicated in the southwestern part of the Province; in the Lake St. John region, the mean annual temperature is slightly lower. Comparatively cool regions may be noted in the Laurentide Park, in the Gaspé plateau section, and in the northwestern part of the Province.

The southwestern part of the Province has a mean annual temperature of 42 degrees F. and the Lake St. John area 36 degrees F. Isothermal centers of 30 degrees F. are seen over the Laurentide Park and the Gaspé plateau. In the northwestern Quebec, temperature decreases northward; this temperature decrease shows much regularity north of 52 degrees latitude.

Summarizing, it may be said that the inhabited portion of the Province of Quebec shows relatively different mean annual temperatures in five broad regions which are: the Montreal or southwestern region of Quebec, the Lake St. John area, the Laurentide Park, the Gaspé plateau and the northwestern part of the Province. North of 52 degrees latitude, the mean annual temperature decreases both inland and northward.

2. Mean temperature for July

From the daily mean temperatures a monthly arithmetic mean has been deduced for July. This mean is based on records from 99 stations and covers a period of ten years. For the month of July the mean air temperature of the Province is 64.9 degrees F. Montreal shows the highest value with 70.6 degrees F. and Port Harrison the lowest with 47.0 degrees F.

Figure M-2 shows various isothermal regions. The Gaspé peninsula has a mean temperature of 60 degrees F. and the Laurentide Park shows a value as low as 56 degrees F. The Lake St. John region with 66 degrees F. and the district of Montreal with 70 degrees F. are the two warmest regions in the Province. North of 50 degrees latitude, temperature decreases; the decrease starts with 60 degrees F.

in the western part of the Province and with 58 degrees F. in the eastern part. The isotherms traced here as in Figure M-1, cover only the inhabited portion of Quebec. High land areas which at this season are so much cooler than the lowlands are clearly outlined.

3. Mean temperature for January

The monthly mean temperatures for January were computed in the same way as the monthly mean temperatures for July. Records from 99 stations were used to compute the mean temperature for January. The mean value for the Province as a whole is 7.4 degrees F. The lowest value (— 18.0 degrees F.) applies to Port Harrison and the highest (14.3 degrees F.) to Montreal. The difference in latitude between these two stations explains the difference between their mean temperatures in January.

Figure M-3 indicates the Lake St. John region with a center of 6 degrees F. and the Montreal region with one of 12 degrees F. The Gaspé peninsula is a cold country since its highest mountains have a temperature far below 6 degrees F. The Laurentide Park registers a more severe winter with an average temperature of 0 degrees F. The northernmost part of Quebec, that is, from 48 degrees latitude in the West, and from 52 degrees latitude in the East, shows a decreasing temperature with latitude. It is seen in the Gaspé plateau and in the Laurentide Park that the effect of altitude is not so great after all, owing to the small lapse rates in winter.

4. Annual range of mean monthly temperature

The difference between the mean monthly temperature in July and the mean monthly temperature in January is designated the annual range of mean monthly temperature.

Port Harrison (lat.: 58°25'N.) has a mean annual range of 65 degrees F. and Anticosti (lat.: 49°21'N.) a value of 45 degrees F. At these stations the difference in latitude is not the only cause of the difference in the range. « The ranges in the North are great because of the large seasonal contrast in insolation » (Brooks and Connor, 1936). Of the two stations registering extreme values, the first is situated inland and the second is located near the ocean. Since the ocean decreases the temperature extremes it is readily understood that the annual range of temperature will be smaller near the sea than inland.

Figure M-4 agrees with Brooks and Connor's map of the same element. It may be observed that the range of temperature is greater inland than in the proximity of the sea. Centers of relatively higher range are situated in the Montreal region, the northwestern part of the Province and the area north of Lake St. John. West of the Laurentide Park there exists a large area of relatively lower temperature range.

5. *Mean maximum temperature in July*

Data for the mean maximum temperature in July have been computed from records for 95 observation stations. La Tuque has the highest mean maximum temperature (93.6 degrees F.) and Natasquan has the lowest (81.0 degrees F.). The mean value shown by the records of a ten year period is 91.3 degrees F. for the entire Province of Quebec.

Figure M-5 shows centers of relatively high values in the Lake St. John and the Montreal regions, and relatively low values in the Laurentide Park. In general, since the warmest winds come from a westerly direction, high temperatures reach the Atlantic coast, and only the Gaspé peninsula, the Laurentide Park and presumably the Anticosti island fail to have warm weather characteristics of the latitude.

6. *Mean minimum temperature in January*

In this series of records Obidjuan is the station having the lowest value (—53.3 degrees F.) and Cap Madeleine has the highest value (—11.1 degrees F.). The mean minimum temperature for the Province during January, based on a ten year period of records at 95 observation stations, is —25.7 degrees F.

Figure M-6 presents isotherms of the mean minimum temperature in January. The influence of the sea is readily apparent. It tends to raise the minimum temperature and lower the maximum. Thus, the highest temperatures indicated on Figure M-6 are at the seashores and as one proceeds inland the minimum temperature becomes progressively lower. The region of Montreal seems to represent an exception since a center of relatively high temperature exists over that part of the Province.

7. *Range of mean extreme temperatures*

The range of mean extreme temperatures is the range between the mean maximum temperature in July and the mean minimum temperature in January.

Data from 95 observation stations in the Province indicate an average value of 114.3 degrees F. for the range with a maximum value of 140.8 degrees F. at Obidjuan and a minimum value of 94.5 degrees F. at Cap Madeleine. Obidjuan is situated inland in the western part of the Province and Cap Madeleine is located in the Gulf of St. Lawrence. This clearly shows the influence of the sea, which has the effect of lessening the temperature range. Large bodies of water tend to serve as thermostats, favoring relatively uniform temperature conditions.

8. *Mean monthly range of temperature for the year*

The absolute temperature range for each month during the last decade has been computed, and from these statistics there has been derived the mean monthly range in temperature for the year.

Mésy in the Laurentide Park is the station having the greatest mean monthly range of temperature (67.5 degrees F.) and Cap Chat in the Gulf of St. Lawrence has the lowest value (40.4 degrees F.). The average value based on the records for the 95 stations in the Province is 54.6 degrees F. Montreal, Lake St. John and the Gaspé plateau are regions of comparatively small temperature range while the Laurentide Park and the Northern part of the Province have remarkably great temperature range (Figure M-8). The region including Montreal and the surroundings has been noted before as exceptional, but Lake St. John and the Gaspé plateau are influenced by bodies of water. On the contrary, the Laurentide Park like the inland part of Quebec have the continental great temperature range.

9. *Mean monthly range of temperature in July*

The mean monthly range of temperature in July is based on the mean values of the absolute range of temperature for this month.

As in the case of the mean monthly range of temperature for the year, the greatest mean monthly range of temperature in July is found at Mésy (55.2 degrees F.) and the lowest is found at Cap Chat (34.1 degrees F.). The average mean monthly range of temperature in July

for the Province as a whole (based on records from 95 stations) is 46.0 degrees F. Inspection of Figure M-9 reveals differences with respect to temperature that are similar to those pointed out earlier. The regions of Montreal and Lake St. John have a comparatively small temperature range during July. The Laurentide Park and the Gaspé plateau on the other hand, have a somewhat higher range of temperature than the surrounding areas. The influence of the St. Lawrence river is evident in the temperature conditions on its north and south shores. In short, Figure M-9 shows a pattern of isolines similar to that of the previous figure.

10. Mean temperature for the four warmest months

The mean temperature for the four warmest months of the year has been considered by some authorities as a basis for recognizing boundary lines between climatic regions. Many authors have also considered this as a major factor governing plant distribution (Mayr, 1925; Livingston and Shreve, 1921; Köppen, 1931). For these reasons it has been considered necessary to study the mean temperature for the four warmest months in the Province of Quebec.

In the Province of Quebec, the four warmest months are June, July, August and September. The average temperature during these four months has been computed from the records for 93 stations. These average values were derived from the mean monthly temperatures.

The values obtained vary from 66.0 degrees F. at Montreal to 51.8 degrees F. at La Galette with an average of 60.9 degrees F. for all the records. Montreal is located in the warmest part of the Province whereas La Galette is situated in the high altitudes of the Laurentide Mountains. Figure M-10 shows the isotherms derived from the temperature data for the four warmest months. The Laurentide Park and the Gaspé plateau are regions of relatively low temperature whereas the Montreal district and the Lake St. John region are characterized by relatively higher temperature than their surroundings. This may be explained by the fact that the Laurentide Park and the Gaspé plateau are at relatively high altitudes with respect to their surrounding areas. This is not the case for the Montreal and the Lake St. John districts; these are relatively flat continental regions with high temperatures during the summer months. In the western part of the Province the temperature gradient is rather regular, the temperature decreasing northward as would be expected.

11. Average length of the frost free period

The frost free period, also referred to as the growth period, is the average number of days between the last frost in the spring and the first frost in the fall. The Atlas of American Agriculture is rather specific on the subject of the frost free period: « The simplest of all summaries is the arithmetical average. In the case of frost the average date of the last killing frost in the spring is the time when the chance of killing frost falls to one in two; that is, in about half the years it will occur on or after the average date and in other years it will be earlier. For records covering less than 20 years the average is the only type of summary which can be obtained with usable accuracy ». The authors ignored the fact that irregular late or early frosts may occur which are relatively abnormal for the season and which cannot be taken into account when computing the normal frost free period. Consequently, in comparing the data obtained during the last decade, a date has been found which represented each year, the last or first regular normal frost. For example, if a frost occurred at station X on the 12th, 13th and 14th of May and if another frost occurred on May the 31st, the 14th has been taken as the last regular spring frost date, with the consideration that during the other years of the decade, the last regular frost occurred also at about the same date.

Data concerning the frost free period have been summarized for 95 observation stations and an average value for the last decade has been computed for each. The average length of this period for all the observation stations is 105 days. Montreal has the longest frost free period with 151 days and Resolution Island the shortest with four days. Montreal is located at $45^{\circ}30'$ latitude and Resolution Island at $61^{\circ}18'$ which explains the difference in the length of the frost free period.

A representation of the frost free period at the various stations is given by Figure M-11. The region of Montreal has the longest frost free period with more than 150 days. The lake St. John region is next in length with more than 120 days. The western portion of the Province shows rather regular isolines decreasing in value with increasing latitude. The Gaspé plateau has a short growing season in its central area and the Laurentide Park has the shortest growth period of the inhabited area of the Province of Quebec, that is, 60 days.

12. Mean annual precipitation

The mean annual precipitation is the total amount of snow and rain received annually at the land surface. The values are customarily expressed in terms of inches of water so it is necessary to convert the amount of snow into the equivalent amount of water. To accomplish this the depth of snowfall has been divided by 10 before being added to the amount of rainfall. This converting factor, although somewhat arbitrary, was used since precise data on snow density were not available.

The mean annual precipitation computed from the data collected at 93 stations during a 10 year period, has been used to draw the isohyets of Figure M-12. Stoneham receives annually 55.77 inches of precipitation and Ville-Marie only 27.42 inches; these are extremes. The average amount of precipitation, based on the records of the 93 stations, is 37.84 inches. Figure M-12 shows that precipitation is heavier in the Laurentide Park than in any other section of Quebec. The isohyets of that region have large values. The Gaspé peninsula stands second in amount of precipitation with more than 40 inches on the plateau. The district north of Montreal also receives more than 40 inches although the area concerned is small. Precipitation in the Lake St. John region ranges between 30 and 35 inches. Northward from the lowlands of that region, in the mountainous sections, precipitation increases (Lac Onatcheway: 47.6 inches). The western part of the Province also receives more than 40 inches in some localities (Amos: 40.3 inches). West of the Laurentide Park, however, there is an area with less than 30 inches. This area coincides with the area mentioned in the description of Figure M-4 in connection with the mean annual range of temperature. As Brooks and Connor (1936) stated « Mountainous regions have complicated rainfall patterns. The precipitation map brings out not only the decrease inland and behind mountains but also the pronounced general decrease in precipitation owing to the lower temperature and consequent reduced absolute humidities ». North of latitude 50 degrees, precipitation decreases remarkably and drops to less than 20 inches over Ungava peninsula.

13. Mean monthly summer precipitation

The mean monthly precipitation for June, July, August and September has been summarized and averaged. In this computation

data covering a seven year period of observation at 176 weather stations were employed.

The average value for the Province as a whole is 3.88 inches. This value is considered as the mean monthly amount of rain during the summer months. Barrière Savanne, in the Laurentide Park, receives 6.68 inches of rainfall and Godbout on the north shore of the St. Lawrence river, receives 2.41 inches, those two values representing the maximum and minimum values in the series of records.

The isohyets of the mean monthly summer precipitation are shown in Figure M-13. The Laurentide Park shows the isohyet with the largest value (6.0 inches) and the Gaspé plateau is indicated as another area with comparatively heavy rainfall. In the southwestern part of Quebec the precipitation amounts to less than 3.0 inches. According to Brooks and Connor (1936) «...the cool Great Lakes reduce the precipitation near by». The southwestern part of the Province being relatively near the Great Lakes must be influenced by them.

14. Mean monthly summer evaporation

Records from 114 weather stations equipped with Wright pan-evaporimeters indicate that the average monthly evaporation during the summer period (June, July, August and September) amounts to 4.43 inches of water. Montreal is the station with the highest value and Godbout has the lowest. The values are 7.13 and 2.22 inches, respectively.

Figure M-14 shows regions of pronounced evaporation in the district of Montreal, in the Laurentide Park and on the Gaspé plateau. The relatively high evaporation in the vicinity of Montreal is presumably caused by high air temperatures while high wind movement is primarily responsible for the pronounced evaporation in the other two sections. In the Baie des Chaleurs there is a center of low evaporation which is probably related to the high humidity which in turn is related to the proximity to the sea.

15. Mean maximum evaporation in summer

Data relative to the maximum amount of evaporation have been computed for each summer month, and the mean monthly value over a period of seven years derived. Mean monthly values for June, July,

August and September were then averaged arithmetically to give the mean maximum monthly evaporation during the summer period.

The evaporation data, obtained by means of Wright pan-evaporimeters, were converted to Livingston units (see Table V: *Units used in tables and figures*). Evaporation data presented in tables in this report, and the values employed in preparing charts on evaporation conditions, are based on the converted measurements.

Barrière Savanne has the lowest value (26 L.U. a day) and Ste Anne de la Pocatière the highest (66 L.U. a day). In Figure M-15 the isopleths representing this element indicate regions of different evaporation intensity. Usually, regions of high evaporation are those of low humidity and vice-versa. Sometimes a region of high evaporation is a region of relatively high temperature: this is the case in the district of Montreal. In the Lake St. John region, the Gaspé peninsula and in northwestern Quebec, it is the wind which is responsible for the relatively high evaporation. In the Baie des Chaleurs region, the Laurentide Park and the mountainous region of the north shore of the St. Lawrence river, evaporation is relatively low on account of the high atmospheric humidity in those sections.

16. Mean monthly relative humidity in summer

The mean monthly relative humidity has been calculated from the minimum daily values for June, July, August and September. The arithmetic average for these four months is referred to as the mean monthly relative humidity during the summer. Ste Anne des Monts was found to have the highest value (73 per cent) and La Galette the lowest (48 per cent). The mean value for the summer months in the Province as a whole (based on records from 104 stations) is 59 per cent.

On Figure M-16 the Laurentide Park, the central part of western Quebec, the eastern side of Lake St. John, the shores of the St. Lawrence river and the Gulf are shown as regions of relatively high humidity. Mountainous sections are more humid than flat regions; this agrees generally with the situation shown by the previous isohyetal maps. Humidity is higher in districts adjacent to the sea than in continental regions, as would be expected.

17. P-E quotient for the summer

Following the procedure of Transeau (1905), an index of precipitation effectiveness, commonly referred to as the P-E quotient, has

been computed for the summer months. In deriving this measure the mean monthly precipitation in inches was divided by the mean monthly evaporation in inches.

The highest P-E quotient during the summer months was established for Barrière Savanne (2.46) and the lowest for Ste Martine (0.40). The average value for the Province as a whole, based on records from 104 stations, was 0.91.

On Figure M-17, the Laurentide Park and the Gaspé peninsula show regions of positive P-E quotient (higher than 1.00). A similar region of high P-E quotient is situated on the highlands of the north shore of the St. Lawrence river. On the other hand, areas of comparatively low P-E quotient exist over the Montreal district, the Lake St. John region and over a small region west of the Laurentide Park. It is probable that the dryness of the air in the northern part of the Province, especially in Ungava peninsula, creates a condition of very low P-E quotient. Figure M-17 also shows a low P-E quotient on both the north and south shores of the St. Lawrence river and at the mouth of the Saguenay river. Evidently a low P-E quotient is caused in the north by the dryness of the air, in the south, by a relatively higher temperature and stronger winds.

18. P-E index for the summer

A monthly P-E quotient computed for May, June, July, August and September from 1939 to 1944, has been arithmetically averaged each year and these five P-E quotients have been summed up and divided by five. The resulting value of the calculation is referred to as the P-E index for the summer. Thornthwaite (1931) has previously defined the P-E index as the sum of the P-E quotients.

Figure M-18 does not differ greatly from Figure M-17. The P-E quotient data and the P-E index data produce charts having approximately the same features. Regions of relatively high P-E index are located in practically the same positions where high values for the P-E quotient are noted. The only dissimilarity between the maps for the P-E quotient and the P-E index is seen in the western part of the Province. There the isolines of P-E index show two centers: a small area of low P-E index and a larger area of comparatively high P-E index. Figure M-17 presenting the P-E quotient shows isolines irregular in shape but increasing in value northward.

Godbout on the north shore of the St. Lawrence river has the highest value (2.25) and Ste Martine, the lowest value (0.42). The average value for all P-E index data from 121 series of records, is 0.97.

FOREST CONDITIONS IN THE PROVINCE OF QUEBEC

a) Review of previous work

THE description and classification of the forest vegetation of Quebec has received attention from many writers. One of the oldest reports located is that of Bell (1882). This author described the geographical distribution of the more important forest trees in Canada and prepared a map on which was indicated the northern limit of their ranges. Bell obtained most of his information on the distribution of forest trees in the Province of Quebec from explorers.

In 1890, Drude divided Quebec into two zones by a line starting at Richmond Gulf in Hudson Bay, thence running northward to Ungava Bay, and from there turning southwestward to the Belle-Isle strait through the Labrador coast. He described the territory north of that line as treeless tundra and that south of the line as the boreal forest region of coniferous trees.

In 1894, Merriam prepared a bio-climatic classification which recognized seven life zones in North America. The Province of Quebec included at least three of these life zones which were as follows:

1 — The Arctic or Arctic-Alpine zone. This zone lies above or to the north of the limit of tree-growth.

2 — The Hudsonian zone. This comprises the northern or more elevated portions of the great transcontinental coniferous forest, a forest of spruce and fir, extending from Labrador to Alaska.

3 — The Canadian zone. This comprises the southern or less elevated portions of the great transcontinental coniferous forest.

Low (1896) in an account of his explorations described the position of the tree line in Quebec as follows: « The tree line skirts the southern shore of Ungava bay and comes close to the mouth of George river, from which it turns south-southeast skirting the western foothills of the Atlantic coast range which is quite treeless, southward to the neighbourhood of Hebron ».

The eastern forests of Canada were classified by Fernow (1908) into five regional types, namely:

- 1 — The Acadian type,
- 2 — The Upper St. Lawrence type,
- 3 — The Middle St. Lawrence type,
- 4 — The Lower St. Lawrence type,
- 5 — The Southern St. Lawrence type.

Later, as it will be shown presently, Fernow made some changes in his classification and shifted the boundary lines delimiting his regions.

In chronological order Mayr (1925) came next when he recognized five forest zones in North America, each of which was divided into the Atlantic, Central and Pacific regions. The Province of Quebec includes three of Mayr's zones:

1 — The polar-alpine zone (a cold zone of stunted and dwarfed trees at the limits of forest growth) which corresponds to Merriam's arctic zone. It is characterized by such species as *Betula*, *Alnus*, *Salix*, *Juniperus*, *Abies balsamea hudsonia* (*Abies hudsonica*), *Pinus banksiana* and *Larix laricina* (*Larix americana*).

The mean annual temperature is 0 degrees C.; the mean temperature during the four warmest months, between 7 and 9 degrees C.; and the average relative humidity from May to September, 80 per cent.

2 — The spruce, fir and larch zone (a moderately cool zone which corresponds to Merriam's Hudsonian zone). The principal forest trees are the following: *Sorbus*, *Betula*, *Populus*, *Salix*, *Abies balsamea*, *Tsuga canadensis*, *Picea*, *Thuja occidentalis*, *Pinus strobus*, *P. resinosa*, *P. banksiana*, *Larix laricina*.

The climate of this zone is characterized by a mean annual temperature of 6 degrees C., a mean temperature during the four warmest months of 15 degrees C., an average relative humidity of 75 to 80 per cent and a rainfall of 15 to 24 inches for the period May to September.

3 — The beech zone comprising the cooler half of the temperate zone of deciduous species. Its limits are almost the same as those of Merriam's Canadian zone. According to Mayr this zone contains the following species: *Fagus grandifolia* (*F. ferruginea*), *Quercus alba*, *Q. macrocarpa*, *Q. coccinea*, *Q. palustris*, *Q. velutina* (*Q. tinctoria*), *Carya ovata* (*C. alba*), *C. glabra* (*C. porcina*), *C. cordiformis* (*C. amara*), *C. alba* (*C. tomentosa*), *Acer rubrum*, *A. saccharum*, *Fraxinus*, *Salix*, *Betula*, *Juglans*, *Liriodendron*, *Prunus*, *Ulmus*, *Populus*, *Tilia*, *Sorbus*, *Pinus strobus*, *P. banksiana*, *P. resinosa*, *P. rigida*, *Thuja occidentalis*, *Abies balsamea*, *Picea*, *Larix laricina* (*L. americana*).

However, these species are not all present in the Province of Quebec. For example, *Liriodendron* is limited to Southern Ontario.

Mayr defined the climate of this zone by the following characterization: a mean annual temperature from 7 to 12 degrees C., a mean temperature of 19 degrees C. during the four warmest months, 65 per cent relative humidity and 8 inches rainfall during the period May to September.

The three zones differ also in respect to their lowest recorded temperatures which are, respectively, -45, -40, and -35 degrees C.

As has been mentioned previously, Fernow's forest classification of the Province, published in 1908, was modified in 1912 and the boundary lines of the forest regions altered. Fernow in delimiting the boundaries of his regional types, specified that Ungava peninsula was a region of treeless tundra and above timberline, that the next region to the south was the northern subarctic type without fir, and that south of this was the type characterized by the spruce and fir forests. The Laurentian plateau was recognized as a coniferous forest region. The St. Lawrence valley from Montreal to Quebec city constituted a fifth region and the sixth was represented by the territory from Quebec city to the Gulf of the St. Lawrence. The Acadian type with both coniferous and deciduous species included the Gaspesian peninsula and the southeastern part of the Province of Quebec adjacent to the state of Maine. To summarize, Fernow recognized the following regions in Quebec:

- 1 — The treeless tundra.
- 2 — The northern subarctic type.
- 3 — The southern subarctic type.
- 4 — The Laurentian type.
- 5 — The Middle St. Lawrence type.
- 6 — The Lower St. Lawrence type.
- 7 — The Acadian type.

In 1917 Macoun and Malte, in a description of the Canadian flora, located the boundary line between the tundra and the forested regions as follows: « East of Hudson bay, the tree line runs from about latitude 56 degrees on Richmond gulf to the mouth of George river on the eastern shore of Ungava bay, and from there in a southeasterly direction along the coast of Labrador to Hamilton inlet ».

Later, McDougall (1925) in his classification of North America in moisture belts, divided the Province of Quebec into two parts: the

northern spruce forest and the northeastern mixed forest. The boundary line lies at 50 degrees north latitude in the western part of the Province and somewhat higher in the eastern part, that is, on the north shore of the St. Lawrence river.

Ab-Yberg (1931) proposed the first modern forest classification for the Province of Quebec. He believed that sufficient differences in temperature, precipitation, solar radiation and wind exist to justify the division of the Province on the basis of both climate and forest. His regions were the following:

- 1 — The St. Lawrence river Plains.
- 2 — The Laurentian Mountains.
- 3 — The Gaspé peninsula and Canadian Labrador.
- 4 — The northern Laurentian plateau draining into James bay.

The annual report (1933-34) of the Association of Forest Engineers of the Province of Quebec contained a map prepared by Roy (1933), of the forest regions of Quebec. The six following regions were indicated:

- 1 — The Subarctic forest region.
- 2 — The Northern forest region.
- 3 — The Transition forest region.
- 4 — The Mixed forest region.
- 5 — The Acadian forest region.
- 6 — The Hardwood forest region.

The most comprehensive and useful forest classification ever made for the Province of Quebec is Halliday's (1937) which was developed with the help of the Provincial Forest Service of Quebec. According to Halliday's classification, two climax formations exist in the entire territory of the Province of Quebec: the Arctic tundra and the Forest formations.

The Forest formation has been subdivided into two great fundamental regions: the Boreal forest region and the Great Lakes — St. Lawrence forest region; the former is primarily a coniferous region though there is a general admixture of certain broad-leaved trees, which play an important part in its composition; the latter, compressed and fragmented by Boreal invasion in glacial times, shows northern coniferous trees with broad-leaved trees which are almost exclusive in the southern deciduous forest of Quebec.

Halliday subdivided his Forest Regions into Forest Sections which are « geographical subdivisions of the Region based on floristic

considerations, and the result of physiographic, edaphic and local climatic conditions ».

Halliday's forest classification in regions and sections for the Province of Quebec is as follows:

I — TUNDRA FORMATION

II — FOREST FORMATION

A) *Boreal Forest Region*

- 1 — Northeastern coniferous section
- 2 — Gaspé section
- 3 — Central Laurentian section
- 4 — Northern clay section
- 5 — Coastal plain section
- 6 — East James bay section
- 7 — Central transition section
- 8 — Hamilton-Ungava valleys section
- 9 — Northeastern transition section

B) *Great Lakes — St. Lawrence Region*

- 1 — Upper St. Lawrence section
- 2 — Lower St. Lawrence section
- 3 — Algonquin-Laurentides section
- 4 — Eastern Townships section
- 5 — Temiscouata-Restigouche section
- 6 — Saguenay section
- 7 — Haileybury section

From the above review of literature, the following features may be pointed out:

1 — Within the Province of Quebec, distinctive regions have long been recognized, namely a treeless tundra and a forest area of various forest types (Bell, 1882; Drude, 1890; Merriam, 1894; Low, 1896; Mayr, 1925; Fernow, 1912; Macoun and Malte, 1917).

2 — The tundra has been the subject of investigation of various authors and a fairly precise boundary line has been located as marking the northern limit of tree growth (Macoun and Malte, 1917).

3 — The forest area south of the treeless tundra has been carefully studied and found to be a boreal forest region (Drude, 1890; Merriam, 1894; Mayr, 1925; Fernow, 1912; McDougall, 1925).

4 — Various authors have subdivided the forest area of Quebec on the basis of:

- a) bio-climatic conditions (Merriam, 1894)
- b) climatic conditions (Mayr, 1925)
- c) moisture conditions (McDougall, 1925)
- d) physiography (Ab-Yberg, 1931)
- e) forest composition (Roy, 1933)
- f) floristic, physiographic, edaphic and climatic conditions (Halliday, 1937)

5 — Halliday's forest classification has been found to be more detailed than that of others and more useful for the present purpose.

Since Halliday's classification was prepared several other papers have been published which deal with the forest composition of various regions of Quebec (Nichols, 1935; Marie-Victorin, 1935; Blanchard, 1935; Auger, 1943; Gosselin, 1943; Halliday and Brown, 1943; Touchet, 1943; Wilson, 1943; Boucher, 1944; Lebleu, 1944; Lessard, 1944; Lussier, 1944; Martel, 1944; Neault, 1944; Racine and Richard, 1944; Richard, 1944; Rivard, 1944; Rousseau, 1944; Roy, 1944).

b) *Classification of forest regions and sections employed in the present investigation*

The forest classification employed in the present investigation is based in part on Halliday's classification and in part on the recent papers mentioned above. Several regions and sections delimited by Halliday have been left unchanged as, for example, those dealing with the area north of 52 degrees latitude. However, in the inhabited part of Quebec, certain changes in boundaries have been made on the basis of new information. A larger scale map than Halliday's has been used in order to delimit each of the forest regions and sections as accurately as possible (Figure M-20).

The forest classification of the Province of Quebec, adopted for present purposes shows the broad regions and their minor subdivisions as follows:

Forest classification of the Province of Quebec

(REGIONS)	(SECTIONS)
I — <i>Tundra</i>	(T) 1 — Ungava Peninsula 2 — Labrador Coast

- II — *Coniferous Forest* (C) 1 — Central Transition
2 — Laurentide Park
3 — South Shore Plateau
4 — Gaspé Plateau
5 — Upper St. Maurice
6 — Northern Clay
7 — Northern Coniferous
8 — North Shore
9 — Hamilton-Ungava Valleys
10 — Hudsonian
11 — Coastal Plain
12 — East James Bay
13 — Anticosti

- III — *Mixed Forest* (M) 1 — Temiscamingue
2 — Laurentian
3 — Lake St. John
4 — St. Lawrence Estuary

- IV — *Hardwood Forest* (H) 1 — Upper St. Lawrence
2 — Eastern Townships
3 — Lower St. Lawrence
-

THE TUNDRA REGION

THE Tundra Region is coextensive with the tundra formation as delimited by Halliday (1937). It includes the area of Ungava peninsula north of a line from Richmond gulf in Hudson bay to Hopes Advance in Ungava bay. It also includes a strip varying in width from ten to sixty miles from Hopes Advance to Hamilton inlet on the Labrador coast (Macoun and Malte, 1917).

The tundra region lacks normally developed trees (Macoun and Malte, 1917). The woody plants characteristic of the zone, assume, in general, either prostrate forms such as that of *Salix arctica* and its varieties or a more shrubby appearance such as that of *Betula nana*, *B. glandulosa* and *Salix Richardsonii*. The woody plants are chiefly of the family Ericaceae.

With the aim of completing the classification work for the entire territory of the Province, two subdivisions have been made in the Tundra Region: the Ungava Peninsula Section and the Labrador Coast Section.

T-1. Ungava Peninsula Section

In this section, only a thin layer of the soil is not permanently frozen. During the summer the area is in reality a vast and uniform swamp. In general the drainage is poor and the soils shallow and immature. Mosses and lichens prevail over the whole area. The main lichen seen is the *Cladonia rangiferina* (Marie-Victorin, 1935).

T-2. Labrador Coast Section

The Labrador coast, which is warmer and more humid than the Ungava peninsula, supports a greater number of plant species. The following list was given by Macoun and Malte (1917):

Salix arctica
Salix orbicularis
Salix anglorum
Betula nana
Betula glandulosa
Salix Richardsonii

Ledum palustre
Rhododendron lapponicum
Vaccinium uliginosum
Vaccinium oxycocceus
Vaccinium Vitis-Idaea
Arctostaphylos alpina

Marie-Victorin (1935) added the following:

Antennaria isolepis
Antennaria pygmaea
Antennaria Sornborgeri
Arnica Sornborgeri
Carex filifolia
Crepis nana

Draba alpina
Draba aurea
Draba crassifolia
Draba Sornborgeri
Pedicularis groenlandica
Petasites sagittatus

THE CONIFEROUS FOREST REGION

THE Coniferous Forest Region is Halliday's Boreal forest region. It is bounded on the north and northeast by the Tundra Region. On the south the boundary line starts a little higher than latitude 48 degrees in the Province of Ontario, runs southeast to latitude 46°30' between longitude 77° and 76°, northward 20 miles beyond Baskatong lake, southeastward to St. Zenon, Berthier Co., northward again to include Windigo on the St. Maurice river and from there continues between Lac Edouard and Beaudet to the base of Cap Tourmente. The Coniferous Forest Region includes all the forested territory north of the St. Lawrence river, with the exception of a strip about 5 to 10 miles wide from the Saguenay river to Comeau Bay and certain river mouths such as Baie St. Paul and Murray Bay. Another exception is the Lake St. John Section which, on account of its broad-leaved species, has to be excluded from the Coniferous Forest Region.

Although this region as above delimited is primarily coniferous, there is a general admixture of certain broad-leaved trees which, particularly in the southern parts, play an important part in its composition. The characteristic species is the black spruce (*Picea mariana* Mill. B. S. P.) (1) which ranges throughout the region. Other conifers are also of wide occurrence and characterize certain portions of the region. In order of their importance these species are the balsam fir (*Abies balsamea* L. Mill.), the white spruce (*Picea glauca* Moench, Voss), the tamarack (*Larix laricina* DuRoi, Koch), and the jack pine (*Pinus banksiana* Lamb.). The broad-leaved trees are the aspen (*Populus tremuloides* Michx.), the paper birch (*Betula papyrifera* Marsh.) and sometimes the balsam poplar (*Populus balsamifera* DuRoi). In the southern part of the region, white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Sol.) are also seen but are not characteristic of the region in general.

Halliday's subdivisions of the Coniferous Forest Region have been somewhat modified for purposes of the present investigation. Following are the forest sections recognized by the present writer:

1. Scientific names will be given the first time a species is mentioned but will not be repeated thereafter.

- C-1. Central Transition Section.
- C-2. Laurentide Park Section.
- C-3. South Shore Plateau Section.
- C-4. Gaspé Plateau Section.
- C-5. Upper St. Maurice Section.
- C-6. Northern Clay Section.
- C-7. Northern Coniferous Section.
- C-8. North Shore Section.
- C-9. Hamilton-Ungava Valleys Section.
- C-10. Hudsonian Section.
- C-11. Coastal Plain Section.
- C-12. East James Bay Section.
- C-13. Anticosti Section.

C-1. Central Transition Section

The Central Transition Section as recognized in this report is essentially the same as Halliday's section of the same name. It is bounded on the north by the Upper St. Maurice and the Northern Clay sections of the Coniferous Forest Region. Lying to the west, south and east of the Central Transition Section is the Mixed Forest Region. The Central Transition Section extends from the Upper St. Maurice valley along the higher southward-facing slopes of the Laurentians to the Temiscamingue Section of the Mixed Forest Region.

Halliday (1937) described the composition of the forests in this section as follows: « The general character of the forest cover is a mixed one, consisting of an association of black spruce, balsam fir, and white birch, with scattered white spruce and aspen. This appears the dominant and mature type on the middle slopes. Here and there will be found, on heavier-textured ridges, patches and specimens of both sugar maple (*Acer saccharum* Marsh.) and yellow birch (*Betula lutea* Michx.). On rocky shores, and also on ridges, there is some presence of white and red pine. » The northern white cedar (*Thuja occidentalis* L.) is present in the swamp associations of black spruce and tamarack and along stream banks. Balsam fir forms pure stands on moist sites and jack pine occupies dry ridges and sandy flats. On account of repeated fires there exist secondary associations of aspen and white birch covering an understory of black spruce and balsam fir.

In this section white birch is a dominant species while it is a secondary species in the adjacent sections. Balsam fir is likewise a more important species here than in the Northern Clay Section. Red and white pine are present locally in the Central Transition Section

but are practically absent in the Upper St. Maurice and the Northern Clay sections.

C-2. Laurentide Park Section

The Laurentide Park is located south of the Lake St. John Section. It is a portion of Halliday's Northeastern Coniferous Section. In this section are situated the highest mountains of the Province north of the St. Lawrence river; topography has been the basis for recognizing this subdivision.

The bulk of the tree cover consists of two species, namely black spruce and balsam fir. White spruce is also encountered but it is numerically of less importance. Aspen and white birch are in general of secondary importance. However, they are of primary importance on lake shores and river banks. Jack pine occurs also on suitable sites, that is to say on dry sandy soils. A characteristic of this region is that the soils belong to the podsol group (Halliday, 1937).

The only two sections of the Coniferous Forest Region which are in contact with this section are the Upper St. Maurice and the North Shore sections. Jack pine is of secondary importance in the Laurentide Park Section while it is a dominant species in the Upper St. Maurice Section. Balsam fir, of primary importance in the Laurentide Park Section, occupies a position secondary to black spruce in the North Shore Section.

C-3. South Shore Plateau Section

The South Shore Plateau Section comprises the highlands of the south shore of the St. Lawrence. This section, based on topography, is larger than the western portion of Halliday's Gaspé Section. It is a section in contact on all sides with the Mixed Forest Region.

The characteristic associations are the black spruce and the white spruce which are well developed on the deeper soils. In swamps these species are of stunted growth. The white birch and balsam fir are present on the lower slopes. Black ash (*Fraxinus nigra* Marsh.), northern white cedar, white pine and sugar maple intrude from the adjoining region.

C-4. Gaspé Plateau Section

This is Halliday's eastern portion of the Gaspé Section. Surrounded by the sea and the Mixed Forest Region, this section presents

the highest plateau of the Province with a relict flora due to the fact that certain portions have not been glaciated.

The forest of the Gaspé plateau is one of pure coniferous stands, the association consisting of black spruce and white spruce. Tamarack and white cedar are seen in swampy areas while black and white spruce occur on slopes. Aspen, white birch, black ash and elm (*Ulmus americana* L.) are intruders from the adjoining sections. In general the vegetation of the Gaspé plateau is a mixture of a relict flora and comparatively recent invaders. Marie-Victorin (1935) has described the flora of the Gaspé plateau in some detail.

C-5. Upper St. Maurice Section

As the name implies, this section is located on the Upper St. Maurice river. It comprises a part of Halliday's Northern Coniferous Section west of Lake St. John and a portion of his Central Laurentian Section to the height of land between rivers draining into the St. Maurice valleys and those draining westward in the Abitibi district. The Upper St. Maurice Section is bounded by the following: the Northern Clay Section, the Northern Coniferous Section, the Laurentide Park Section, the Central Transition Section and the Mixed Forest Region.

Black spruce, balsam fir and jack pine are the predominant species in this section. However, white spruce, white birch and aspen are of importance. Black spruce occurs on swampy soils while white birch and aspen develop most commonly on the shores of lakes and along rivers. After forest fires, jack pine is the dominant; it develops best in soil that is deep and sandy. « The more rocky parts have stands of black spruce and jack pine, and the heavier soil deposits, such as those on lake shores and river-banks, support some mixed associations of white spruce, aspen, balsam poplar and white birch » (Halliday, 1937). Tamarack is mentioned by various authors as occurring in the Upper St. Maurice Section but it is much less abundant there than in the Northern Clay Section where it is a species of primary importance. The situation is the same for northern white cedar. On the other hand, jack pine is an important species in the Upper St. Maurice Section although it is of secondary importance in adjoining sections.

C-6. Northern Clay Section

This section is practically the same as Halliday's section of the same name. « It is bounded on the north by the marine clays and sedimentary rocks of the Coastal Plain Section » (Halliday, 1937). It is also bordered by the East James Bay Section, the Hudsonian Section, the Northern Coniferous Section, the Upper St. Maurice Section and the Central Transition Section.

This section is « conditioned by the extensive clay deposits available for soil formation » (Halliday, 1937). The soil type is a podsol influenced in many instances by the high water-table. « The relatively poor drainage has favoured extensive coniferous associations with black spruce the dominant species, mixed with tamarack and some northern white cedar. Improvement in drainage, due to slight elevations, is reflected in mixed stands of white birch, balsam fir, white spruce, aspen and balsam poplar » (Halliday, 1937). Black spruce however, covers more than 60 per cent of the area and jack pine cannot be ignored in some localities. Tamarack is important here while it is of little importance in the Northern Coniferous Section. Northern white cedar is also an important species in this section although it is almost absent in the Hudsonian Section. In the Coastal Plain Section and the East James Bay Section, tamarack, black spruce and balsam fir are stunted or reduced in size, but they are of commercial size in the Northern Clay Section.

C-7. Northern Coniferous Section

This section, which is a part of the Northeastern Coniferous Section of Halliday, is bounded on the north by the Hudsonian Section, on the south by the Upper St. Maurice Section and the Lake St. John Section (the latter being in the Mixed Forest Region), on the west by the Northern Clay Section and on the east by the North Shore Section. The height of land dividing the St. Lawrence river basin and the Lake St. John basin is the boundary line between the North Shore Section and the Northern Coniferous Section. On the south the boundary line is the height of land between the St. Maurice valley and Lake St. John basin.

The forests of the Northern Coniferous Section are constituted mainly of two species, black spruce and balsam fir, which seem to be of equal importance. On the north shore, balsam fir stands next to black and white spruce in importance. In this section, the Northern

Coniferous Section, jack pine and white spruce are the secondary species with white birch and aspen as associates on lake shores and river-banks. As in other sections with the same general characteristics, jack pine is abundant on deep sandy soil after forest fires. Racine and Richard (1944) reported annual growth in this section of almost 20 cubic feet per acre.

C-8. North Shore Section

The North Shore Section reaching the height of land between the St. Lawrence river basin and the Lake St. John basin, extends to the Labrador coast on the east, and on the north to the southern limit of Halliday's Northeastern Transition Section. It is a portion of Halliday's Northeastern Coniferous Section. This section is quite different from the Laurentide Park Section, the Upper St. Maurice Section and the Northern Coniferous Section.

The dissimilarities between those sections have already been mentioned and it is only necessary to add here that black spruce and balsam fir exhibit differences in growth between the North Shore and the Hudsonian sections. Indeed, in the North Shore Section these species show a normal growthform while they are stunted or reduced in size in the other section.

In general, black spruce is the main species of the North Shore Section. Balsam fir is also very important and white spruce and jack pine are seen in some localities. After forest fires aspen and white birch take a predominant place. Balsam fir always develops on fresh soils whereas jack pine occurs on deep and dry soils. As a general rule pure coniferous stands are seen on summits while broad-leaved trees appear in valleys or on the shores of the St. Lawrence. Northern white cedar and yellow birch are noted occasionally, the first in moist soils, the second on rich and well-aerated soils. Bellefeuille (1933) after a careful study of the site-types in the forest of this section concluded that after fires the indicator types *Calliargon* and *Hylocomium* favored a new generation of spruce; *Kalmia* — *Vaccinium* — *Cladonia*, a generation of jack pine, aspen and white birch; *Rubus* — *Sphagnum* and *Kalmia* — *Ledum*, a generation of slowly growing black spruce.

C-9. Hamilton-Ungava Valleys Section

Nothing may be added at the moment to Halliday's paper on this section. Referring to Low (1885), Halliday wrote: « Certain

of the river-valleys of the Labrador-Quebec peninsula show a marked contrast in tree-cover and growth-quality to the prevailing character as described under the Northeastern Transition Section (the Hudsonian Section of the adopted classification). Protection is certainly one of the controlling factors, but the presence of heavier soil deposits and the influence in places of the underlying rock has undoubtedly been another. The valley of the Hamilton river, 500 to 800 feet below the surrounding country is the largest of these areas, and supports a forest of commercial size, the species being white and black spruce, balsam fir, white birch, aspen and balsam poplar. Another area is part of the valley of the Koksoak around Cambrian lake and northward; here weathered deposits from the altered sedimentaries of the late Precambrian appear to have favoured tree distribution and growth. There is an open forest cover of large-sized white spruce, balsam poplar, tamarack, white birch and black spruce. This area is decidedly northerly, and the surrounding country has an arctic type of vegetation with an almost complete absence of white spruce and balsam poplar. »

C-10. Hudsonian Section

This name has been adopted to designate the Northeastern Transition Section of Halliday following the classification of Marie-Victorin (1935). This section is covered by a transition forest in the sense that there is a transition between forest vegetation and tundra vegetation. It is not a transition between two different Forest Regions. However, the boundary lines are Halliday's boundary lines.

In this section the forest cover is generally light with relatively dense stands confined to the vicinity of lakes in the lowlands. Black spruce and balsam fir are of relatively small size. Swamps are covered by shallow-rooted tamarack and black spruce. Scattered paper birch and jack pine occur in some localities.

C-11. Coastal Plain Section

This section is not important in the Province of Quebec, being located between the East James Bay Section and the Northern Clay Section, and covering a comparatively small area.

Here black spruce and tamarack form the prevailing forest types. They are reduced in growth by the high water-table. Along the rivers are also present species such as white spruce, balsam fir, aspen, balsam poplar, white birch and some northern white cedar. Halliday

(1937) pointed out that « evidence of edaphic rather than climatic conditioning is shown by the presence at several points of white elm and black ash on river-banks ».

C-12. East James Bay Section

This is Halliday's section of the same name. « The limits of the section to the east are indicated by the presence of white spruce and balsam poplar, which are not found beyond the range of the marine deposits » (Halliday, 1937).

Black and white spruce, balsam fir, jack pine and tamarack are the main species of the forest although balsam poplar, aspen and white birch are also important in size and distribution. This section produces trees of normal growth: a remarkable fact when one considers the vegetation of the adjoining Coastal Plain and Hudsonian sections between which it lies.

C-13. Anticosti Section

This section was recognized by Marie-Victorin (1935) as a region distinguished by peculiar geological and edaphic conditions. The vegetation is explained by two main factors. First, the high latitude, the low altitude and the proximity to cold ocean currents result in a subarctic vegetation peculiar to the southern part of the Canadian Labrador. Secondly, the calcareous nature of the stratified horizontal rocks which constitute Anticosti exerts a marked influence upon the species composition of the vegetation. This flora is characterized by a spruce forest in which white spruce, black spruce, balsam fir and white birch are the dominants. The characteristic lesser vegetation species are *Clintonia borealis*, *Cornus canadensis*, *Listera cordata*, *Maianthemum canadense*, *Oxalis montana* and *Thelypteris spinulosa*. In swampy sections are found *Kalmia angustifolia*, *K. polifolia*, *Ledum groenlandicum*, *Vaccinium pennsylvanicum* and *V. uliginosum* (Marie-Victorin, 1935).

THE MIXED FOREST REGION

THE Mixed Forest Region includes that portion of the Province where hardwood trees are approximately as plentiful as are coniferous trees. Here the broad-leaved species are too numerous to permit assignment of the area to the Coniferous Forest Region and there are too many evergreens to permit inclusion in the Hardwood Forest Region.

The Mixed Forest Region then, is a region situated between the Coniferous Forest Region and the Hardwood Forest Region. Roy (1930), Marie-Victorin (1935), Blanchard (1935), Racine and Richard (1944), and Roy (1944), have mentioned the presence of a Mixed Forest Region and described its composition. Halliday (1937) described his Great Lakes — St. Lawrence Region as a Mixed Forest Region. However, he wrote: « In many respects certain portions of the Great Lakes — St. Lawrence Forest might by now be considered part of the Deciduous Forest. I have considered it best, however, to retain them within the Great Lakes — St. Lawrence Forest and restrict the latter Forest Region to parts characterized by species such as tulip tree (*Liriodendron tulipifera* L.), chestnut (*Castanea dentata* Marsh. Borkh.), magnolia (*Magnolia acuminata* L.), mockernut hickory (*Hicoria alba* L. Brit.), chestnut oak (*Quercus montana* Willd.), and black walnut (*Juglans nigra* L.) ». Based on a careful study of reports and observations by the author it appears reasonable to describe the Mixed Forest Region as follows: The northern boundary line of the Mixed Forest Region has been indicated when describing the southern limit of the Coniferous Forest Region. On the south the Mixed Forest Region is bounded by the Hardwood Forest Region. The boundary between these last two leaves the Province of Ontario at Mattawa to follow the Ottawa river as far as longitude 77 degrees. From there the boundary line runs within ten miles south of Maniwaki, southward to pass through Chénéville and northward through Joliette, around the head of the St. Maurice river between Curtiss depot and St. Tite. Then the line extends to St. Joachim in a southward curve. At St. Joachim, the boundary line between the Mixed Forest Region and the Hardwood Forest Region runs southward along the summit of the hills between Bellechasse and Dorchester counties.

The presence or absence of certain species in the Mixed Forest region has been the basis in cases of its differentiation from the Conif-

erous or Hardwood Forest Region. White and red pine which are scattered in the Coniferous Forest Region, are important species in all sections of the Mixed Forest Region and dominant species in half of this region. Jack pine occurs scattered in the Mixed Forest Region and is almost absent from the Hardwood Forest Region. Hemlock (*Tsuga canadensis* L. Carr.) which is absent from the Coniferous Forest Region is abundant in the Mixed Forest Region and becomes a dominant species in some hardwood sections. Large-toothed aspen (*Populus grandidentata* Michx.), yellow birch, red oak (*Quercus borealis* Michx. f.), beech (*Fagus grandifolia* Ehrh.), white elm, sugar maple and black ash are present only when their soil requirements are satisfied; they are scattered in the Coniferous Forest Region but are abundant in the Mixed Forest Region. This Mixed Forest Region nevertheless contains most of the species mentioned in the Coniferous Forest Sections; the basis for distinction of the regions and sections is more one of relative abundance of the component species rather than a mere presence or absence.

The Mixed Forest Region has been subdivided into four sections as follows:

- M-1. Temiscamingue Section.
- M-2. Laurentian Section.
- M-3. Lake St. John Section.
- M-4. St. Lawrence Estuary Section.

M-1. Temiscamingue Section

The Temiscamingue Section is bounded on the east by the Central Transition Section of the Coniferous Forest Region and the Laurentian Section; on the west it is bounded by the Province of Ontario. This section is larger than the Haileybury Section of Halliday, the boundary line having been extended on account of the distinctive forest composition and also of soil conditions. In this section, the soil is a lacustrine clay deposit (Halliday, 1937).

The forest associations are made up of two coniferous species, black spruce and balsam fir, and two broad-leaved species, aspen and white birch. Fires have increased the extent of area occupied by the two broad-leaved species. Northern white cedar and balsam poplar are abundant in swamps, on river-banks and on moist lowlands. Sugar maple and red oak are found with red maple (*Acer rubrum* L.) and yellow birch at the head of Lake Temiscamingue and near the mouth of the river Blanche (Barlow, 1897). In this Temiscamingue Section

black spruce, balsam fir, aspen and white birch are dominant species compared with the Laurentian Section where the dominant species is white pine. Besides this difference between the two sections, red pine, jack pine, hemlock and beech, species which are almost absent in this region, are quite important in the Laurentian Section. Balsam poplar however, is more abundant in the Temiscamingue Section than in the Laurentian.

M-2. Laurentian Section

This section is almost exactly the same as Halliday's Algonquin-Laurentides Section but covers a smaller area. In other words, it corresponds to the Algonquin-Laurentides Section of Halliday, less the subdivision called the Temiscamingue Section. It is the largest of the four sections in the Mixed Forest Region and it lies between sections of the Coniferous Forest Region on the north and sections of the Hardwood Forest Region on the south.

Macoun (1900) has classified the general character of this section as that of a mixed forest, although white pine was once the dominant species (Ab-Yberg, 1931). Fires and lumbering have removed a large part of the white pine however, and to-day the association is one of white pine, hemlock, sugar maple, white birch and red maple. Black spruce and balsam fir are abundant in the northern part of the section. These species are mixed with aspen and white birch on river-banks and lake shores. South of 47 degrees latitude, white, red and jack pine, black spruce, balsam fir and northern white cedar are mixed with white birch, aspen, yellow birch and black ash (Rivard, 1944). On fertile soils basswood (*Tilia glabra* Vent.), white spruce, beech, red oak, elm, cedar, ironwood (*Ostrya virginiana* Mill. Koch.) and large-toothed aspen are secondary associates. The annual growth in this section is eleven cubic feet per acre for coniferous trees and six cubic feet per acre for the broad-leaved trees (Rivard, 1944). As far as soils are concerned Halliday (1937) said: « A podsol type of soil is to be expected, but areas of gray-brown and brown forest soils may be present, particularly in the southern parts ».

M-3. Lake St. John Section

The Lake St. John Section is entirely surrounded by the Coniferous Forest Region. In lowlands around the lake the surface deposits are largely marine clays; along the Saguenay river, from few miles below Chicoutimi almost to the mouth of the Saguenay, the soils and topography belong to the Coniferous Forest Region. Due to those two

facts the Lake St. John Section has been differentiated from the Saguenay river shores. It is a mixed forest section adjoined on all sides by sections of the Coniferous Forest.

The forest associations are composed of white pine, yellow birch, white birch, white cedar, basswood, balsam poplar, white elm, red maple and black ash. Balsam fir, aspen and white spruce are also common but their abundance is greater as one travels from the lowlands to the hills of the surrounding country. Following fires, aspen, white birch and balsam fir come in abundantly (Racine and Richard, 1944). The commercial annual growth of sixteen cubic feet per acre for coniferous and four for deciduous species (Racine and Richard, 1944) does not represent the exact situation because the estimate includes growth in a wide strip surrounding the Lake St. John region which really belongs to the Coniferous Forest Region.

M-4. St. Lawrence Estuary Section

The St. Lawrence Estuary Section includes all that part of the Province of Quebec located south of the St. Lawrence river which has not been included in the Coniferous Forest Region. The southern limit is the boundary line of the Hardwood Forest Region. A strip about ten miles wide on the North Shore extending from Tadoussac to Comeau Bay and certain other bays into which rivers empty, for example, Baie St. Paul and Murray Bay, have been included in the St. Lawrence Estuary Section. This treatment differs from that of Halliday (1937) who classified the lands in question in his Saguenay Section. The reason for departing from the classification of Halliday was that the vegetation of the North Shore portion is similar to that of the South shore of the Gulf of St. Lawrence.

The St. Lawrence Estuary Section is marked by the absence of hemlock (Roy, 1944). Red spruce (*Picea rubra* Link.) which is a dominant species in Halliday's Acadian forest region, is likewise absent (Marie-Victorin, 1927). According to Roy (1944) mixed forest types exist northeast of Rimouski on the shores and in valleys. From Rivière-du-Loup to the southern boundary line of this section, coniferous species have disappeared by lumbering and the present forest consists mostly of deciduous species (Neault, 1944). Cedar is a characteristic species as a bottom type with black spruce and tamarack. In valleys associations of white spruce, balsam fir, white and yellow birch are common. South of Rimouski red and sugar maple are more abundant. In alluvial flats are found white spruce, black ash, balsam poplar and white elm. Following fires old field birch (*Betula populifolia* Marsh.), white birch and aspen increase (Roy, 1944).

THE HARDWOOD FOREST REGION

IN the Hardwood Forest Region broad-leaved trees make up the majority of the stands. This region lies between the southern boundary of the Mixed Forest Region, the Province of Ontario and the States of New York, Vermont, New Hampshire and Maine.

According to Weaver and Clements (1938) « the general northern limit of the deciduous forest (in North America) runs from Central Minnesota along the southern shore of Lake Superior eastward to southwestern Quebec ». Halliday (1937) in deciding to include that region in the Great Lakes — St. Lawrence Region said: « In many respects certain portions of the Great Lakes — St. Lawrence Forests might by now be considered part of the Deciduous Forest. » He restricted the latter Forest Region « to parts characterized by species such as tulip tree, chestnut, magnolia, mockernut hickory, chestnut oak and black walnut ». In describing the only section of his Deciduous Forest Region this author stated that the association of species of the section is « made up of widely distributed broad-leaved trees common in part to both the Great Lakes — St. Lawrence and the Deciduous Forest Regions ». This association consists primarily of beech, sugar maple, basswood, red maple and red, white and bur oak (*Quercus borealis* Michx. f., *Quercus alba* L. and *Quercus macrocarpa* Michx.).

The area classified by the writer as the Hardwood Forest Region contains beech, sugar maple, basswood, red maple and red, white and bur oak but the coniferous species are also represented while they are not in Halliday's Deciduous Forest Region. In other words, Halliday (1937) based his classification of the Deciduous Forest Region on the absence of coniferous species while the present classification of the Hardwood Forest Region is based on the much greater representation of broad-leaved species.

The three sections of the Hardwood Forest Region bear the following designation:

- H-1. Upper St. Lawrence Section.
- H-2. Eastern Townships Section.
- H-3. Lower St. Lawrence Section.

H-1. Upper St. Lawrence Section

This Upper St. Lawrence Section is the southernmost portion of the Province of Quebec. On the north is the Mixed Forest Region; on the northeast and east are the other two sections of the Hardwood Forest Region. The Province of Ontario and the State of New York are adjacent to its southern limits.

The forest character of the Upper St. Lawrence Section is decidedly broad-leaved with a fair admixture of coniferous trees. Species well represented are: beech, white elm, sugar and red maple, basswood and white ash (*Fraxinus americana* L.). Red and white oak, large-toothed aspen and rock elm (*Ulmus racemosa* Thomas.) are less common and important. Among the coniferous species, red pine, tamarack, hemlock and balsam fir constitute the greater percentage although they form together the small representation of the coniferous growth. Scattered northern white cedar and black spruce or black ash characterize the poorly drained areas. This section is the richest portion of the whole Province of Quebec as far as number of species is concerned. The forest floor reflects consequently the wealth of the forest cover.

H-2. Eastern Townships Section

The Eastern Townships Section is the northern termination of the Green mountains of the Appalachian system. It is bounded on the north by the Mixed Forest Region and on the northwest by the Upper and Lower St. Lawrence Sections, the boundary line being the height of land.

The distinctive features of this section compared with the Upper and Lower St. Lawrence Sections are the abundance of aspen and white birch together with the following species: sugar maple, yellow birch, white spruce, balsam fir, white pine and hemlock. According to Wilson (1943) « the timber is largely hardwood with sometimes an understory of hemlock » and « white pine has been replaced by gray birch (*Betula populifolia* Marsh.) ». There is considerable disagreement amongst observers with regard to the presence or absence of red spruce (*Picea rubra* Link.) and its substitution for white spruce (*Picea glauca* Moench. Voss.) as a dominant. Halliday (1937) in accordance with Marie-Victorin (1927) has considered red spruce as absent. However the writer believes that red spruce is the main species of spruce in the Eastern Townships Section on the basis of its abundance in New England and at the Canado-American border in Quebec.

H-3. Lower St. Lawrence Section

The Lower St. Lawrence Section coincides with Halliday's section bearing the same name. It is bordered by the Mixed Forest Region and the two other sections of the Hardwood Forest Region.

The dominant species in this section are white pine, hemlock and balsam fir with aspen, yellow and white birch and sugar maple. The three coniferous species are not dominant in the Upper St. Lawrence and Lower St. Lawrence Sections although they are abundant in the northern part and on higher elevations of the Upper St. Lawrence Section. White spruce, silver maple (*Acer saccharinum* L.), red oak, beech, white ash, butternut (*Juglans cinerea* L.) red and white pine are of scattered occurrence. In swamps, northern white cedar and black spruce are common while cottonwood (*Populus deltoides* Marsh.) and red maple are seen on river-banks. On river shores balsam poplar is generally abundant (Marie-Victorin, 1935).

RELATIONSHIP BETWEEN CLIMATIC AND FOREST CONDITIONS IN THE PROVINCE OF QUEBEC

SINCE it is recognized that climate is the most important factor controlling forest vegetation, it follows that, after a description of the climatic and forest conditions in the Province of Quebec, relationships between these conditions may logically be considered.

Thus, a description of the principal features is given for each region and section of the adopted forest classification, and the major climatic differences with respect to adjacent regions or sections are examined.

Four broad regions, previously specified, are included in the territory of the Province of Quebec as follows:

- 1 — The Tundra Region.
- 2 — The Coniferous Forest Region.
- 3 — The Mixed Forest Region.
- 4 — The Hardwood Forest Region.

The arrangement of these regions with their respective sections or subdivisions, is the same as was previously indicated in describing forest conditions.

THE TUNDRA REGION

CLIMATIC records for the Tundra Region are very scarce as has already been mentioned. Brooks and Connor (1936), however, gave a good representation of the climate in this portion of the Province of Quebec, and from interpolations of their climatic isolines adequate conclusions may be drawn.

The mean annual temperature is below the freezing point in the Tundra Region, or more precisely between 26 and 32 degrees F. In July, the mean temperature varies from 42 to 51 degrees F., and the mean maximum temperature from 65 to 75 degrees F. The mean annual precipitation may be as low as 10 inches.

The Tundra Region is the product of its climate. Low temperatures, light precipitation and short, cool summers are the factors responsible for the treelessness of this region.

If a climatic comparison is made between the Tundra and the Coniferous Forest Region, it will reveal higher temperatures and heavier precipitation in the Coniferous Forest Region. In the Coniferous Forest Region the mean annual temperature ranges from 30 to 38 degrees F., the mean temperature for July from 50 to 66 degrees F., and the mean maximum temperature in July from 70 to 90 degrees F. The lowest values of these measures of temperature conditions in the Coniferous Forest Region are not much exceeded by the highest values in the Tundra Region. The mean annual precipitation ranges between 20 and 56 inches in the Coniferous Forest Region whereas it ranges between 10 and 30 inches in the Tundra Region.

The differences in temperature and precipitation between these two regions as well as evident vegetational differences, are sufficient to differentiate them as two wholly unlike climatic regions. The cold and dry climate of the Tundra Region is the cause of its scanty vegetation and the absence of forests. Warmer temperatures and heavier precipitation characterize the Coniferous Forest Region and are responsible for the development of forest vegetation. Soil conditions in the two regions differ but are not regarded as causing the differences in vegetation; rather climate is the primary control, influencing the nature of both the vegetation and the soil.

On the basis of Brooks and Connor's maps, climatic conditions have been described for each of the two Tundra Sections.

T-1. Ungava Peninsula Section

The mean annual precipitation varies from 10 to 18 inches in the Ungava Peninsula Section. It is the driest part of the Province of Quebec and is also the coldest area as may be seen by reference to the mean annual temperature and the mean minimum temperature for January. Temperatures for January show a -22 degrees F. isotherm (Brooks and Connor, 1936). Only a thin layer (one foot) of the surface soil is not permanently frozen. The result is that the region is in reality a vast and uniform swamp (Marie-Victorin, 1935). Mosses and lichens constitute the prevailing vegetation of the section.

T-2. Labrador Coast Section

This section of the Tundra Region receives annually from 18 to 30 inches of precipitation. The higher precipitation of the Labrador Coast, compared with that on the Ungava Peninsula, is caused by proximity to the sea. July and January temperature values reflect the influence of the sea. Humidity and cloudiness values are higher than those of the interior.

A greater number of plant species occur in the Labrador Coast Section than in the Ungava Peninsula Section. This is regarded as an effect of the somewhat warmer and more humid climate of the Labrador Coast. Although the flora of the Labrador Coast is richer floristically than that of the Ungava Peninsula, ecological differences in the plants are slight.

THE CONIFEROUS FOREST REGION

THE Coniferous Forest Region is characterized by a mean annual temperature of 30 to 38 degrees F., a mean temperature for July of 50 to 66 degrees F., and a mean temperature for the four warmest months of the year of 50 to 60 degrees F. The length of the frost free period is between 60 and 120 days. The mean annual precipitation varies from 20 to 56 inches.

Climatic dissimilarities between the Tundra Region and the Coniferous Forest Region have been shown. A similar differentiation between the Coniferous Forest Region and the Mixed Forest Region may be made.

The mean annual temperature, the mean temperature for July and the mean maximum temperature for July are all at least two degrees lower in the Coniferous Forest Region than in the Mixed Forest Region. The mean temperature for the four warmest months shows a variation of 10 degrees in the former and a variation of only five degrees in the latter. An equally striking climatic difference between these two regions is manifested in the average length of the frost free period. Although an average frost free period of 100 to 130 days is recorded in the Mixed Forest Region, only 60 to 120 days constitute the average length of this period in the Coniferous Forest Region. Furthermore, during the short summer season of the latter region, frosts may occur at any time. An additional climatic difference between these two regions is expressed by the P-E quotient which varies from 0.6 to 2.5 in the Coniferous Forest Region and from 0.5 to 1.3 in the Mixed Forest Region. Climate is the principal factor controlling vegetation in the Coniferous Forest Region. Indeed, the evergreen habit and the ecological characteristics of the dominant tree species of the region appear to be well-adapted to the climatic conditions. The short growing season, relatively low summer temperatures, and long, cold winters are not incompatible with normal development of conifer forests. In the Mixed Forest Region where temperatures are higher, coniferous trees are generally found in moister and consequently colder soils or at higher elevations than the broad-leaved trees. Thus, climate is here the most important factor in producing a coniferous forest although secondary factors, such as soils, may influence differentiation of coniferous associations within sections.

In the Coniferous Forest Region, the fact of a general decrease in size of the trees with increasing latitude may be mentioned. This concerns mainly the northern sections of the region where there is a sharp transition between the Tundra Region and the Coniferous Forest Region. The transition in climatic elements explains the transition in plant growth.

Climatic conditions have also been studied in each subdivision of the Region. The principal features of each section and the major differences with respect to adjacent sections are given below.

C-1. Central Transition Section

Precipitation seems to be a fundamental differentiating factor in the Central Transition Section when compared with the neighbouring northern sections. The Central Transition Section has a mean annual precipitation varying from 28 to 35 inches whereas in the Upper St. Maurice and the Northern Clay Sections it is heavier, amounting to 36 to 42 inches and 39 to 41 inches, respectively. The mean monthly summer precipitation shows similar differences, ranging from 3.5 to 4.0 inches in the Central Transition Section, from 4.0 to 4.5 inches in the Upper St. Maurice Section and from 4.0 to 5.0 inches in the Northern Clay Section.

The mean monthly values for summer evaporation are from 5.0 to 5.5 for the Central Transition Section, from 3.5 to 4.5 for the Upper St. Maurice Section, and from 4.0 to 4.5 for the Northern Clay Section. Other minor dissimilarities are also observable in the length of the frost free period, the P-E index and the mean monthly range of temperature in July.

The Central Transition Section characteristically supports an association of black spruce, balsam fir and white birch; subordinate species include white and red pine, aspen and white spruce. White and red pine are more important than in the Upper St. Maurice and Northern Clay Sections.

Compared with adjacent sections, the Central Transition Section shows higher evaporation figures. It is situated at a somewhat higher altitude than the surrounding sections and the soil profile is typically a podsol.

Since this section is characterized by high, southward-facing slopes, exposure may be a causative factor in the white birch dominance with black spruce and balsam fir as associates. Moisture is not a

limiting factor for white birch since it develops on relatively dry sites (Cheyney, 1942).

The soils on which white pine grows naturally are characteristically sands, and red pine is usually found on rather dry, sandy, often gravelly ridges (Cheyney, 1942). Occurrence of these two species in the Central Transition Section seems to confirm these observations. The dry, well-drained sites support white and red pine in addition to the dominant association of black spruce, balsam fir and white birch.

In the Upper St. Maurice Section the forest association resembles that of the Central Transition Section but also includes jack pine as a dominant species. In the Northern Clay Section tamarack is found with black spruce and balsam fir in the dominant type. These are the main differences in forest conditions of the three sections. Soil conditions are the primary cause of the differences. The soils of the Central Transition Section are typically podzols while sand plains prevail in the Upper St. Maurice Section. In the Northern Clay Section clay soils with high water-table and poor drainage are highly influential in determining forest conditions. Jack pine is characteristic of dry sandy soils but tamarack usually occurs in swampy areas. Thus, climatic conditions, although influential are of secondary importance in the differentiation of these sections.

C-2. Laurentide Park Section

Only two sections of the region under consideration are adjacent to the Laurentide Park Section. They are the Upper St. Maurice and the North Shore Section.

The Laurentide Park Section differs from the Upper St. Maurice Section in having higher a mean temperature and a higher mean maximum temperature during July. Furthermore, the mean monthly summer evaporation and the mean maximum daily evaporation are higher in the Laurentide Park Section. The mean monthly relative humidity during summer and the P-E quotient are also higher in the Laurentide Park. The Laurentide Park Section differs from the North Shore Section in having a higher mean temperature for the four warmest months and a shorter frost free period; in addition, the mean monthly summer precipitation is heavier in the Laurentide Park. The mean temperature for the four warmest months shows a striking difference, ranging from 54 to 58 degrees F. in the Laurentide Park Section and from 50 to 54 degrees F. in the North Shore Section.

Pure stands of black spruce and balsam fir evidently reflect a cold and moist climate, conditions favoured by the high altitude of this section. The soil profile, which is a podsol, must in this section, be considered an effect, not a cause, of forest composition. Zon (1914) recognized four types of balsam fir: swamps, flats, hardwood slopes and mountain types. In the Laurentide Park three types occur, namely swamps, flats and mountain types. Zon recognized black spruce as an associate of balsam fir and this relationship is found to occur in the types under consideration. Stated briefly, climate and soils are the factors chiefly responsible for the forest conditions found in the Laurentide Park Section.

C-3. South Shore Plateau Section

The South Shore Plateau Section is entirely surrounded by the St. Lawrence Estuary Section of the Mixed Forest Region. The South Shore Plateau and the St. Lawrence Estuary sections being in two different regions, it is not necessary to describe in detail the climatic conditions because the differentiation has already been set forth in dealing with the two regions. Being higher in altitude than the surrounding country, the South Shore Plateau Section has heavy precipitation (4.0 to 5.0 inches compared to 3.0 to 4.5 as the mean monthly summer rainfall). The mean temperature for the four warmest months here varies between 56 and 58 degrees F., compared with values of 58 to 60 degrees F. in the surrounding section. These climatic differences, resulting from the greater altitude, are evidently responsible for the differences in forest composition on the South Shore Plateau and in the surrounding area of mixed forest. Forests of the former consist chiefly of black and white spruce, often associated with balsam fir and white birch. The mixed forest of the adjacent territory contains white spruce, balsam fir, white and yellow birch, and south of Rimouski, red and sugar maple as the principal dominants.

C-4. Gaspé Plateau Section

The Gaspé Plateau Section, like the South Shore Plateau Section, is entirely surrounded by the St. Lawrence Estuary Section of the Mixed Forest Region. The Gaspé Plateau Section receives a mean annual precipitation ranging from 36 to 43 inches whereas the South Shore Plateau Section receives from 30 to 38 inches. The proximity to the sea and higher altitude are the principal factors responsible for heavy precipitation in the Gaspé Plateau Section.

As in the Laurentide Park, high altitude and heavy precipitation have favoured pure stands of black spruce and balsam fir, often mixed with white spruce, aspen, and white birch on slopes. Sandy soils are general over all the section so cannot be regarded as a causative factor in explaining forest composition. As has been pointed out earlier the vegetation of the highest peaks is a mixture of a relict flora that escaped destruction during the Ice Age and comparatively recent invaders.

C-5. Upper St. Maurice Section

The Upper St. Maurice Section is climatically different from the Northern Clay and the Northern Coniferous sections with respect to the average length of the frost free period. This period amounts to 80 to 90 days in the Upper St. Maurice Section, 70 to 80 days in the Northern Clay Section, and 90 to 100 days in the Northern Coniferous Section. Additional differences in climate are indicated by the mean maximum temperature in July (higher in the Upper St. Maurice Section than in the two other sections), the mean monthly relative humidity during summer (lower in the Upper St. Maurice Section than in the others), and the mean monthly range of temperature for the year (lower in the Upper St. Maurice than in the adjoining sections previously mentioned). The range of mean extreme temperatures in the Upper St. Maurice Section differs also (120 to 125 degrees F.) from the equivalent values in the Northern Clay Section (130 to 140 degrees F.) and the Northern Coniferous Section (125 to 135 degrees F.). It may be added that the Upper St. Maurice Section has a higher temperature for the four warmest months (56 to 58 degrees F.) and a heavier mean monthly summer precipitation (4.0 to 4.5 inches) than the Northern Coniferous Section (54 to 56 degrees F. and 3.5 to 4.0 inches, respectively). Climatic comparison with the other neighbouring sections has already been given.

The forest conditions are briefly as follows: black spruce, balsam fir and jack pine are the predominant species in the Upper St. Maurice Section; black spruce, tamarack and white cedar constitute the main association of the Northern Clay Section; black spruce and balsam fir are the principal dominants in the Northern Coniferous Section. These three associations occur on sandy plains, clay soils and typical podsol soils, respectively. It is apparent that both climate and soils are of equal importance here as causative factors influencing the occurrence of these three types of forest. Differences in soil conditions

are related to topography and drainage as well as to differences in the nature of the parent material.

C-6. Northern Clay Section

In the Northern Clay Section the mean temperature of the four warmest months varies from 56 to 58 degrees F. In the Northern Coniferous Section it ranges from 54 to 56 degrees F. The mean monthly summer precipitation (4.0 to 5.0 inches) and the P-E index (1.0 to 1.4) are also higher in this section than in the Northern Coniferous Section. However, the annual range of mean monthly temperature is lower, varying from 58 to 64 degrees F. whereas it ranges from 64 to 66 degrees F. in the Northern Coniferous Section. These values characterize the main climatic differences between the two sections.

The fundamental climatic differences between the Northern Clay Section and the Hudsonian Section concerns the mean annual precipitation. Indeed, 39 to 41 inches are registered in the former section whereas only 20 to 30 inches fall in the latter. The mean monthly summer precipitation shows a similar difference between the two sections. The mean temperature and the mean maximum temperature values for July are also higher in the Northern Clay Section than in the adjacent sections. Mean temperature for July, mean maximum temperature for July and the annual range of mean monthly temperature are additional climatic elements in which the Northern Clay Section differs from the three northern neighbouring sections, that is, the Hudsonian, the Coastal Plain and the East James Bay. As may be seen on the annexed maps, temperature and precipitation decrease as one travels northward in these sections.

Although climatic factors are slightly different, differences in soils seem to account for the abundance of tamarack as a dominant species in the Northern Clay Section and its relative unimportance in the Northern Coniferous Section. In the Hudsonian Section, the Coastal Plain Section and the East James Bay Section, tamarack, black spruce and balsam fir are stunted or reduced in size. This is due to low temperature, reduced length of frost free period and presumably also to the low amount of annual precipitation in those northern sections. As far as soils are concerned, it may be stated that they are thinner northward and consist generally of marine clay deposits. The water-table is high and the drainage is generally poor.

C-7. Northern Coniferous Section

In comparing the climatic data of the North Shore Section and the Hudsonian Section with those of the Northern Coniferous Section, it may be stated that the mean temperature for the four warmest months, the mean temperature for July, the mean maximum temperature in July and the annual range of mean monthly temperature show striking dissimilarities. Available data make it clear that temperature is lower towards the north and higher in coastal areas than in localities situated inland. Precipitation also decreases northward but is more abundant near the sea than inland. Since no marked difference has yet been found in the soils of these sections, the conclusion may be drawn that climate is the primary causative factor in determining the forest composition.

The Northern Coniferous Section has a lower temperature than the North Shore Section and the soils of both sections are characterized by podsol profiles. Thus, temperature as well as moist soils may explain the presence of black spruce and balsam fir as the co-dominant species in the colder section and also their presence in the North Shore Section with black spruce as dominant.

C-8. North Shore Section

The North Shore Section previously has been compared with all adjacent sections, excepting the Hudsonian Section. Precipitation is the fundamental element of differentiation between these two sections although temperature range may appear as a secondary derived element. Indeed, the mean annual precipitation varies from 35 to 42 inches in the North Shore Section while it is only 20 to 30 inches in the Hudsonian Section. The mean monthly summer precipitation likewise differs, paralleling the mean annual precipitation.

In the North Shore Section forest trees attain normal size but in the Hudsonian Section trees are generally smaller because of the lower temperature, the less abundant precipitation and the thinner soils. The North Shore Section is still relatively unknown as far as climate is concerned. Weather stations are operated only during the short summer and data collected represent intermittent periods. Consequently no definite conclusions can be drawn.

C-9. Hamilton-Ungava Valleys Section

Weather records for this special section, as delimited by Halliday (1937), are scanty. According to Brooks and Connor (1936) the mean temperature for July ranges from 50 to 54 degrees F. in the Hamilton district, whereas it varies from 50 to 60 degrees F. in the Hudsonian Section. The mean maximum temperatures in July range from 70 to 75 degrees F. in the Hamilton-Ungava Valleys Section and from 75 to 85 degrees F. in the Hudsonian Section. By interpolating Brooks and Connor's climatic isolines, the mean annual range of temperature is found to be between 54 and 64 degrees F. in the Hamilton-Ungava Valleys Section and between 60 and 68 degrees F. in the Hudsonian Section.

The presence of normally developed forests in this section indicates that the climatic conditions are not distinctly unfavorable to tree growth. Valleys which are protected against extremely cold temperatures and strong winds support forest stands of commercial importance, the species being white and black spruce, balsam fir, white birch and aspen as has been previously mentioned. Probabilities are, however, that soil conditions in valleys, being more favorable to vegetation than mountainous soils, may help tree growth.

C-10. Hudsonian Section

The Hudsonian Section is a vast area marking the transition between the coldest sections of the Coniferous Forest Region and the Tundra Region.

In this section, the mean temperature for July is between 50 and 60 degrees F. and the mean maximum temperature for July between 75 and 85 degrees F. The annual range of mean monthly temperature varies from 60 to 68 degrees F. The mean annual precipitation is 30 inches in the southeastern part of the section while it is less than 20 inches in the northern part, at the border of the Tundra Region. In the Hudsonian Section, climatic conditions are more rigorous than in any other part of the Coniferous Forest Region. They account for the small size of forest trees. The short growing season and relatively low temperatures during this period appear to be the critical factors; precipitation, although low, is not regarded as critical.

C-11. Coastal Plain Section

In this section, the mean maximum temperature for July ranges from 80 to 85 degrees F. compared with 85 to 88 degrees F. in the

Northern Clay Section. Compared with the East James Bay Section, the mean temperature for July is here higher, being from 60 to 65 degrees F. in the Coastal Plain Section and from 54 to 60 degrees F. in the East James Bay Section. The same climatic element varies from 50 to 60 degrees F. in the Hudsonian Section.

In the Coastal Plain Section, black spruce and tamarack form the prevailing forest type. Halliday (1937) pointed out that edaphic factors are the cause of the forest conditions in this section.

C-12. East James Bay Section

The name indicates the location of this section. Climatic conditions are similar in the Coastal Plain Section, the Hudsonian Section and the East James Bay Section. However, differences exist in the mean temperature for July which varies from 54 to 60 degrees F. in the East James Bay Section, from 50 to 60 degrees F. in the Hudsonian Section and from 60 to 65 degrees F. in the Coastal Plain Section. The mean annual precipitation in the East James Bay Section varies from 20 to 25 inches compared with 20 to 30 inches in the Coastal Plain Section.

Black and white spruce, balsam fir, balsam poplar, jack pine and tamarack are the main species in this section. Since balsam poplar is not found beyond the limits of the marine deposits, soils of this section are the primary cause of the distribution of that species. According to Low (1896) « clays and sand deposits are responsible for the vegetation and character of the tree growth ».

C-13. Anticosti Section

The Anticosti Section being an island and consequently under the influence of the sea, shows climatic elements different from those of the North Shore Section and also those of the Gaspé Plateau Section.

The mean temperature for the four warmest months ranges from 54 to 60 degrees F. compared with 50 to 54 in the North Shore Section. The average length of the frost free period varies from 110 to 140 days; in the North Shore and Gaspé Plateau Sections, it varies from 70 to 100 days and from 80 to 120 days, respectively. The mean monthly summer precipitation ranges from 3.0 to 4.0 inches in Anticosti Section whereas it varies from 4.0 to 5.5 on the Gaspé Plateau. Anticosti

island reflects the influence of the sea as may be seen by the mean monthly relative humidity in summer, 80 to 90 per cent. In the North Shore Section and in the Gaspé Plateau Section, this climatic element has a maximum value of 70 per cent.

The flora of Anticosti island is characterized by a spruce forest in which the dominants are white and black spruce, balsam fir and white birch.

In this section the effects of high latitude are compensated for by the proximity to the sea. Temperature ranges are comparatively small and the frost free period is comparatively longer than in the adjacent sections. Climatic conditions being favorable for the forest vegetation, it appears that soil characteristics may be responsible for local variations in the composition of the flora and consequently of the forest vegetation (Marie-Victorin, 1935).

THE MIXED FOREST REGION

COMPARISON has already been made between the Mixed Forest Region and the Coniferous Forest Region. It is necessary here to show the main climatic features of the Mixed Forest Region in order to demonstrate the differences between this region and the Hardwood Forest Region.

The Mixed Forest Region is characterized by a mean annual temperature of 34 to 40 degrees F., a mean temperature for July of 62 to 68 degrees F., and a mean maximum temperature in July of 85 to 92 degrees F. The mean temperature for the four warmest months ranges from 58 to 63 degrees F. and the average length of the frost free period from 100 to 130 days. These are the main climatic features of the Mixed Forest Region.

Values for the climatic elements of this region, although higher than in the Coniferous Forest Region, are lower than in the Hardwood Forest Region. For example, the mean temperature for the four warmest months falls between 58 and 63 degrees F. in the Mixed Forest Region and between 60 and 66 degrees F. in the Hardwood Forest Region. The average length of the frost free period falls between 100 and 130 days and between 110 and 150 days, respectively. Precipitation and evaporation, however, are not appreciably different in these two regions.

In view of the fact that the general character of the soils in the forest sections adjacent to the Mixed Forest Region is the same as in the Mixed Forest Region, it is reasonable to conclude that climate is the cause of the transition in forest composition. Indeed, the climatic changes, — warmer temperature, longer summer season, etc., — encountered in travelling southward, are responsible for the change from conifer forest, to conifer-hardwood forest and finally to hardwood forest.

It is necessary to examine the climatic characteristics of each section of the Mixed Forest Region so that the distinguishing features may be made clear.

M-1. Temiscamingue Section

In this section, the mean annual temperature ranges from 38 to 40 degrees F. as compared with 36 to 40 degrees F. in the Lauren-

tian Section. In the two other sections, that is, the Lake St. John and the St. Lawrence Estuary Sections, the mean annual temperature is below 38 degrees F. (34 to 38 degrees F. in the former and 36 to 38 degrees F. in the latter). The mean temperature for July varies from 66 to 68 degrees F. and the mean maximum in July from 90 to 92 degrees F., both records representing the highest values for the Mixed Forest Region. The mean temperature of the four warmest months (60 to 63 degrees F.) is also the highest in the region; the average length of the frost free period comprises 110 to 125 days which is longer than in other parts of the region, excepting the St. Lawrence Estuary Section.

Striking differences between the neighbouring Laurentian Section and the Temiscamingue Section are noted in the mean maximum temperature in July, the annual range of mean monthly temperature and the mean maximum evaporation in summer. The mean maximum temperature in July is higher than 90 degrees F. in the Temiscamingue Section, but lower than 90 degrees F. in the Laurentian Section. The annual range of mean monthly temperature is above 58 and below 58 degrees F., respectively, and the mean maximum evaporation in summer varies from 45 to 50 L.U. in the Temiscamingue Section and from 35 to 45 L.U. in the Laurentian Section.

If types of soils are considered it is evident that clay deposits are general in the Temiscamingue Section, while sandy soils are most common in the Laurentian Section. Thus soils as well as climate differ in these two sections.

Forests in the Temiscamingue Section are characterized by four dominant species: black spruce, balsam fir, aspen and white birch. The adjacent Laurentian Section supports, besides these four species, white pine, hemlock, sugar and red maple, red and jack pine.

It is certain that both soils and climate control the development of these two different associations of forest species in the Temiscamingue Section and in the Laurentian Section.

M-2. Laurentian Section

The Laurentian Section is characterized by the following climatic features: a mean annual temperature between 36 and 40 degrees F., a mean temperature for July between 64 and 68 degrees F., and a mean maximum temperature in July between 85 and 90 degrees F. The length of the frost free period extends from 100 to 125 days with

a mean temperature for the four warmest months varying from 60 to 62 degrees F. The annual range of the mean monthly temperature and the mean maximum evaporation in summer vary from 56 to 58 degrees F., and from 35 to 45 L.U., respectively.

A comparison of this section and the Temiscamingue Section shows that they have different climatic conditions. Likewise, comparison between the Laurentian Section, the Lake St. John Section and the St. Lawrence Estuary Section also shows important dissimilarities

The mean annual temperature, which is between 36 and 40 degrees F. in the Laurentian Section, does not exceed 38 degrees F. in the Lake St. John and the St. Lawrence Estuary Sections. The mean temperature for July and the mean temperature for the four warmest months also show values two degrees higher in the Laurentian Section than in the adjacent areas. However, the mean maximum evaporation has the lowest value in the entire region.

Soils of the Lake St. John are primarily organic soils; in the St. Lawrence Estuary they are marine clays in the western part and deep residual soils on the Atlantic coast. In the Laurentian Section, sandy soils are the most common type as was previously mentioned.

The Laurentian Section differs from the Temiscamingue Section in both climate and soils; it also differs from the Lake St. John and St. Lawrence Estuary Sections in these features.

Forest composition in the Laurentian Section has previously been described and compared with the Temiscamingue Section. Further comparisons with the Lake St. John Section and the St. Lawrence Estuary Section are not necessary since these last sections are both entirely surrounded by sections different in forest composition.

M-3. Lake St. John Section

This section is entirely surrounded by the Coniferous Forest Region. Climatic dissimilarities between the Coniferous Forest Region and the Mixed Forest Region have already been discussed. However, a comparison between the climatic elements of the Lake St. John Section and those of other sections of the Mixed Forest Region, particularly the St. Lawrence Estuary Section, shows certain differences.

The mean maximum temperature in July varies from 88 to 91 degrees F. in the Lake St. John Section, and from 85 to 88 degrees F. in the St. Lawrence Estuary Section. The average length of the frost free period extends from 100 to 125 days in the Lake St. John Section and from 110 to 130 days in the St. Lawrence Estuary Section. The mean maximum evaporation in summer varies from 40 to 50 L.U. in the former section and from 40 to 60 L.U. in the latter. The annual range of mean monthly temperature here shows higher values than in any of the other sections of the region.

Compared with the adjacent areas, the Lake St. John Section shows a higher summer temperature, a longer frost free period, a different type of soil and consequently a different forest vegetation. Climate and soils, as factors responsible for characterizing the forest vegetation, seem to be equally important.

M-4. St. Lawrence Estuary Section

The St. Lawrence Estuary Section is characterized by a mean annual temperature of 36 to 38 degrees F., a mean temperature for July of 62 to 66 degrees F., and a mean maximum temperature in July of 85 to 88 degrees F. The mean temperature for the four warmest months varies from 58 to 60 degrees F., and the average length of the frost free period extends from 110 to 130 days.

Due to the proximity of the sea this section has an annual range of mean monthly temperature varying from 52 to 56 degrees F.; in the other sections of the Mixed Forest Region, the values of this climatic element are higher than 56 degrees F. Although the mean maximum evaporation in summer is never above 45 or 50 L.U. in the other sections, it attains values as high as 60 L.U. in the St. Lawrence Estuary Section.

Edaphic and climatic comparison have been made between this section and other sections of the Mixed Forest Region and the adjacent Coniferous Forest Region. Favorable temperature conditions resulting from the proximity to the sea and low altitude are chiefly responsible for the forest composition of this section. However, soils derived from marine clays, rather than climatic conditions, seem to account for the occurrence of such broad-leaved species as black ash, balsam poplar and white elm.

THE HARDWOOD FOREST REGION

THE Hardwood Forest Region is the warmest region of the Province of Quebec. This is also the region with the longest summer period and consequently with the longest frost free period.

Climatic data for this region show a mean annual temperature between 38 and 43 degrees F. compared with 34 to 40 degrees F. in the Mixed Forest Region. In July the mean temperature and the mean maximum temperature attain values as high as 70 and 93 degrees F., respectively. The mean temperature for the four warmest months is between 60 and 66 degrees F. and the average length of the frost free period ranges from 110 to 150 days.

A comparison of the climatic data between each region of the Province of Quebec shows a general increase in temperature and moisture values from the Tundra, the most northerly region, through the Coniferous Forest Region and the Mixed Forest Region to the Hardwood Forest Region. A similar statement may be made with regard to the length of the frost free period. Temperature and moisture, however, depend upon factors other than latitude, and for this reason, differ in each region and section.

An analysis of the climatic data for the three sections of the Hardwood Forest Region shows that each section has a different climate, and consequently a different forest vegetation.

H-1. Upper St. Lawrence Section

The Upper St. Lawrence Section is the warmest section of the region; its mean annual temperature ranges from 40 to 43 degrees F. and its mean maximum temperature in July from 90 to 93 degrees F. The average length of the frost free period is also longer than in other sections, amounting to 125 to 150 days compared with 110 to 130 and 110 to 140 days in the two other parts of the region. The mean monthly summer precipitation is light, amounting to 2.5 to 4.0 inches whereas the other sections receive 4.0 to 5.0 inches. The P-E quotient and the P-E index also show low values in this section, ranging from 0.4 to 0.6 and from 0.4 to 0.8, respectively.

In this section there are found numerous species which cannot develop in other sections of the Province of Quebec on account of the

more rigorous climate. Among these rare species are basswood and rock elm.

The soils of this region do not differ greatly from those of the two other hardwood sections so the peculiarities in forest composition must be explained chiefly on the basis of climate.

H-2. Eastern Townships Section

This section, located west of the Upper St. Lawrence Section and south of the Lower St. Lawrence Section, as a mean annual temperature varying from 38 to 40 degrees F., that is, lower than that of the last two sections. Mean temperature in July is also lower. The average length of the frost free period ranges from 110 to 130 days, being shorter than in any other part of the region. In the Upper St. Lawrence Section the average frost free period varies from 125 to 150 days, and in the Lower St. Lawrence Section from 110 to 140 days. The P-E quotient, ranging from 0.6 to 1.0, is also different from that of the two other sections where it varies from 0.4 to 0.6 in the Upper St. Lawrence and from 1.0 to 1.2 in the Lower St. Lawrence Sections. It may be added that the annual range of mean monthly temperature ranges from 54 to 58 degrees F. in the Eastern Townships Section whereas the value of this climatic element elsewhere in the region varies from 58 to 60 degrees F.

The soils of this section are similar to those throughout Hardwood Forest Region. In this section the relative abundance of aspen, white birch, sugar maple and yellow birch are due first to the comparatively warm climate, and second to the removal of conifer stands during lumbering operations. The comparatively warm temperature of this section is due to latitude and geographic location.

H-3. Lower St. Lawrence Section

The Lower St. Lawrence Section is the most northerly division of the Hardwood Forest Region; from the standpoint of mean annual temperature, however, it occupies a position intermediate between the Upper St. Lawrence and Eastern Townships Sections. Mean annual temperature ranges from 39 to 41 degrees F. The mean temperature for July is higher than in the Eastern Townships Section but equal to that of the Upper St. Lawrence Section. Mean maximum temperature in July, although the same as that of the Eastern

Townships Section, is lower than the value for the Upper St. Lawrence Section. In the Lower St. Lawrence Section the average length of the frost free period varies from 110 to 140 days and the P-E quotient for the summer ranges from 1.0 to 1.2; this is the highest P-E quotient established within the Hardwood Forest Region.

In this section, the soils are predominantly podsolic. The forest shows the influence of the Coniferous Forest Region in its species composition. Indeed, extensive forest areas support white and yellow birch, sugar and red maple, and aspen in mixture with white pine, balsam fir, hemlock and white spruce. The comparatively warm climate of the Hardwood Forest Region accounts for the presence of such species as red oak, beech, white ash, butternut, cottonwood and balsam poplar.

SUMMARY AND CONCLUSIONS

AN understanding of the general principles of forest distribution in relation to climate is essential as a background for establishing and interpreting the correlation between local climates and local forest areas. The objective of the present investigation has been to analyse the climatic conditions in the Province of Quebec and to relate the climatic conditions to the forest vegetation.

Meteorological observations obtained at more than 200 weather stations in the Province during a decade, have been used as a basis for the investigation of climatic conditions. Standard climatic elements for each of four major vegetational regions (and for their subdivisions or sections) were derived from the original data. The climatic factors having greatest ecological importance were then considered from the standpoint of their significance in accounting for differences in forest conditions in the several regions and sections.

From the analysis of climatic conditions and forest distribution the following conclusions may be stated:

1 — The Province of Quebec may be divided into two distinct broad regions: a treeless tundra and a forest formation.

2 — The treeless tundra is caused primarily by the low temperature and secondarily by the low precipitation.

3 — The forest formation includes associations varying from relatively pure stands of conifers to relatively pure stands of hardwoods.

4 — The forest formation may be subdivided from North to South into three different regions: a Coniferous Forest Region, a Mixed Forest Region and a Hardwood Forest Region. Temperatures are lowest in the conifer region and highest in the hardwood region.

5 — The three principal forest regions are delimited on the basis of forest composition, as follows: (a) Coniferous Forest Region — conifers dominant, (b) Mixed Forest Region — dominance shared by conifers and hardwoods, (c) Hardwood Forest Region — hardwoods dominant.

6 — It is recognized that climatic conditions, and consequently forest conditions, are dependent on geographic features such as latitude,

altitude and location. For example, the South Shore Plateau Section is higher in altitude than the surrounding country. Thus, it receives a larger amount of precipitation, registers a lower mean temperature for the four warmest months and consequently has soil and forest conditions characteristic of the local climatic elements. In the Lake St. John Section climatic conditions are the result of relatively low altitude and local topographic features. There also soil and forest conditions are affected by climate. The South Shore Plateau Section and the Lake St. John Section support coniferous forests and mixed forests, respectively. In both instances, the forests of the surrounding country differ in composition.

7 — Climatic conditions are different in the three forest regions. Temperature increases from the Coniferous Forest Region to the Hardwood Forest Region through the Mixed Forest Region. The same statement holds for the length of the frost free period and the mean monthly summer evaporation. However, precipitation is lowest in the Mixed Forest Region and the P-E quotient decreases in value from the Coniferous Forest Region to the Hardwood Forest Region. In general, the influence of the climatic elements such as temperature and rainfall on species distribution is pronounced. These two elements determine the broad forest regions.

8 — The soils within the forested parts of the Province are generally podsoils. Textural differences due to differences in the nature of the parent materials are locally important in determining forest composition.

9 — General vegetation conditions within the Province of Quebec depend primarily upon climatic conditions and only secondarily upon soil conditions. Soil conditions may influence rate of growth, size and form of trees without calling forth differences in species composition. This is the situation in all but four sections; these are the Central Transition, the Northern Clay, the Coastal Plain and the East James Bay Sections.

10 — Local climatic conditions induced by topographic or other features frequently exert an important influence on vegetation. For example, in the Hudsonian Section, black spruce on elevated plateaus differs from that in the valleys, being reduced in size on the former but attaining normal development in the latter. Strong winds, low temperatures and presumably thin soils are the causes of the dwarf or stunted trees.

11 — Regional climatic and vegetational differences are pronounced but climatic and vegetation differences between individual sections of a given region are usually small.

12 — Climatic data for each of the minor subdivisions of the forest classification adopted for the Province of Quebec, have been analysed. Although differences between sections are sometimes small, no two have been found in which climatic conditions are identical.

13 — Differences in vegetation of climatically similar sections appear to be the result of differences in soils.

14 — Certain species such as black spruce, northern white cedar and tamarack occur on relatively dry soils in the northern parts of the Province and on relatively moist soils in the southern parts. Soil temperature appears to be the principal factor influencing this occurrence since these species are best suited to cold or wet soils.

15 — First, temperature, and second, precipitation are the two principal climatic factors controlling the general distribution and composition of forest vegetation in Quebec. It is not possible however, to select a single climatic element which, in itself, may be regarded as controlling the distribution and composition of vegetation. Soils are factors of primary importance after climate. It may be said that it is the combined operation of all factors, climatic, edaphic and physiographic, which produce the vegetation. When one of these factors varies, the variation affects both the other factors and the vegetation.

16 — In the Province of Quebec it will be necessary to accumulate more climatic data and for a longer period of years before it will be possible to give an accurate representation of the climatic conditions. More complete information on forest types and on ranges of species is needed before precise boundary lines can be drawn between forest regions and within forest regions. More accurate soil surveys are also necessary to evaluate more closely the interrelations of climate, forests and soils.

17 — Summarizing, known climatic, edaphic and forest conditions of the Province of Quebec induce a classification of the forest sections as follows:

A) The following sections differ greatly from adjacent sections because of climatic conditions:

- T-1. Ungava Peninsula Section
- T-2. Labrador Coast Section
- C-2. Laurentide Park Section
- C-3. South Shore Plateau Section
- C-4. Gaspé Plateau Section
- C-7. Northern Coniferous Section
- C-8. North Shore Section
- C-9. Hamilton-Ungava Valleys Section
- C-10. Hudsonian Section
- C-13. Anticosti Section
- M-4. St. Lawrence Estuary Section
- H-1. Upper St. Lawrence Section
- H-2. Eastern Townships Section
- H-3. Lower St. Lawrence Section

B) Soils seem to be the primary causative factors of vegetation conditions in the following sections:

- C-1. Central Transition Section
- C-6. Northern Clay Section
- C-11. Coastal Plain Section
- C-12. East James Bay Section

C) Climate and soils both appear to have an equal importance in controlling the development of forest vegetation in the following sections:

- C-5. Upper St. Maurice Section
 - M-1. Temiscamingue Section
 - M-2. Laurentian Section
 - M-3. Lake St. John Section
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BIBLIOGRAPHY

- AB-YBERG, W., 1931. A proposed system of forest classification for the Province of Quebec. Association des Ingénieurs-Forestiers de la province de Québec. Rapport annuel 1932. Pp. 5-55.
- ACKERMAN, EDWARD A., 1941. The Köppen classification of climates in North America. *Geogr. Rev.* **31**: 105-111.
- ANONYME, 1937. Arbres indigènes du Canada. Canada. Ministère des Mines et des Ressources. Service Forestier. Bul. 61. 220 pp.
- AUGER, HERMAS, 1943. L'étude du problème économique de la région du Saguenay. *La Forêt Québécoise.* **5**: 207-218.
- BARLOW, A. E., 1897. Report on the geology and natural resources of the area included by the Nipissing and Temiscamingue map sheets. Canada. Dept. of Mines and Resources. Geological Survey. Annual Report for 1897. 3021 pp.
- BELL, ROBERT, 1882. The geographical distribution of the forest trees of Canada. The Gazette Printing Co., Montreal. 21 pp.
- BELLEFEUILLE, ROBERT, 1933. Rapport du comité technique. Association des Ingénieurs-Forestiers de la province de Québec. Rapport annuel 1934. Pp. 5-18.
- BLANCHARD, RAOUL, 1935. L'Est du Canada français. Beauchemin, Montréal. Part I: 366 pp., Part II: 336 pp.
- BOUCHER, GERMAIN, 1944. Les richesses forestières des Cantons de l'Est. *La Forêt Québécoise.* **7**: 42-45.
- BROOKS, C. F., A. J. CONNOR and others, 1936. Climatic Maps of North America. Harvard University Press, Cambridge, Mass. 26 maps.
- CHEYNEY, E. G., 1942. American silvics and silviculture. Minnesota Press, Minneapolis. x + 472 pp.
- CHRISTIE, H. R., 1913. Northern limits of east Canadian trees in relation to the climate. *Forestry Quart.* **2**: 64-66.
- CLEMENTS, F. E., 1916. Plant succession, an analysis of the development of vegetation. Carnegie Inst. Wash. Pub. 242. xiii + 512 pp.
- CONNOR, A. J., 1931. Meteorological tables. Canada. Dept. of Marine. Reprinted from the Canada Yearbook 1931. 32 pp.
- DE MARTONNE, EMMANUEL, 1926. Aréisme et indice d'aridité. *Comptes-rendus de l'Acad. des Sciences de Paris.* **182**: 1395-1398.

- DICE, LEE R., 1938. The Canadian biotic province with special reference to the mammals. *Ecology*. **19**: 503-514.
- DRUDE, OSCAR, 1890. *Handbuch der Pflanzengeographie*. J. Engelhorn, Stuttgart. xvi + 582 pp.
- ELLIS, J. H., 1932. Soil problems and soil investigations in Manitoba (Unpublished report and map). 1st Session of Soils Group. Can. Soc. Tech. Agr. 1932 (quoted by Halliday, W. E. D., 1937, in: *A Forest Classification for Canada*).
- FERNOW, B. E., 1908. An analysis of Canada's timber wealth. *Forestry Quart.* **6**: 337-353.
- , 1912. Forest Resources and problems of Canada. *Soc. Amer. Foresters Proc.* **7**: 133-144.
- GORCZYNSKI, W., 1942. Climatic types of California, according to the decimal scheme of world climates. *Amer. Meteor. Soc. Bul.* **23**: 161-165.
- GOSSELIN, CHARLES, 1943. La situation forestière dans le Lac Saint-Jean-Saguenay. *La Forêt Québécoise* **5**: 219-225.
- HALLIDAY, W. E. D., 1937. *A Forest Classification for Canada*, Canada. Dept. of Mines and Resources. Forest Service. Bul. 89. 50 pp.
- , and A. W. A. BROWN, 1943. The distribution of some important forest trees in Canada. *Ecology*. **24**: 353-373.
- KNOCHE, WALTER, 1942. Nuevo método de clasificación climática. *Proceedings of the Eighth Scientific Congress.* **7**: 357-372.
- KOEPE, CLARENCE EUGENE, 1931. *The Canadian Climate*. McKnight & McKnight, Bloomington, Illinois. 280 pp.
- KOPPEN, WLADIMIR, 1918. Klassifikation der Klimate nach Temperatur, Niederschlag und Jahreslauf. *Petermanns Mitt.* **64**: 193-203; 243-248.
- , 1931. *Grundriss der Klimakunde*. Walter de Gruyter Co., Berlin. 2nd ed. 388 pp.
- LANDSBERG, HELMUT, 1943. *Physical Climatology*. State College, Pennsylvania. xii + 283 pp.
- LEBLEU, JEAN, 1944. La forêt dans l'économie de l'Ouest du Québec. *L'Association Forestière Québécoise. Compte-rendu du 1er Congrès provincial.* Bul. 10. Pp. 335-366.
- LESSARD, EUGÈNE, 1944. La forêt dans l'économie de l'Outaouais. *La Forêt Québécoise.* **8**: 223-235.
- LIVINGSTON, BURTON E. and FORREST SHREVE, 1921. The distribution of vegetation in the United States, as related to climatic conditions. *Carnegie Inst. Wash. Pub.* 284. 590 pp.

- Low, A. P., 1885. Report on the Mistassini Expedition. Canada. Dept. of Mines and Resources. Geological and natural history survey. Annual Report for 1885. Part D: 55 pp.
- , 1896. Report on explorations in the Labrador Peninsula along the East Main, Koksoak, Hamilton, Manicouagan and portions of other rivers in 1892-93-94-95. Canada. Dept. of Mines and Resources. Geological Survey. Annual Report for 1895. 387 pp.
- LUSSIER, OMER, 1944. La forêt dans l'économie du Québec. *La Forêt Québécoise*. 8: 367-379.
- MACOUN, JOHN, 1900. Report on natural history. Canada. Dept. of Mines and Resources. Geological Survey. Summ. Rep. (quoted by Halliday, W. E. D., 1937, in: A Forest Classification for Canada).
- MACOUN, J. M. and M. O. MALTE, 1917. The Flora of Canada. Canada. Dept. of Mines and Resources. Geological Survey. Museum Bul. 26. 16 pp.
- MARIE-VICTORIN, 1927. Les gymnospermes du Québec. Contribution du Laboratoire de Botanique de l'Université de Montréal. No 10. xii + 147 pp.
- , 1935. Flore Laurentienne. Imprimerie de la Salle, Montréal. 917 pp.
- MARTEL, J. P., 1944. Situation forestière dans les comtés d'Abitibi et du Témiscamingue. *La Forêt Québécoise*. 7: 56-60.
- MAYR, HEINRICH, 1925. Waldbau auf Naturgesetzmäßiger Grundlage. P. Parey, Berlin. 2nd ed. viii + 568 pp.
- MCDougALL, ERIC, 1925. The Moisture Belts of North America. Ecology. 6: 325-332.
- McKIBBIN, R. R., 1929. Forest Soils of Eastern Canada. Canadian Woodlands Rev. 1: 9.
- MERRIAM, C. HART, 1894. Laws of temperature control of the geographic distribution of terrestrial animals and plants. Nat. Geogr. Mag. 6: 229-238.
- , 1894. The geographic distribution of animals and plants in North America. U. S. Dept. of Agr. Yearbook 1894. Pp. 202-214.
- NEAULT, ARTHUR, 1944. La forêt dans l'économie de la Rive Sud. *La Forêt Québécoise*. 8: 239-257.
- NICHOLS, GEORGE ELWOOD, 1913. Summer evaporation intensity as a determining factor in the distribution of vegetation in Connecticut. The Botanical Gazette. 56: 143-152.
- , 1935. The hemlock — white pine — northern hardwood region of eastern North America. Ecology. 16: 403-422.

- PATTERSON, J., 1939. A Century of Canadian Meteorology. Quart. Jour. of the Royal Meteor. Soc. **66**: (supp. 1940). 32 pp.
- PEARSON, G. A., 1920. Factors controlling the Distribution of Forest Types. Ecology. **1**: 139-159; 289-308.
- RACINE, EUDORE and RENÉ RICHARD, 1944. La forêt dans l'économie du Saguenay — Lac Saint-Jean. *La Forêt Québécoise*. **8**: 310-336.
- RICHARD, RENÉ, 1944. La forêt dans l'économie de la Côte Nord. L'Association Forestière Québécoise. Compte-rendu du 1er Congrès provincial. Bul. 10. Pp. 233-275.
- RIVARD, FÉLICIEN, 1944. La forêt dans l'économie du Saint-Maurice. L'Association Forestière Québécoise. Compte-rendu du 1er Congrès provincial. Bul. 10. Pp. 401-437.
- ROUSSEAU, L. Z., 1944. La forêt québécoise. in: *La Forêt*. Editions Fides, Montréal. Pp. 41-78.
- ROY, HENRI, 1930. Principes de classification des peuplements. Association des Ingénieurs-Forestiers de la province de Québec. Rapport annuel 1931. Pp. 51-67.
- , 1933. Carte montrant les zones forestières du Québec. Université Laval, Ecole d'Arpentage et de Génie Forestier. Cours d'exploitation (non publié).
- ROY, GÉDÉON, 1944. Aperçu du problème forestier dans les comtés du Bas Saint-Laurent et de la Gaspésie. *La Forêt Québécoise*. **8**: 65-81.
- SARGENT, C. S., 1884. Report on the forests of North America (exclusive of Mexico). U. S. Depr. of Int., Census Off., Washington, D.C. 612 pp.
- SHANTZ, H. L. and R. ZON, 1924. Natural vegetation. in: *Atlas of American Agriculture*, Part I: The Physical Basis of Agriculture, Sect. E. U.S. Dept. of Agr. Adv. Sheets 6. 29 pp.
- SHREVE, FORREST, 1914. The rôle of winter temperatures in determining the distribution of plants. Amer. Jour. Bot. **1**: 194-202.
- THORNTHWAITTE, C. WARREN, 1931. The climates of North America according to a new classification. Geogr. Rev. **21**: 633-655.
- , 1933. The climates of the earth. Geogr. Rev. **23**: 433-440.
- , 1943. Problems in the classification of climates. Geogr. Rev. **33**: 233-255.
- TOUCHET, LOUIS, 1943. Description géographique et conditions forestières d'un secteur de la vallée de l'Outaouais. *La Forêt Québécoise*. **5**: 96-106.
- TOUMEY, J. W. and C. F. KORSTIAN, 1937. Foundations of silviculture upon an ecological basis. John Wiley & Sons Inc., New York. xxi + 456 pp.

- TRANSEAU, E. N., 1905. Forest Centers of Eastern America. *Amer. Nat.* **39**: 875-889.
- VAN ROYEN, W., 1927. The Climatic Regions of North America. *U. S. Mo. Weather Rev.* **55**: 315.
- VILLENEUVE, G. OSCAR, 1943. Forest-Meteorology in Quebec. *The Forestry Chronicle.* **19**: 203-218.
- , 1943. Relation entre les résultats de l'évaporimètre Wright et ceux de l'atmomètre Piché dans l'observation de l'évaporation. *Annales de l'ACFAS.* **9**: 86.
- WARD, ROBERT DECOURCY, 1918. Climate considered especially in relation to man. G. P. Putnam's Sons, New York. 2nd ed. rev. 380 pp.
- WEAVER, J. E. and F. E. CLEMENTS, 1938. Plant ecology. McGraw-Hill Book Co., New York. 520 pp.
- WILSON, ELWOOD, 1943. An analysis of the forest situation in Eastern Townships. *La Forêt Québécoise.* **6**: 167-171.
- ZON, RAPHAEL, 1914. Balsam fir. U.S. Dept. of Agr. Bul. 55. 68 pp.
- , 1941. Climate and the Nation's Forests. *in: Climate and man.* U.S. Dept. of Agr. Yearbook 1941. Pp. 477-498.
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APPENDIX

TABLE I

Stations	Latitude	Longitude	Altitude (feet)
Albanel.....	48 53	72 27	635
Amos.....	48 36	78 07	1,002
Ancienne Lorette.....	46 48	71 23	245
Annonciation.....	46 24	74 53	846
Anse au Griffon.....	48 56	64 19	70
Anticosti, East Point.....	49 12	61 40	
Armagh.....	46 44	70 32	1,150
Bagotville.....	48 20	71 00	536
Baie Comeau.....	49 10	68 25	100
Baie Saint-Paul.....	47 27	70 30	500
Bark Lake.....	47 03	76 20	1,569
Barrage « A » (Lac Kempt)....	47 28	74 12	1,380
Barrage Cabonga.....	47 18	76 28	1,225
Barrage « C » (Via Manouan)...	47 54	73 53	1,200
Barrage Ciconcine.....	47 23	73 02	
Barrage des Quinze.....	47 34	79 16	870
Barrage du Témiscamingue.....	46 44	79 07	591
Barrage Gouin.....	48 23	74 06	1,325
Barrage Lac Morin.....	47 36	69 30	650
Barrage Mattawin.....	46 51	73 52	1,200
Barrage Mercier.....	46 43	75 54	740
Barrage Mitchinamékus.....	47 13	75 10	1,265
Barrage Mondonac.....	47 28	73 56	
Barrage Passe Dangereuse.....	49 53	71 16	
Barrage Péribonka.....	50 38	71 32	
Barrière à Cheval.....	48 18	70 50	30
Barrière Louvicourt.....	48 04	77 23	1,041
Barrière Quinn.....	46 43	74 06	841
Barrière Rivière Alex.....	48 42	71 45	725
Barrière Rivière Mistassibi.....	49 05	72 06	725
Barrière Savanne.....	47 29	70 31	2,726
Beauceville.....	46 11	70 48	557
Beaudet.....	47 19	72 14	
Bell Falls.....	45 39	74 40	475
Berry Mountain.....	48 37	66 08	
Bersimis.....	48 55	68 37	

TABLE I — (*Continued*)

Stations	Latitude	Longitude	Altitude (feet)
Berthierville.....	46 06	73 11	27
Bic.....	48 25	68 53	10
Big Brook.....	48 33	65 01	2,000
Boileau.....	48 03	70 55	1,375
Bonaventure.....	48 05	65 26	64
Brôme.....	45 10	72 36	678
Cap Chat.....	49 07	66 42	87
Cape Hope's Advance.....	61 05	69 33	240
Cap Madeleine.....	49 16	65 20	93
Causapscal.....	48 21	67 12	450
Chelsea.....	45 29	75 46	369
Chénéville.....	45 54	75 05	730
Chicoutimi.....	48 25	71 05	180
Chûte à Murdock.....	48 31	71 15	300
Chûte aux Galets.....	48 39	71 12	500
Clark City.....	50 12	68 38	186
Clova.....	48 07	75 22	1,389
Clyde.....	70 25	68 17	10
Coral Harbour.....	64 11	83 21	195
Curtiss Depot.....	46 42	73 01	
Dépot John.....	48 38	77 16	850
Dépot Lac Alex.....	49 14	71 28	750
Disraéli.....	45 55	71 21	980
Donnacona.....	46 43	71 44	35
Dorval.....	45 27	73 45	98
Drummondville.....	45 50	72 30	270
Duchesnay.....	46 52	71 39	503
Duparquet.....	48 32	79 15	
Eagle Depot.....	46 16	76 19	720
East Angus.....	45 30	71 39	676
Ellis Bay, Anticosti.....	49 50	64 25	
Escoumains.....	45 30	71 39	676
Eshwahani.....	47 49	75 43	1,500
Fame Point.....	49 07	64 36	176
Father Point.....	48 31	68 28	20
Fond d'Ormes.....	48 13	68 28	520

TABLE I — (*Continued*)

Stations	Latitude	Longitude	Altitude (feet)
Forêtville	48 46	69 03	143
Forsythe	48 13	76 26	1,229
Fort Chimo	58 06	68 25	50
Fort George	53 50	79 05	320
Garthby	45 50	71 23	
Gaspé	48 50	65 29	92
Godbout (7 milles)	49 19	67 35	
Grande Vallée	49 15	65 04	30
Grand Lac Poisson Blanc	45 57	75 49	
Grand Lac Victoria	47 32	75 27	1,080
Grand'Mère	46 40	72 43	364
Grassy Narrow	47 44	78 47	864
Great Whale River	55 17	77 46	50
Grindstone Island	47 22	62 00	
Harrington Harbour	50 32	59 30	30
Hemming-Falls	45 50	72 30	325
Hemmingford	45 03	73 35	278
Hémon	49 08	72 35	470
Hervey-Jonction	46 51	72 28	568
Hope Depot	46 35	77 25	
Huberdeau	45 59	74 37	636
Ile Maligne	48 40	71 45	390
John Bull Depot	46 25	76 55	
Joliette	46 02	73 25	192
Kapatachouan	48 04	76 00	1,904
Kawasajewan	47 18	77 52	1,164
Kénogami	48 25	71 17	485
Kipawa	46 48	79 01	886
Lac à la Croix	48 37	72 52	
Lac Beauport	46 59	71 15	746
Lac Clair	47 02	73 48	1,306
Lac Desmarais	47 27	75 05	1,120
Lac Doré (Chibougamou)	49 54	74 18	1,234
Lac Édouard	47 39	72 16	
Lac Gagnon	47 20	73 42	1,250
Lac Jacques-Cartier	47 33	71 13	2,600

TABLE I — (*Continued*)

Stations	Latitude	Longitude	Altitude (feet)
Lac Manouan.....	50 38	70 32	1,625
Lac Onatcheway.....	49 00	71 02	1,050
Lac Sainte-Anne.....	50 07	67 49	1,420
Lac Tchitagama.....	48 51	71 27	307
Lac Tremblant.....	46 14	74 40	
La Galette.....	47 44	70 42	2,430
Lake Harbour.....	62 50	69 55	54
La Malbaie.....	47 40	70 10	
Lambton.....	45 52	71 05	112
La Moelle.....	48 22	72 40	2,250
La Sarre.....	48 48	79 13	882
L'Assomption.....	45 50	73 28	69
La Tuque.....	47 27	72 48	551
Laurierville.....	45 18	71 38	503
Lennoxville.....	45 22	71 52	498
Lepine Depot.....	46 54	76 08	750
Les Cèdres.....	45 21	74 05	132
Les Fourches (Manicouagan)...	49 36	68 25	
Maniwaki.....	46 21	76 00	570
Manouan.....	47 54	73 50	1,171
Manouan-Casey.....	47 35	74 10	
Manouan-Péribonka.....	49 30	71 10	596
Matapédia.....	47 58	66 57	53
Mégantic.....	45 36	70 52	1,314
Mésy.....	48 08	71 41	1,250
Mistassini.....	48 53	72 10	443
Mitis.....	48 20	67 50	875
Montebello.....	45 33	74 57	172
Mont-Joli.....	48 36	68 13	150
Mont-Laurier.....	46 34	75 30	733
Mont-Louis.....	49 15	65 42	21
Mont-Orford.....	45 18	72 15	800
Mont-Tremblant.....	46 12	74 40	746
Montréal (Jardin Botanique)...	45 21	73 35	130
Montréal (McGill).....	45 30	73 35	185
Morin Heights.....	45 53	74 15	812

TABLE I — (*Continued*)

Stations	Latitude	Longitude	Altitude (feet)
Natashquan.....	50 12	61 49	18
New Richmond.....	48 10	65 51	25
Nicolet.....	46 15	72 36	74
Nitchequon.....	53 12	70 35	1,820
Nominingue.....	46 27	75 30	860
Normandin.....	48 38	72 29	
Notre-Dame du Laus.....	46 06	75 39	680
Nottingham Island.....	63 07	77 56	54
Obidjuan.....	48 30	74 57	1,340
Oskélanéo.....	48 07	75 11	1,345
Ouimet.....	48 18	68 13	960
Parent.....	47 55	74 35	1,405
Parke.....	47 35	69 31	800
Pentecôte.....	49 47	47 10	150
Perkins.....	45 38	75 38	400
Pond Inlet.....	72 43	78 30	13
Portage des Roches.....	48 13	71 12	540
Port-Daniel.....	48 13	64 57	15
Port-Harrison.....	58 25	78 08	20
Price.....	48 36	68 09	
Québec.....	46 48	71 13	296
Rapide Blanc.....	47 43	72 57	920
Rapide des Joachims.....	46 11	77 44	390
Rapide No 7.....	47 46	78 19	1,020
Rawdon.....	46 01	73 37	264
Red Pine Chute.....	46 51	78 37	889
Red Pine Depot.....	47 18	74 47	1,500
Rémigny.....	47 45	79 12	
Resolution Island.....	61 18	64 53	127
Rivière à Mars.....	48 00	71 00	1,700
Rivière à Pierre.....	46 59	72 12	
Rivière au Tonnerre.....	50 16	64 46	
Rivière aux Écorces.....	47 49	71 31	2,290
Rivière aux Rats.....	49 25	72 18	610
Rivière Brisson.....	49 25	63 13	665
Rivière du Chef.....	49 30	75 23	

TABLE I — (*Continued*)

Stations	Latitude	Longitude	Altitude (feet)
Rivière Permit.....	45 59	76 49	600
Rivière Saint-Jean.....	50 17	64 19	
Roberval.....	48 31	72 13	532
Rougemont.....	45 27	73 34	198
Rouyn.....	48 14	79 02	1,051
Rowanton.....	46 28	77 46	670
Sacré-Cœur de Tourelle.....	49 05	66 18	1,410
Salmon River, Anticosti.....	49 28	62 20	
Sangirt Lake.....	53 50	65 30	1,650
Sanmaur.....	47 53	73 48	1,170
Sault-au-Cochon.....	48 57	69 30	
Sault-au-Mouton.....	48 33	69 16	90
Senneterre.....	48 07	77 15	1,030
Shawbridge.....	45 52	74 05	700
Shawinigan.....	46 34	72 43	306
Shelter Bay.....	50 01	66 53	50
Sherbrooke.....	45 24	71 53	620
Skiminac.....	48 19	65 58	100
Sorel.....	46 02	73 06	48
Southwest Anticosti.....	49 24	63 33	30
Squateck.....	47 53	68 43	550
Saint-Alexis-des-Monts.....	46 27	73 08	519
Saint-Bruno.....	45 30	73 22	81
Saint-Charles-de-Mandeville.....	46 21	73 20	
Saint-Donat.....	46 17	73 13	
Sainte-Adèle.....	45 57	74 13	700
Sainte-Agathe.....	46 05	74 18	1,260
Sainte-Anne-de-Bellevue.....	45 27	73 59	120
Sainte-Anne-de-la-Pocatière.....	47 22	70 22	100
Sainte-Anne-des-Monts.....	49 08	66 29	19
Sainte-Anne-du-Lac.....	46 53	75 20	860
Sainte-Cécile-de-Masham.....	45 38	76 02	
Sainte-Clotilde.....	45 10	76 40	
Sainte-Justine.....	46 23	70 19	1,370
Saint-Elzéar.....	48 10	65 23	
Sainte-Marguerite.....	45 59	74 13	900

TABLE I — (*Continued*)

Stations	Latitude	Longitude	Altitude (feet)
Sainte-Martine	45 14	73 48	123
Saint-Éphrem	46 04	70 54	737
Sainte-Rose-du-Déglé	47 30	68 30	495
Saint-Félicien	48 48	72 20	366
Saint-Féréol	47 08	70 51	975
Saint-Gabriel-de-Brandon	46 17	73 23	605
Saint-Guy	48 02	68 47	1,093
Saint-Hilaire	45 33	73 11	
Saint-Hyacinthe	45 46	72 56	102
Saint-Jean-de-Cherbourg	48 50	67 10	1,010
Saint-Jérôme	45 47	73 59	310
Saint-Jovite	46 07	74 36	701
Saint-Laurent	45 30	73 35	125
Saint-Léon-de-Labrecque	48 40	70 31	430
Saint-Léon-le-Grand	48 28	67 35	536
Saint-Lin-des-Laurentides	45 48	73 47	212
Saint-Michel-des-Saints	46 40	73 55	860
Saint-Sauveur	45 54	74 10	726
Saint-Tite	46 45	72 39	465
Stoneham	47 10	71 15	1,960
Sully	47 29	69 09	1,200
Sutton	45 07	72 37	582
Tadoussac	48 10	69 40	
Tapini Farm	46 55	75 08	900
Thetford-Mines	46 05	71 17	1,020
Tour Bellevue	50 31	67 42	1,650
Tour Chevalier	49 45	69 00	
Tour Lacroix	48 32	66 49	2,765
Tour Patapédia	48 07	67 42	1,627
Tour Tabouret	50 18	68 33	
Tourville	47 06	69 58	1,155
Trois-Rivières	46 21	72 49	50
Val David	46 02	74 10	1,050
Val d'Espoir	48 29	64 24	532
Val d'Or	48 06	77 46	1,000
Vallée-Jonction	46 23	70 50	491

TABLE I — (*Continued*)

Stations	Latitude	Longitude	Altitude (feet)
Val Paquin (Lucerne).....	45 38	75 36	350
Van Bruyssels.....	47 57	72 10	1,294
Victoria Lake.....	47 03	77 28	
Ville-Marie.....	47 20	79 25	590
Vingt-Deux Milles (Dépot)....	47 48	75 00	1,500
Wakeham.....	48 51	64 37	50
Waterloo.....	45 21	72 30	677
Watopeka.....	45 38	71 45	590
Windigo.....	47 46	73 20	929

TABLE II

Stations	Mean annual temp. (1)	Mean temp. for July (2)	Mean temp for January (3)	Annual range of mean Monthly temp. (4)	Mean max. temp. in July (5)	Mean min. temp. in January (6)
Albanel.....	35.9	66.8	1.8	65.0	90.8	-30.3
Amos.....	33.7	63.0	4.5	58.5	89.7	-43.0
Anticosti, East Point.....	35.0	57.0	12.0	45.0	.....	.....
Armagh.....	39.1	66.4	10.2	56.2	87.8	-22.7
Bark Lake.....	38.0	67.0	7.0	60.0	.....	.....
Barrage « A » (Lac Kempt).....	33.4	61.7	4.2	57.5	89.3	-36.8
Barrage Cabonga.....	36.6	63.4	6.8	56.6	87.5	-33.4
Barrage des Quinze.....	38.9	68.2	6.3	61.9	91.4	-35.0
Barrage du Témiscamingue.....	39.7	67.0	8.8	58.2	91.0	-25.0
Barrage Gouin.....	33.4	62.3	1.8	60.5	88.1	-34.1
Barrage Mattawin.....	36.8	63.2	7.2	57.0	86.6	-34.8
Barrage Mercier.....	38.5	64.8	7.5	57.3	88.8	-26.3
Barrière Savanne.....	35.0	60.7	7.2	53.5	82.3	-28.7
Beauceville.....	39.5	66.1	10.0	56.1	86.4	-24.1
Bersimis.....	35.3	60.0	8.0	52.0	81.2	-24.8
Berthierville.....	40.4	66.4	9.2	57.2	88.6	-29.0

TABLE II — (Continued)

Stations	Mean annual temp. (1)	Mean temp. for July (2)	Mean temp. for January (3)	Annual range of mean Monthly temp. (4)	Mean max. temp. in July (5)	Mean min. temp. in January (6)
Bic.....	38.2	64.3	9.7	54.6	87.4	-17.7
Bonaventure.....	38.8	65.5	11.9	53.6	91.4	-16.4
Brôme.....	41.2	67.1	13.1	54.0	88.8	-19.0
Cap Chat.....	37.7	63.8	12.3	51.5	82.6	-13.3
Cap Madeleine.....	36.6	62.0	11.2	50.8	83.4	-11.1
Causapscal.....	36.2	63.8	5.9	57.9	89.6	-27.2
Chelsea.....	40.8	69.4	9.3	60.1	90.6	-23.3
Chicoutimi.....	37.0	66.6	4.8	61.8	89.5	-25.4
Châte à Murdock.....	36.9	65.7	2.8	62.9	91.5	-33.8
Châte aux Galets.....	33.6	63.0	0.6	62.4	87.7	-38.0
Clark City.....	33.0	60.0	2.0	58.0	.....	.....
Disraeli.....	38.1	63.9	9.3	54.6	87.6	-32.0
Donnacona.....	39.9	68.5	9.7	58.8	88.8	-19.6
Drummondville.....	41.7	68.3	11.4	56.9	89.6	-19.7
Duchesnay.....	36.6	64.4	4.0	60.4	85.7	-30.2

East Angus.....	39.4	65.2	10.1	55.1	89.6	-23.7
Father Point.....	36.0	58.0	9.0	49.0	.....	.....
Forêtville.....	35.8	62.6	6.8	55.8	88.3	-22.3
Fort George.....	25.0	54.0	-12.0	66.0	.....	.....
Gaspé.....	37.8	65.9	9.4	56.5	87.3	-18.1
Hemmingfalls.....	41.3	68.6	11.6	57.0	88.8	-25.4
Hemmingford.....	41.4	68.5	13.2	55.3	92.7	-24.0
Hervey-Jonction.....	37.5	63.8	6.5	57.3	86.5	-27.6
Huberdeau.....	39.2	66.7	10.0	56.7	90.2	-21.7
Ile Maligne.....	36.0	64.3	4.8	59.5	90.6	-29.3
Joliette.....	40.9	69.4	9.5	59.9	92.0	-24.0
Kénogami.....	36.4	65.7	2.8	62.9	90.6	-26.4
Lac Onatcheway.....	33.4	62.3	-0.1	62.4	88.6	-36.4
La Galette.....	30.3	56.0	0.5	55.5	84.5	-34.5
La Malbaie.....	37.0	62.5	8.5	54.0	87.0	-25.2
Lambton.....	.....	.....	.....	.....	89.3	-19.3
L'Assomption.....	40.8	69.2	9.0	60.2	91.1	-27.8
La Tuque.....	37.3	64.7	3.7	61.0	93.6	-31.2
Laurierville.....	39.2	66.4	6.8	59.6	87.7	-22.0
Lennoxville.....	40.9	67.1	12.2	54.9	88.7	-25.0
Les Cèdres.....	42.7	70.0	13.4	56.6	89.7	-13.3
Maniwaki.....	39.3	65.9	7.3	58.6	89.8	-27.4
Manouan.....	36.0	63.8	5.0	58.8	89.2	-33.1
Matapédia.....	37.4	65.2	8.2	57.0	92.0	-26.3
Mégantic.....	38.6	64.9	10.1	54.8	84.8	-22.3

TABLE II.—(Continued)

Stations	Mean annual temp. (1)	Mean temp. for July (2)	Mean temp. for January (3)	Annual range of mean monthly temp. (4)	Mean max. temp. in July (5)	Mean min. temp. in January (6)
Mésy.....	32.9	59.1	1.7	57.4	86.5	-38.5
Montebello.....	40.8	67.9	9.8	58.1	91.4	-27.7
Mont-Laurier.....	38.6	64.1	7.7	56.4	87.7	-30.0
Mont-Louis.....	37.8	63.3	11.9	51.4	87.4	-12.1
Montréal (Jar. Bot.).....	41.9	70.1	9.5	60.6	90.7	-16.5
Montréal (McGill).....	43.7	70.6	14.3	56.3	89.1	-12.1
Natashquan.....	34.6	58.7	10.2	48.5	81.0	-21.7
Nominingue.....	38.2	66.8	7.8	59.0	88.0	-35.0
Normandin.....	34.6	63.8	3.7	60.1	88.3	-40.2
Notre-Dame du Laus.....	39.0	66.8	8.0	58.8	90.8	-26.0
Obidjuan.....	33.0	62.8	-1.9	64.7	87.5	-53.3
Portage des Roches.....	34.5	63.0	2.5	60.5	89.0	-28.6
Port Daniel.....	37.2	63.6	10.7	52.9	86.4	-17.4
Port Harrison.....	18.0	47.0	-18.0	65.0	.....	.....
Price.....	37.5	64.3	9.0	55.3	86.1	-18.7

Québec.....	40.9	69.2	11.3	57.9	88.0	-16.6
Rapide Blanc.....	35.6	64.3	3.5	60.8	91.4	-35.1
Rivière à Mars.....	33.0	61.4	1.4	60.0	88.0	-33.6
Roberval.....	34.2	63.0	0.0	63.0	89.0	-31.5
Rougemont.....	42.9	69.6	11.4	58.2	90.3	-18.3
Sanmaur.....					87.7	-38.3
Shawinigan.....	39.8	67.9	7.5	60.4	91.3	-21.4
Sherbrooke.....	41.6	67.7	13.1	54.6	89.3	-18.3
Sorel.....	40.8	69.0	9.1	59.9	91.4	-22.6
St-Bruno.....	41.9	69.3	12.2	57.1	90.1	-15.7
Ste-Agathe.....	37.9	64.6	8.5	58.1	85.6	-25.4
Ste Anne de Bellevue.....	42.6	70.1	12.7	57.4	90.6	-16.3
Ste Anne de la Pocatière.....	38.8	65.6	9.6	56.0	87.7	-15.7
Ste Martine.....	42.7	69.6	11.4	58.2	93.0	-22.5
St-Ephrem.....	39.4	65.9	10.5	55.4	87.5	-23.5
Ste Rose du Dégelé.....	37.4	63.9	6.8	57.1	88.1	-25.6
St-Féréol.....	36.7	63.7	6.4	57.3	86.7	-30.3
St-Gabriel de Brandon.....	39.0	67.3	6.2	61.1	90.0	-25.0
St-Hyacinthe.....	41.4	67.8	10.9	56.9	90.6	-18.3
St-Jérôme.....	40.0	67.9	9.4	58.5	89.9	-24.7
St-Laurent.....	42.5	70.3	12.8	57.5	90.7	-18.3
St-Lin des Laurentides.....	40.7	69.1	9.2	59.9	91.8	-25.6
St-Tite.....	39.4	67.9	8.1	59.8	89.4	-24.8
Stoneham.....	32.4	58.3	3.0	55.3	82.0	-29.6
Tadoussac.....	37.2	63.4	8.8	54.6	82.7	-21.6

TABLE II — (Continued)

Stations	Mean annual temp. (1)	Mean temp. for July (2)	Mean temp. for January (3)	Annual range of mean Monthly temp. (4)	Mean max. temp. in July (5)	Mean min. temp. in January (6)
Thetford-Mines.....	37.8	64.3	8.8	55.5	86.6	-25.7
Trois-Rivières.....	41.5	69.9	11.2	58.7	90.6	-18.3
Val Paquin (Lucerne).....	35.7	60.5	6.7	53.8	83.0	-26.8
Ville-Marie.....	38.5	65.8	6.2	59.6	90.2	-29.4
Number of stations.....	100	99	99	99	95	95
Average value.....	37.6	64.9	7.4	57.5	91.3	-25.7
The highest value.....	43.7	70.6	14.3	65.0	93.6	-11.1
The lowest value.....	18.0	47.0	-18.0	45.0	81.0	-53.3

TABLE III

Stations	Range of mean ext. temp. (7)	Mean monthly range of temp. for the year (8)	Mean monthly range of temp. in July (9)	Mean temp. for the four warmest months (10)	Av. length of the frost free period (11)	Mean annual precipit- ation (12)
Albanel.....	121.1	56.6	49.1	60.4	125.8	30.59
Amos.....	132.7	64.2	53.4	58.1	89.0	40.30
Annonciation.....					114.0	
Anticosti, East Point.....					138.3	
Armagh.....	110.5	53.7	43.2	61.7		37.72
Baie Comeau.....					129.0	
Barrage « A » (Lac Kempt).....	126.1	60.5	51.1	57.0		28.88
Barrage Cabonga.....	120.9	58.2	49.8	59.1		35.49
Barrage des Quinze.....	126.4	57.0	46.7	62.8		37.56
Barrage du Témiscamingue.....	116.0	54.3	48.8	62.8		30.50
Barrage Gouin.....	122.2	58.7	47.7	57.3		41.38
Barrage Mattawin.....	121.4	59.8	46.3	59.2		33.10
Barrage Mercier.....	115.1	53.5	46.0	60.9	123.0	34.66
Barrière Louvicourt.....					82.5	
Barrière Quinn.....					111.5	

TABLE III — (Continued)

Stations	Range of mean ext. temp. (7)	Mean monthly range of temp. for the year (8)	Mean monthly range of temp. in July (9)	Mean temp. for the four warmest months (10)	Av. length of the frost free period (11)	Mean annual precipit- ation (12)
Barrière Savanne	111.0	49.4	48.0	56.6	92.0	53.60
Beauceville	110.5	54.6	41.7	61.5	121.0	37.40
Bersimis	106.0	48.1	38.6	56.1	.....	35.11
Berthierville	117.6	56.3	44.4	63.4	129.3	36.56
Bic	105.1	50.2	44.7	59.8	.....	33.78
Bonaventure	107.8	46.4	49.2	59.5	134.5	31.71
Brôme	107.8	60.0	48.2	63.0	121.0	44.13
Cap Chat	95.9	40.4	34.1	58.0	.....	36.56
Cap Madeleine	94.5	44.1	39.5	56.7	133.2	35.63
Causapscal	116.8	55.8	49.0	59.3	.....	31.12
Chelsea	113.9	52.9	41.7	64.3	.....	33.80
Chicoutimi	114.9	54.4	43.8	60.8	.....	30.01
Chûte à Murdock	125.3	62.1	50.3	60.5	119.5	33.90
Chûte aux Galets	125.7	61.7	50.5	57.7	86.0	42.11
Disraeli	119.6	60.9	51.7	60.2	.....	42.82

Donnacona	108.4	51.4	42.4	63.5		42.89
Drummondville	109.3	53.6	46.2	64.2	130.1	40.10
Duchesnay	115.9	56.2	46.5	60.1	121.1	48.64
Duparquet					107.6	
East Angus	113.3	58.0	47.8	62.0		44.12
Forêtville	110.6	52.7	53.0	57.3	126.0	35.88
Fort Chimo					49.8	
Fort George					84.3	
Gaspé	105.4	51.8	46.5	60.1	100.5	43.30
Grande Vallée					119.6	
Grand Lac Poisson Blanc					115.5	
Great Whale River					53.3	
Hemmingfalls	114.2	57.0	44.4	64.2	131.1	42.85
Hemmingford	116.7	57.2	48.3	63.9	126.8	34.08
Hémon					93.3	
Hervey-Jonction	114.1	54.4	46.6	60.0		
Huberdeau	111.9	55.7	49.0	61.4		37.54
Ile Maligne	119.9	56.7	48.2	59.7		38.76
Joliette	116.0	53.2	44.2	64.6		33.67
Kénogami	117.0	55.4	47.1	60.5	122.8	33.76
Lac Edouard					68.7	
Lac Jacques-Cartier					60.8	
Lac Manouan					95.0	
Lac Onatcheway	125.0	62.4	52.7	57.4	99.0	47.62
Lac Tchitagama					100.5	

TABLE III — (Continued)

Stations	Range of mean ext. temp. (7)	Mean monthly range of temp. for the year (8)	Mean monthly range of temp. in July (9)	Mean temp. for the four warmest months (10)	Av. length of the frost free period (11)	Mean annual precipit- ation (12)
La Galette.....	119.0	61.8	55.0	51.8	72.1	32.44
Lake Harbour.....					49.4	
La Malbaie.....	112.2	55.9	47.6	58.0		34.91
Lambton.....	118.6	54.5	44.3		143.2	36.02
L'Assomption.....	118.9	56.9	44.0	64.6		36.76
La Tuque.....	124.8	60.4	53.2	60.4		36.24
Laurierville.....	109.7	56.1	45.0	61.1	116.7	33.60
Lennoxville.....	113.7	59.2	46.3	63.0		41.84
Les Cèdres.....	103.0	48.9	39.7	65.6		37.16
Maniwaki.....	117.2	56.3	47.8	62.0	122.3	30.58
Manouan.....	122.3	58.2	48.5	59.4		36.20
Matapédia.....	118.3	57.5	50.0	59.7		40.30
Mégantic.....	107.1	53.5	40.5	60.7	113.1	37.54
Mésy.....	125.0	67.5	55.2	55.3	62.1	40.47
Mistassini.....					120.1	

Mitis.....					103.0	
Montebello.....	119.1	58.0	48.6	63.6		40.27
Mont-Laurier.....	117.7	59.9	49.0	60.6	117.7	35.90
Mont-Louis.....	99.5	45.9	42.2	58.0	127.5	33.94
Montréal (Jar. Bot.).....	107.2	51.1	41.7	65.3	151.0	35.41
Montréal (McGill).....	101.2	45.2	35.6	66.0		40.41
Natashquan.....	102.7	45.2	36.2	54.6		41.51
New-Richmond.....					132.2	
Nicolet.....	111.8	51.7	44.2	64.1		40.90
Nominingue.....	123.0	49.0	46.3	61.6		33.69
Normandin.....	128.5	59.7	47.5	59.1	116.8	32.98
Notre-Dame du Laus.....	116.8	55.6	48.7	62.3	119.1	39.72
Nottingham Island.....					13.6	
Obidjuan.....	140.8	58.2	42.5	57.6		37.05
Oskélanéo.....	81.0					
Ouimet.....	74.0					
Parke.....	104.5					
Pond Inlet.....	27.9					
Portage des Roches.....	117.6	58.4	49.5	58.9	106.0	37.56
Port-Daniel.....	103.8	53.6	46.1	58.5	103.0	43.00
Port Harrison.....					45.6	
Price.....	104.8	49.8	44.1	59.1	130.0	39.72
Québec.....	104.6	48.0	37.8	63.6	147.0	48.49
Rapide Blanc.....	126.5	59.0	47.8	59.7		37.86
Resolution Island.....					4.5	

TABLE III — (Continued)

Stations	Range of mean ext. temp. (7)	Mean monthly range of temp. for the year (8)	Mean monthly range of temp. in July (9)	Mean temp. for the four warmest months (10)	Ave. length of the frost free period (11)	Mean annual precipit- ation (12)
Rivière à Mars.....	121.6	58.9	53.0	55.7	84.5	39.06
Rivière aux Rats.....					105.6	
Roberval.....	120.5	55.2	46.8	58.9	127.0	38.59
Rougemont.....	108.6	50.8	41.0	65.1	138.2	36.59
Rouyn.....					116.5	
Sacré-Cœur de Tourelle.....					125.0	
Sandgirt Lake.....					89.3	
Sanmaur.....	126.0	60.0	49.3			
Shawinigan.....	112.7	50.7	44.8	64.2		35.38
Shelter Bay.....					78.0	
Sherbrooke.....	107.6	53.6	43.8	63.4		41.69
Skiminac.....					104.6	
Sorel.....	114.0	54.3	45.8	64.9		36.20
Squateck.....					121.5	
St-Bruno.....	105.8	46.3	40.7	64.5		31.28

St-Donat.....					125.0	
Ste Agathe.....	111.0	52.4	43.3	61.0	125.0	41.90
Ste Anne de Bellevue.....	106.9	50.1	42.8	65.5		35.80
Ste Anne de la Pocatière.....	103.4	49.7	42.8	60.9	133.2	43.06
Ste Anne des Monts.....					132.6	
Ste Justine.....					111.1	
Ste Martine.....	115.5	53.0	47.3	64.6	133.5	29.02
St-Ephrem.....	111.0	54.5	43.3	61.5		37.42
Ste Rose du Dégelé.....	113.7	56.0	49.0	59.8	113.5	33.29
St-Féréol.....	117.0	58.4	47.2	59.1		49.03
St-Gabriel de Brandon.....	115.0	55.9	47.3	62.7	126.8	37.07
St-Guy.....					124.2	
St-Hilaire.....					140.3	
St-Hyacinthe.....	108.9	54.0	45.2	64.5	130.8	39.90
St-Jean de Cherbourg.....					92.5	
St-Jérôme.....	114.6	56.2	46.8	63.2		43.15
St-Laurent.....	109.0	52.0	43.2	65.7		35.71
St-Léon de Labrecque.....					81.4	
St-Lin des Laurentides.....	117.4	52.3	48.2	64.1		33.75
St-Michel des Saints.....					116.0	
St-Tite.....	114.2	54.8	46.1	62.6	128.0	37.40
Stoneham.....	111.6	57.6	50.2	54.2	64.0	55.77
Sully.....					89.0	
Tadoussac.....	104.3	47.8	36.2	59.0		31.42
Thetford-Mines.....	112.3	57.1	47.6	60.1	127.5	48.11

TABLE III — (Continued)

Stations	Range of mean ext. temp. (7)	Mean monthly range of temp. for the year (8)	Mean monthly range of temp. in July (9)	Mean temp. for the four warmest months (10)	Av. length of the frost free period (11)	Mean annual precipitation (12)
Tour Lacroix					109.0	
Tour Patapédia					109.3	
Tourville					85.8	
Trois-Rivières	108.9	50.5	41.1	64.4		40.04
Val d'Espoir					139.5	
Val Paquin (Lucerne)	109.8	46.8	40.3	58.6		35.61
Van Bruyssels					71.1	
Ville-Marie	119.6	58.9	48.3	62.3		27.42
Number of station	95	95	95	93	95	93
Average value	114.3	54.6	46.0	60.9	105.0	37.80
The highest value	140.8	67.5	55.2	66.0	151.0	55.77
The lowest value	94.5	40.4	34.1	51.8	4.5	27.42

TABLE IV

Stations	Mean monthly summer precipitation (13)	Mean monthly summer evaporation (14)	Mean max. evaporation in summer (15)	Mean monthly rel. hum. during summer (16)	P-E quotient for the summer (17)	P-E index for the summer (18)
Albanel.....	3.73					
Amos.....	4.40	4.25	46	54	1.03	1.05
Annonciation.....	4.15	4.31	40	56	0.96	0.90
Anse-au-Griffon.....	3.87	5.50	58	68	0.70	0.73
Armagh.....	3.84					
Baie Comeau.....	2.68	4.42	45	69	0.61	0.80
Bark Lake.....	2.80	4.81	43	57	0.58	0.69
Barrage « A » (Lac Kempt).....	2.51					
Barrage Cabonga.....	4.11					
Barrage des Quinze.....	4.45					
Barrage du Témiscamingue.....	3.06					
Barrage Gouin.....	4.63	3.87			1.20	0.80
Barrage Mattawin.....	3.57					
Barrage Mercier.....	3.57					
Barrière à Cheval.....	3.78	5.22	49	59	0.72	1.49

TABLE IV — (Continued)

Stations	Mean monthly summer precipitation (13)	Mean monthly summer evaporation (14)	Mean max. evaporation in summer (15)	Mean monthly rel. hum. during summer (16)	P-E quotient for the summer (17)	P-E index for the summer (18)
Barrière Louvicourt.....	3.16	4.14	37	53	0.76	1.09
Barrière Quinn.....		3.92	40	56	.....	1.03
Barrière Rivière Alex.....	4.21	5.19	50	59	0.81	0.79
Barrière Rivière Mistassibi.....		3.44	.....	.....	.....	1.06
Barrière Savanne.....	6.68	2.71	26	73	2.46	1.56
Beauceville.....	4.04	5.64	45	57	0.72	0.80
Beaudet.....	3.61	3.44	33	65	1.05	1.31
Berry Mountain.....	4.23	5.20	48	58	0.81	0.94
Bersimis.....	3.29	.....	.....	.....	.....	.....
Berthierville.....	3.54	5.25	52	56	0.67	0.63
Bic.....	3.15	.....	.....	.....	.....	.....
Big Brook.....	2.45	4.27	.....	.....	.....	.....
Boileau.....	3.32	5.97	64	58	0.56	0.49
Bonaventure.....	3.28	.....	.....	.....	.....	.....
Brôme.....	4.26	.....	.....	.....	.....	.....

Cap Chat	3.53					
Cap Madeleine	3.60	4.40	44	67	0.82	0.93
Causapscal	3.31					
Chelsea	2.83					
Chénéville	3.43	5.12	44	56	0.67	0.73
Chicoutimi	4.03	4.79	44	54	0.84	0.76
Chûte à Murdock	4.18					
Chûte aux Galets	4.76					1.35
Curtiss Depot	2.77	3.90	38	57	0.71	0.63
Dépot John	3.52	3.08	29	56	1.11	1.38
Disraéli	4.01					
Donnacona	4.49					
Drummondville	3.93					
Duchesnay	5.10	4.42	41	54	1.15	1.05
Duparquet	3.71	3.45	42	58	1.07	1.00
Eagle Depot	2.74	4.37	38	59	0.63	0.66
East Angus	4.63					
Escoumains	3.08	4.26	42	59	0.72	0.47
Eshwahani	3.83	5.43	53	49	0.70	0.84
Fond d'Ormes	2.59	3.93	37	55	0.66	0.89
Forêtville	3.72	4.06	41	54	0.92	0.95
Forsythe	4.02	4.15	42	62	0.97	1.32
Garthby						0.90
Gaspé	3.88					
Godbout (7 milles)	2.41	2.22				2.25

TABLE IV — (Continued)

Stations	Mean monthly summer precipitation (13)	Mean monthly summer evaporation (14)	Mean max. evaporation in summer (15)	Mean monthly rel. hum. during summer (16)	P-E quotient for the summer (17)	P-E index for the summer (18)
Grande Vallée.....	3.17	5.15	53	61	0.61	0.79
Grand Lac Victoria.....	3.18	2.96	30	60	1.07	1.19
Grassy Narrow.....	3.93					
Hemmingfalls.....	3.92	5.32	49	58	0.74	0.67
Hemmingford.....	3.30	4.80	48	63	0.69	1.40
Hémon.....	4.03	4.41	42	57	0.91	0.80
Hervey-Jonction.....	6.11					
Huberdeau.....	3.64					
Ile Maligne.....	4.10					
John Bull Depot.....	3.58					
Joliette.....	3.33					
Kapatachouan.....	3.91	3.62	41	64	1.08	1.20
Kawasajewan.....	2.74	5.64	48	61	0.48	0.62
Kénogami.....	4.03					
Lac à la Croix.....	3.01	5.52	59	66	0.54	0.49

Lac Clair.....	3.41	3.29	37	.....	.....	0.88
Lac Doré (Chibougamou).....	3.81	4.71	51	60	0.81	0.91
Lac Édouard.....	5.38	4.83	45	58	1.10	0.81
Lac Gagnon.....	3.53	5.48	52	58	0.64	0.59
Lac Jacques-Cartier.....	5.81	3.48	39	62	1.67	1.75
Lac Manouan.....	4.03	4.55	40	64	0.88	0.64
Lac Onatcheway.....	4.70	.....	.....	.....	.....	.....
Lac Tchitagama.....	4.41	3.38	32	58	1.30	1.40
La Galerte.....	3.82	4.11	41	48	0.93	0.86
La Malbaie.....	3.85	.....	.....	.....	.....	.....
Lambton.....	3.67	.....	.....	.....	.....	.....
La Moëlle.....	3.41	5.04	57	54	0.68	0.61
La Sarre.....	.....	.....	.....	.....	.....	0.60
L'Assomption.....	3.50	.....	.....	.....	.....	.....
La Tuque.....	3.82	4.64	40	.....	0.82	0.43
Laurierville.....	4.42	6.36	65	60	0.70	0.68
Lennoxville.....	4.33	.....	.....	.....	.....	.....
Lepine Depot.....	3.96	4.85	39	49	0.82	0.76
Les Cèdres.....	2.97	.....	.....	.....	.....	.....
Les Fourches (Manicouagan).....	3.73	5.03	47	68	0.74	0.72
Maniwaki.....	3.21	4.59	39	57	0.70	0.78
Manouan.....	3.89	4.34	45	54	0.90	0.71
Manouan-Péribonka.....	3.89	4.39	43	65	0.89	0.95
Matapédia.....	4.13	.....	.....	.....	.....	.....
Mégantic.....	3.92	4.04	35	51	0.97	0.94

TABLE IV — (Continued)

Stations	Mean monthly summer precipit- ation (13)	Mean monthly summer evapor- ation (14)	Mean max. evapor- ation in summer (15)	Mean monthly rel. hum. during summer (16)	P-E quotient for the summer (17)	P-E index for the summer (18)
Mésy.....	4.33	4.11	42	57	1.05	1.22
Mistassini.....	4.15	4.67	41	53	0.89	0.76
Montebello.....	3.77					
Mont-Laurier.....	3.58	4.73	45	56	0.76	0.86
Mont-Louis.....	3.27					
Montréal (Jar. Bot.).....	3.20	7.13	61	55	0.45	0.54
Montréal (McGill).....	3.77					
Natashquan.....	3.67					
New-Richmond.....	3.92	3.76	36	65	1.04	1.05
Nicolet.....	3.96					0.86
Nominingue.....	3.66					
Normandin.....	3.78					
Notre-Dame du Laus.....	3.73	4.92	43	54	0.76	0.86
Obidjuan.....	4.61					
Oskélanéo.....	5.15	4.56	42	54	1.13	0.71

Ouimet.....	4.59	3.79	37	52	1.21	1.08
Parke.....	4.01	3.75	33	57	1.07	0.95
Pentecôte.....	4.38	2.50	31	70	1.75	1.48
Portage des Roches.....	4.46					
Port-Daniel.....	3.61					
Price.....	3.83					
Québec.....	5.00					
Rapide Blanc.....	4.02					
Rapide des Joachims.....	3.60	4.41	39	66	0.82	1.03
Red Pine Depot.....	4.64	5.00	48	60	0.93	1.17
Rivière à Mars.....	3.79	4.36	44	52	0.87	0.87
Rivière à Pierre.....						0.91
Rivière aux Écorces.....	4.19	4.16				1.40
Rivière aux Rats.....	4.50	4.08	41	61	1.10	1.09
Rivière Brisson.....	4.09	3.33				1.39
Rivière du Chef.....						2.23
Rivière Permit.....	4.70					
Roberval.....	3.16	4.53	43	60	0.70	0.72
Rougemont.....	3.51	6.13	48	54	0.57	0.57
Rouyn.....	4.38	5.99	58	57	0.73	0.74
Rowanton.....	5.43	4.37	36	54	1.24	1.29
Sacré-Cœur de Tourelle.....	3.61	5.12	58		0.70	0.67
Sault au Cochon.....						1.47
Sault au Mouton.....	3.70	3.16	31	69	1.17	1.24
Senneterre.....	4.53	4.18	41	59	1.08	1.08

TABLE IV — (Continued)

Stations	Mean monthly summer precipitation (13)	Mean monthly summer evaporation (14)	Mean max. evapor- ation in summer (15)	Mean monthly rel. hum. during summer (16)	P-E quotient for the summer (17)	P-E index for the summer (18)
Shawinigan.....	3.77					
Shelter Bay.....	3.84	3.94	52	71	0.97	1.08
Sherbrooke.....	4.36					
Skiminac.....	5.55	2.67	28	60	2.08	1.49
Sorel.....	3.48					
Squateck.....	3.65	4.87	45	58	0.75	1.38
St-Alexis des Monts.....						0.63
St-Bruno.....	3.21					
St-Donat.....	3.78	4.96	46	52	0.76	0.71
Ste-Agathe.....	3.62					
Ste-Anne de Bellevue.....	3.15					
Ste-Anne de la Pocatière.....	3.42	6.14	66	52	0.71	0.57
Ste-Anne des Monts.....	3.42	4.29	49	73	0.80	0.82
Ste-Anne du Lac.....	3.85	4.46	39	56	0.86	0.91
Ste-Cécile de Masham.....		2.64				

Ste-Justine.....	4.45	5.47	51	66	0.81	0.75
St-Elzéar.....	2.82	3.66	34	54	0.77	1.38
Ste-Martine.....	2.73	6.89	58	51	0.40	0.42
St-Éphrem.....	4.13					
Ste-Rose du Dégelé.....	3.54					
St-Féréol.....	4.82					
St-Gabriel de Brandon.....	3.73	4.55	37	61	0.82	0.84
St-Guy.....	4.22	5.57	48	60	0.76	1.08
St-Hilaire.....	3.62	4.66	38	59	0.78	
St-Hyacinthe.....	3.73	4.31	36	52	0.86	0.77
St-Jean de Cherbourg.....	5.69	5.22	54	59	1.09	1.43
St-Jérôme.....	3.78					
St-Jovite.....	3.59	4.55	41	57	0.79	0.82
St-Laurent.....	3.26					
St-Léon de Labrecque.....	4.17	4.66	43	59	0.76	0.89
St-Léon le Grand.....	3.51	3.82	35	56	0.90	0.77
St-Lin des Laurentides.....	3.41					
St-Michel des Saints.....	3.52	4.00	43	63	0.82	0.84
St-Tite.....	3.83					
Stoneham.....	6.01	3.57	34	60	1.68	1.58
Sully.....	3.81	6.14	51	57	0.57	0.99
Tadoussac.....	3.04					
Tapini Farm.....	4.84	3.54	32	59	1.37	1.49
Thetford-Mines.....	5.30					
Tour Bellevue.....						0.98

TABLE IV — (Continued)

Stations	Mean monthly summer precipit- ation (13)	Mean monthly summer evapor- ation (14)	Mean max. evapor- ation in summer (15)	Mean monthly rel. hum. during summer (16)	P-E quotient for the summer (17)	P-E index for the summer (18)
Tour Chevalier.....	4.31	3.40	33	53	1.27	1.65
Tour Lacroix.....	4.28	3.75	39	61	1.14	0.63
Tour Patapédia.....	4.27	2.87	27	60	1.49	1.66
Tourville.....		4.80	48	60		1.14
Trois-Rivières.....	4.10					
Val d'Espoir.....	3.74	3.99	43	64	0.94	0.84
Val d'Or.....	4.74	4.47	42	54	1.06	1.08
Val Paquin (Lucerne).....	2.89					
Van Bruyssels.....		4.04	38	63		1.02
Victoria Lake.....						0.92
Ville-Marie.....	3.63	4.68	51	58	0.80	0.91
Vingt-Deux Milles (dépot).....	4.49	4.00	38	58	1.12	1.10
Wakeham.....	3.39	3.69	37	59	0.92	0.91
Windigo.....	2.54	4.41	37	55	0.57	0.63

Number of stations.....	176	114	107	104	104	121
Average value.....	3.88	4.43	43.2	58.6	0.91	0.97
The highest value.....	6.68	7.13	66.0	73.0	2.46	2.25
The lowest value.....	2.41	2.22	26.0	48.0	0.40	0.42

TABLE V

UNITS USED IN TABLES AND FIGURES

CLIMATIC CRITERIA	UNITS
Temperature	Degrees Fahrenheit
Length of frost free period	Number of days
Precipitation	Inches
Monthly evaporation	Inches
Daily evaporation	Cubic centimeters x 0.45 (Livingston units)
Relative humidity	Percentage
P and E in P-E	Inches

TABLE VI
CLIMATIC RECORDS IN THE FOUR REGIONS OF THE PROVINCE OF QUEBEC

Climatic Criteria	— T — Tundra Region	— C — Coniferous Forest Region	— M — Mixed Forest Region	— H — Hardwood Forest Region
Mean annual temperature	26-32	30-38	34-40	38-43
Mean temperature for July	42-51	50-66	62-68	64-70
Mean maximum temperature in July	65-75	70-90	85-92	85-93
Mean temperature for the four warmest months		50-60	58-63	60-66
Average length of the frost free period		60-120	100-130	110-150
Mean annual precipitation	10-30	20-56	30-38	30-49
Mean monthly summer precipitation		2.0-7.0	3.0-4.5	2.5-5.0
Mean monthly summer evaporation		3.5-6.0	3.5-6.5	4.0-7.0
P-E quotient for the summer		0.6-2.5	0.5-1.3	0.4-1.2

TABLE VII
CLIMATIC RECORDS IN THE TUNDRA SECTIONS

Climatic Criteria	T-1	T-2
Mean temperature for July	42-50	46-51
Mean annual precipitation	10-18	18-30
Mean monthly summer precipitation	2-3	3-4
Mean temperature for January	(-22)-(-14)	(-15)-(-10)
Mean minimum temperature in January	(-50)-(-40)	(-40)-(-20)

TABLE VIII
CLIMATIC RECORDS IN THE CONIFEROUS FOREST SECTIONS

Climatic Criteria	C-1	C-2	C-3	C-4	C-5
Mean temperature for July.....	62-66	56-62	64-66	60-62	62-64
Mean maximum temperature in July.....	87-90	82-88	87-88	80-85	88-90
Mean temperature for the four warmest months.....	57-60	54-58	56-58	56-58	56-58
Average length of the frost free period.....	80-110	60-90	70-110	80-120	80-90
Mean annual precipitation.....	28-35	32-56	30-33	36-43	36-42
Mean monthly summer precipitation.....	3.5-4.0	4.0-7.0	4.0-5.0	4.0-5.5	4.0-4.5
Mean monthly summer evaporation.....	5.0-5.5	4.0-6.0	4.0-5.5	4.0-6.0	3.5-4.5
P-E quotient for the summer.....	0.7-1.2	1.0-2.5	0.6-1.5	0.8-1.5	0.6-1.2
Annual range of mean monthly temperature.....	56-58	54-58	54-56	56-58	56-64
Range of mean extreme temperatures.....	120-125	110-125	115-120	100-120	120-125
Mean monthly range of temperature for the year.....	58-60	56-64	48-54	42-50	58-60
Mean monthly range of temperature in July.....	48-50	46-54	46-50	40-52	50-54
Mean maximum evaporation in summer.....	40-50	25-40	25-35	40-60	40-50
Mean monthly relative humidity during summer.....	50-60	55-70	52-60	55-70	50-55
P-E index for the summer.....	0.6-1.2	0.8-1.8	0.8-1.1	0.8-1.1	0.8-2.0

TABLE IX
CLIMATIC RECORDS IN THE CONIFEROUS FOREST SECTIONS (*Continued*)

Climatic Criteria	C-6	C-7	C-8	C-9	C-10
Mean temperature for July.....	60-64	62-64	58-60	50-54	50-60
Mean maximum temperature in July.....	85-88	85-88	80-85	70-75	75-85
Mean temperature for the four warmest months.....	56-58	54-56	50-54	.....	.....
Average length of the frost free period.....	70-80	90-100	70-100	.....	.....
Mean annual precipitation.....	39-41	39-42	35-42	20-30	20-30
Mean monthly summer precipitation.....	4.0-5.0	3.5-4.0	3.5-4.5	2.0-3.0	2.0-3.0
Mean monthly summer evaporation.....	4.0-4.5	4.0-4.5	4.0-5.0	.....	.....
P-E quotient for the summer.....	0.7-1.2	0.8-1.2	0.9-1.2	.....	.....
Annual range of mean monthly temperature.....	58-64	64-66	50-64	54-64	60-68
Range of mean extreme temperatures.....	130-140	125-135	110-140	.....	.....
Mean monthly range of temperature for the year.....	62-64	60-64	50-64	.....	.....
Mean monthly range of temperature in July.....	50-55	50-55	38-56	.....	.....
Mean maximum evaporation in summer.....	40-60	40-50	30-55	.....	.....
Mean monthly relative humidity during summer.....	55-60	55-65	60-70	.....	.....
P-E index for the summer.....	1.0-1.4	0.8-1.0	0.8-1.4	.....	.....

TABLE X
CLIMATIC RECORDS IN THE CONIFEROUS FOREST SECTIONS (*Continued*)

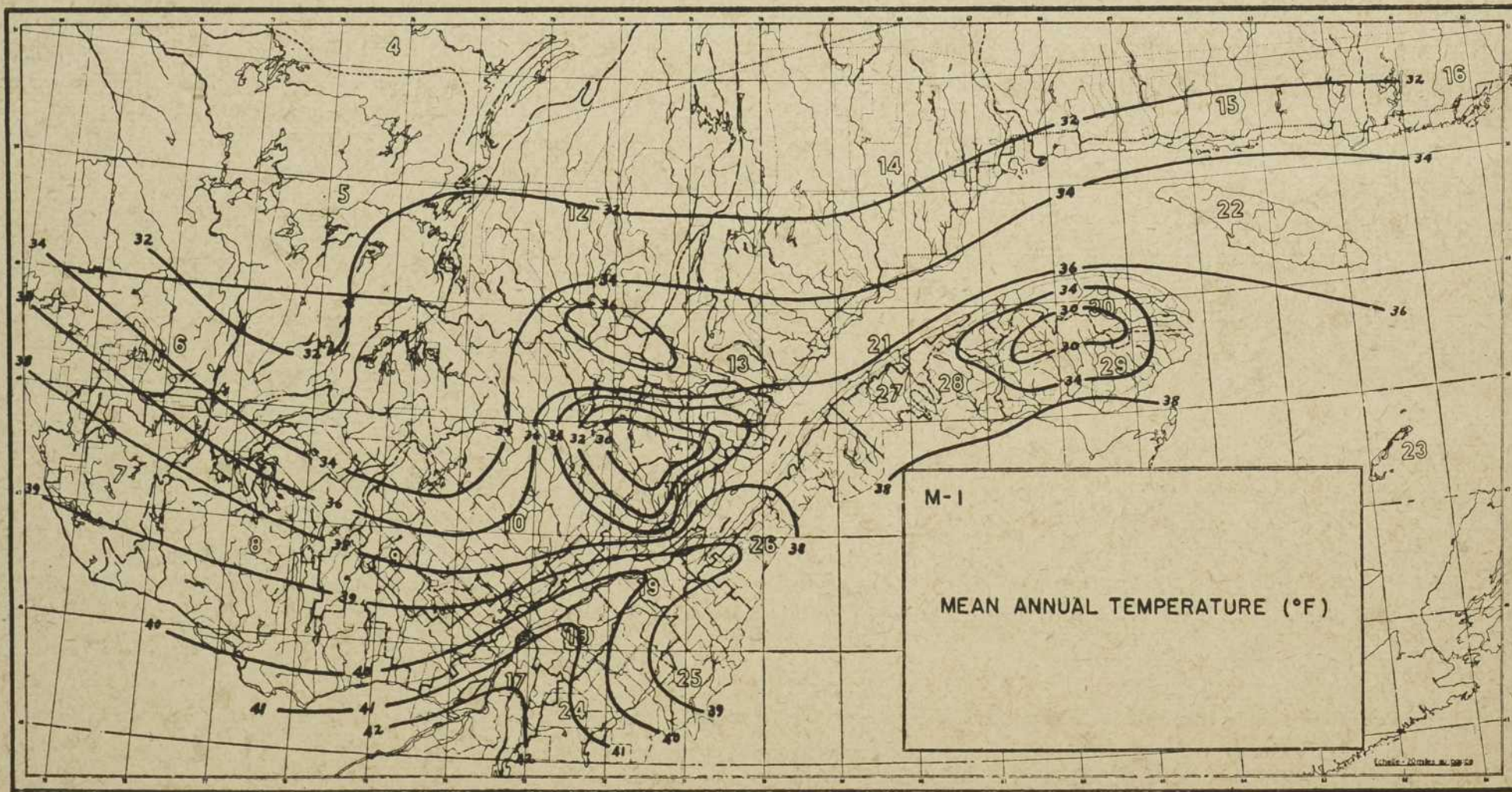
Climatic Criteria	C-11	C-12	C-13
Mean temperature for July.....	60-65	54-60	58-62
Mean maximum temperature in July.....	80-85	78-86	80-85
Mean temperature for the four warmest months.....			54-60
Average length of the frost free period.....			110-140
Mean annual precipitation.....	20-30	20-25	35-40
Mean monthly summer precipitation.....	2.0-3.0	2.0-3.0	3.0-4.0
Mean monthly summer evaporation.....			
P-E quotient for the summer.....			
Annual range of mean monthly temperature.....	64-68	64-68	44-50
Range of mean extreme temperatures.....			90-100
Mean monthly range of temperature for the year.....			40-46
Mean monthly range of temperature in July.....			34-38
Mean maximum evaporation in summer.....			
Mean monthly relative humidity during summer.....			70-80
P-E index for the summer.....			

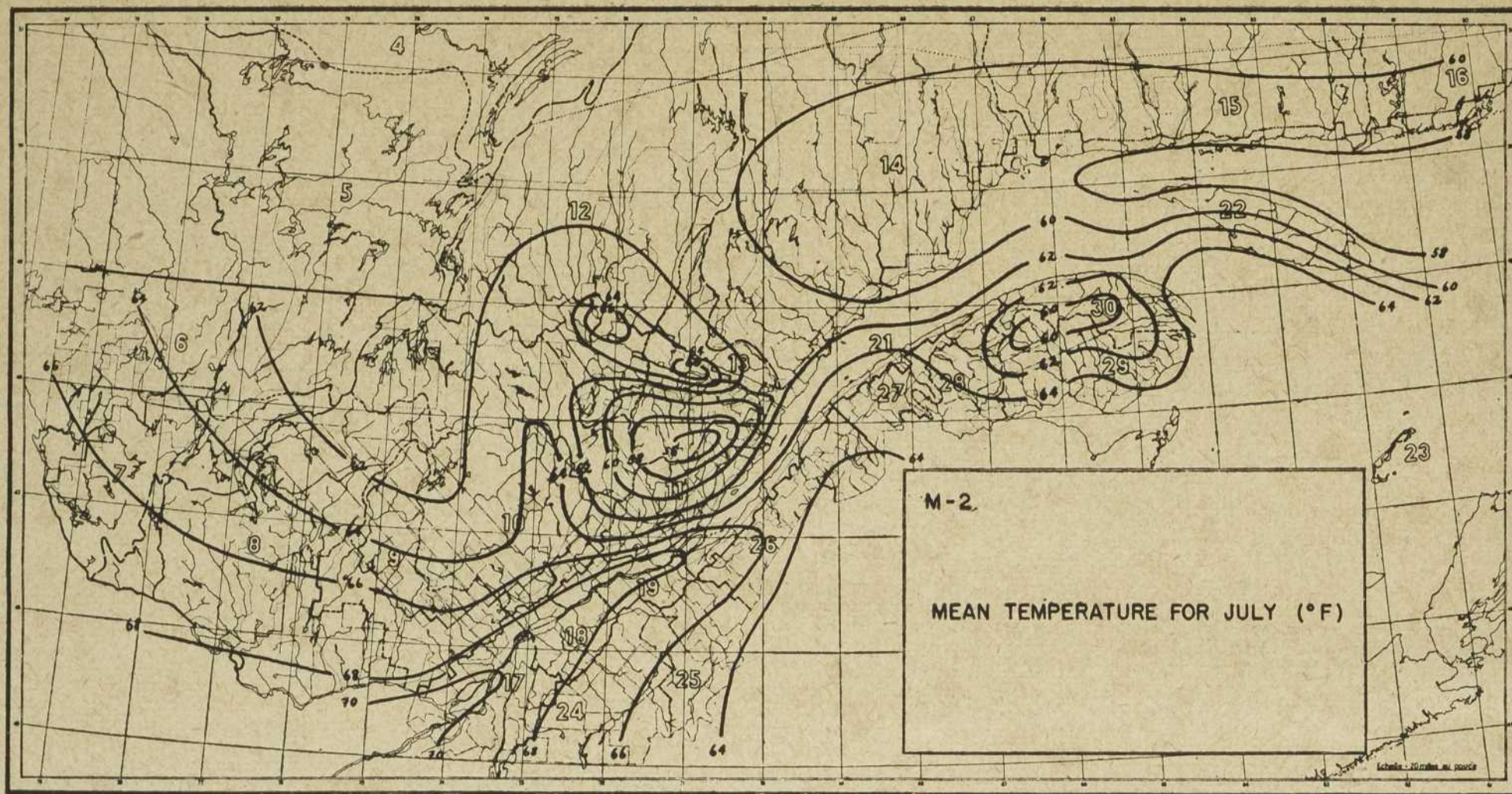
TABLE XI
CLIMATIC RECORDS IN THE MIXED FOREST SECTIONS

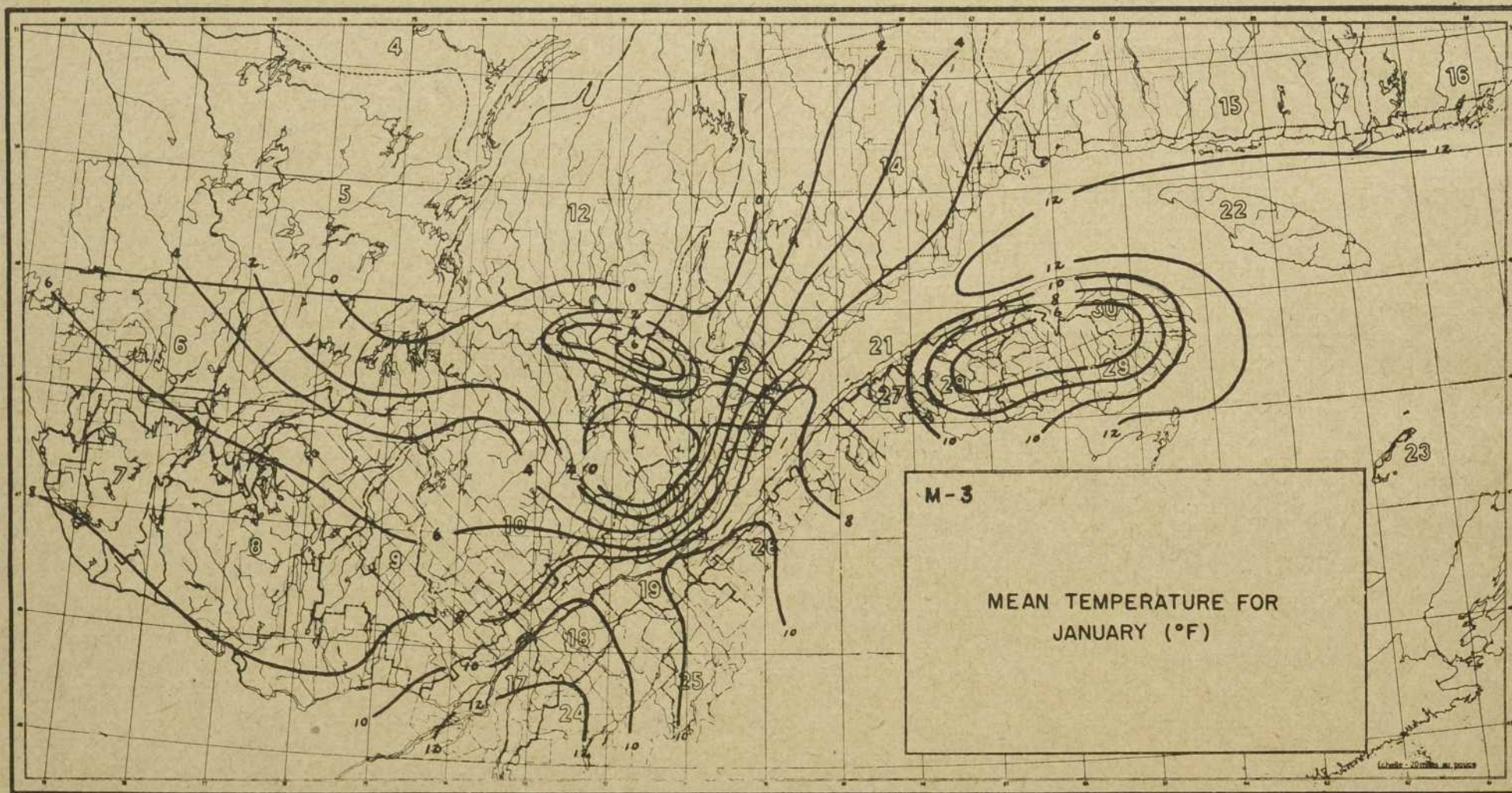
Climatic Criteria	M-1	M-2	M-3	M-4
Mean annual temperature.....	38-40	36-40	34-38	36-38
Mean temperature for July.....	66-68	64-68	62-66	62-66
Mean maximum temperature in July.....	90-92	85-90	88-91	85-88
Mean temperature for the four warmest months.....	60-63	60-62	58-60	58-60
Average length of the frost free period.....	110-125	100-125	100-125	110-130
Annual range of mean monthly temperature.....	58-60	56-58	58-64	52-56
Mean maximum evaporation in summer.....	45-50	35-45	40-50	40-60

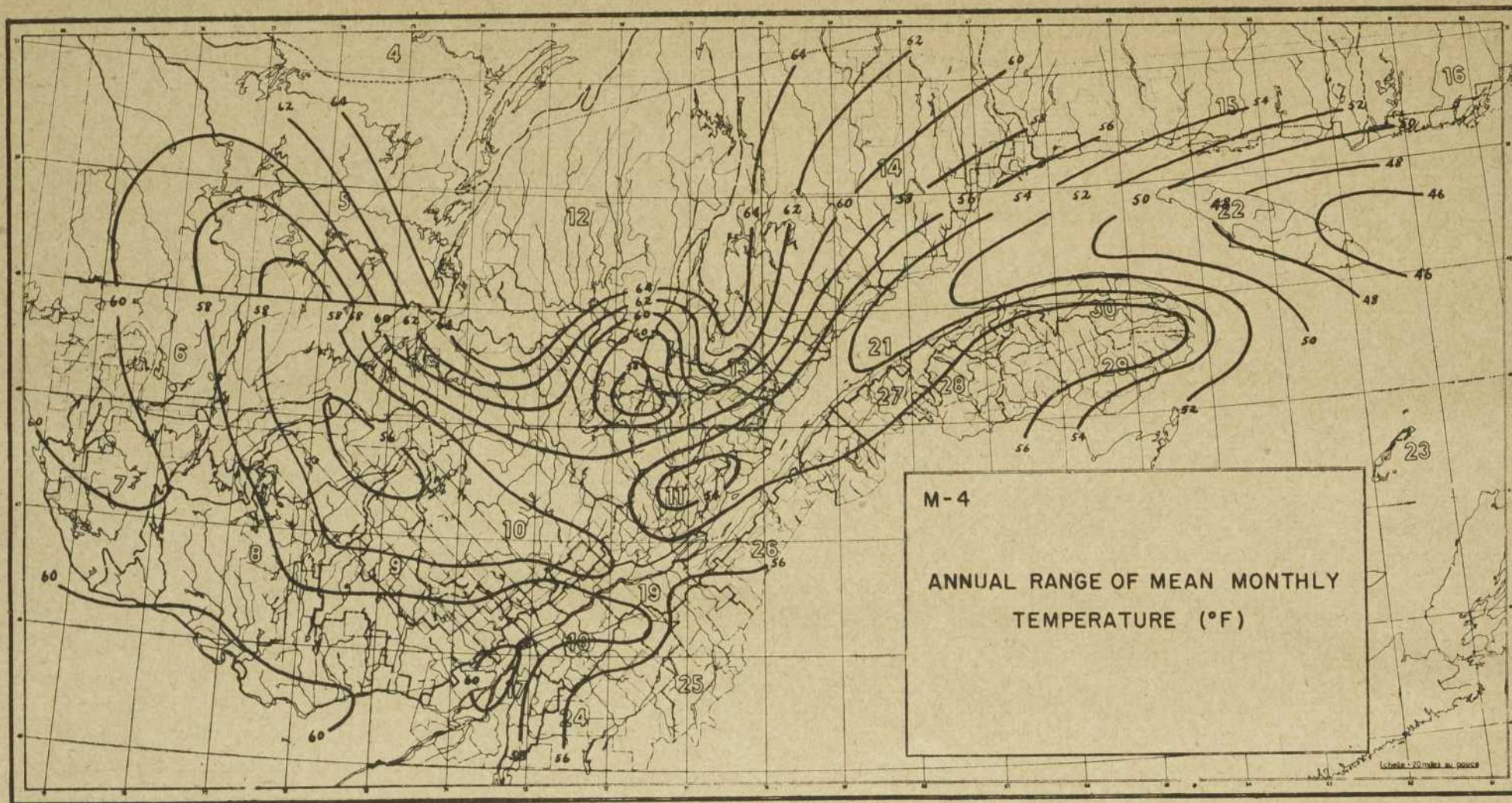
TABLE XII
CLIMATIC RECORDS IN THE HARDWOOD FOREST SECTIONS

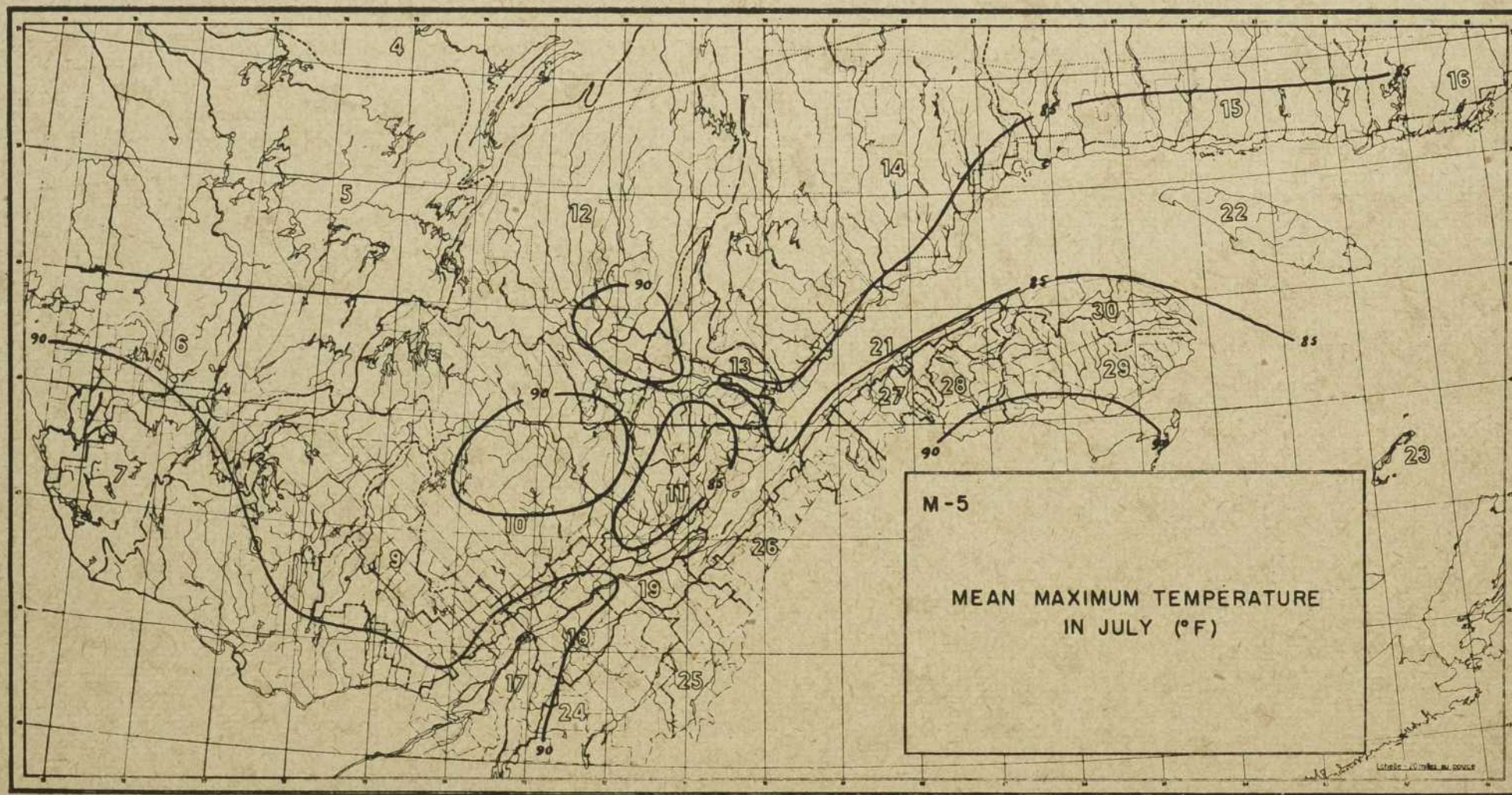
Climatic Criteria	H-1	H-2	H-3
Mean annual temperature.....	40-43	38-40	39-41
Mean temperature for July.....	68-70	64-68	68-70
Mean maximum temperature in July.....	90-93	85-90	85-90
Mean temperature for the four warmest months.....	63-66	60-64	60-64
Average length of the frost free period.....	125-150	110-130	110-140
Mean monthly summer precipitation.....	2.5-4.0	4.0-5.0	4.0-5.0
P-E quotient for the summer.....	0.4-0.6	0.6-1.0	1.0-1.2
P-E index for the summer.....	0.4-0.8	0.8-1.0	0.7-1.0
Annual range of mean monthly temperature.....	58-60	54-58	58-60

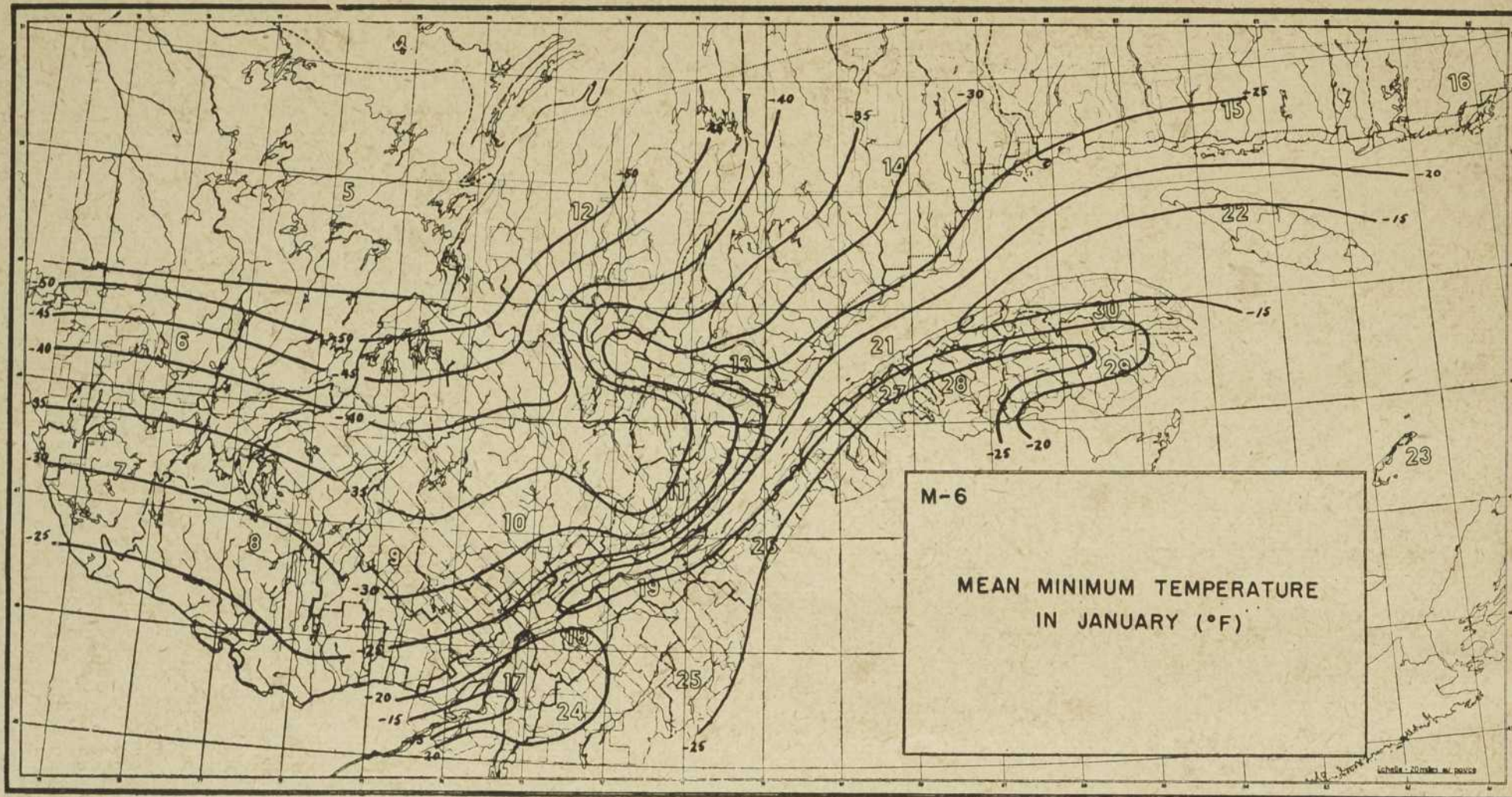


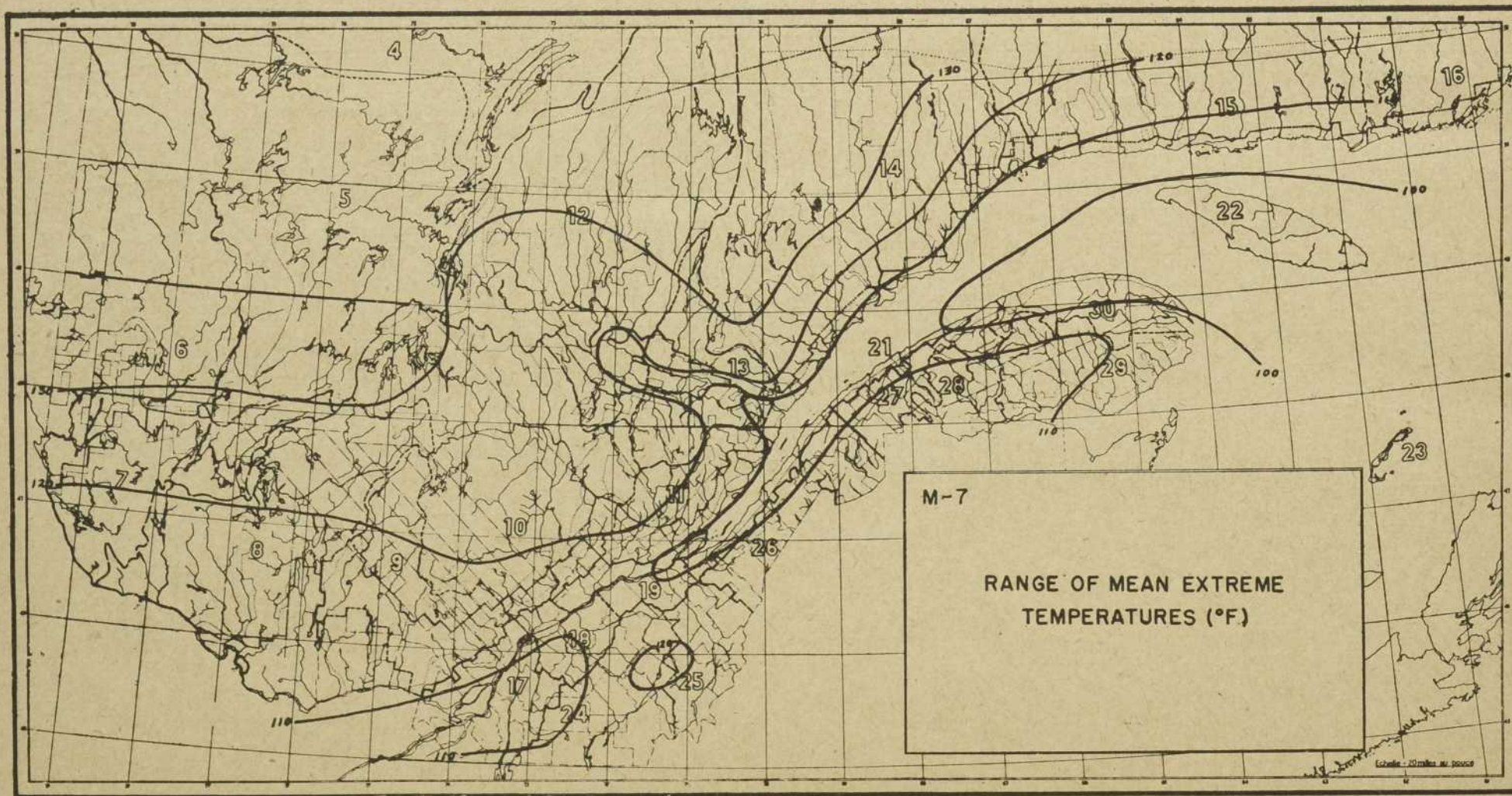


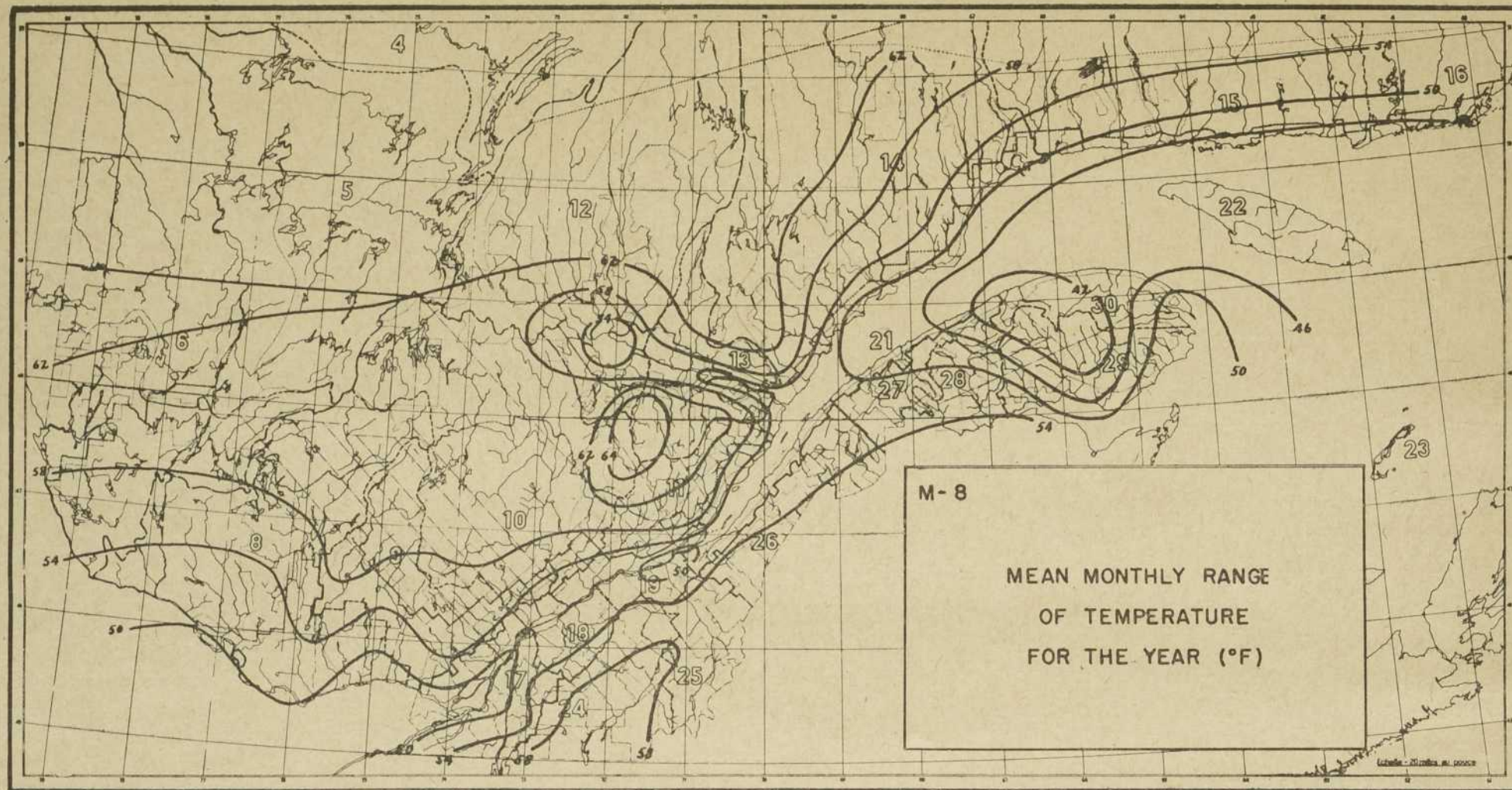


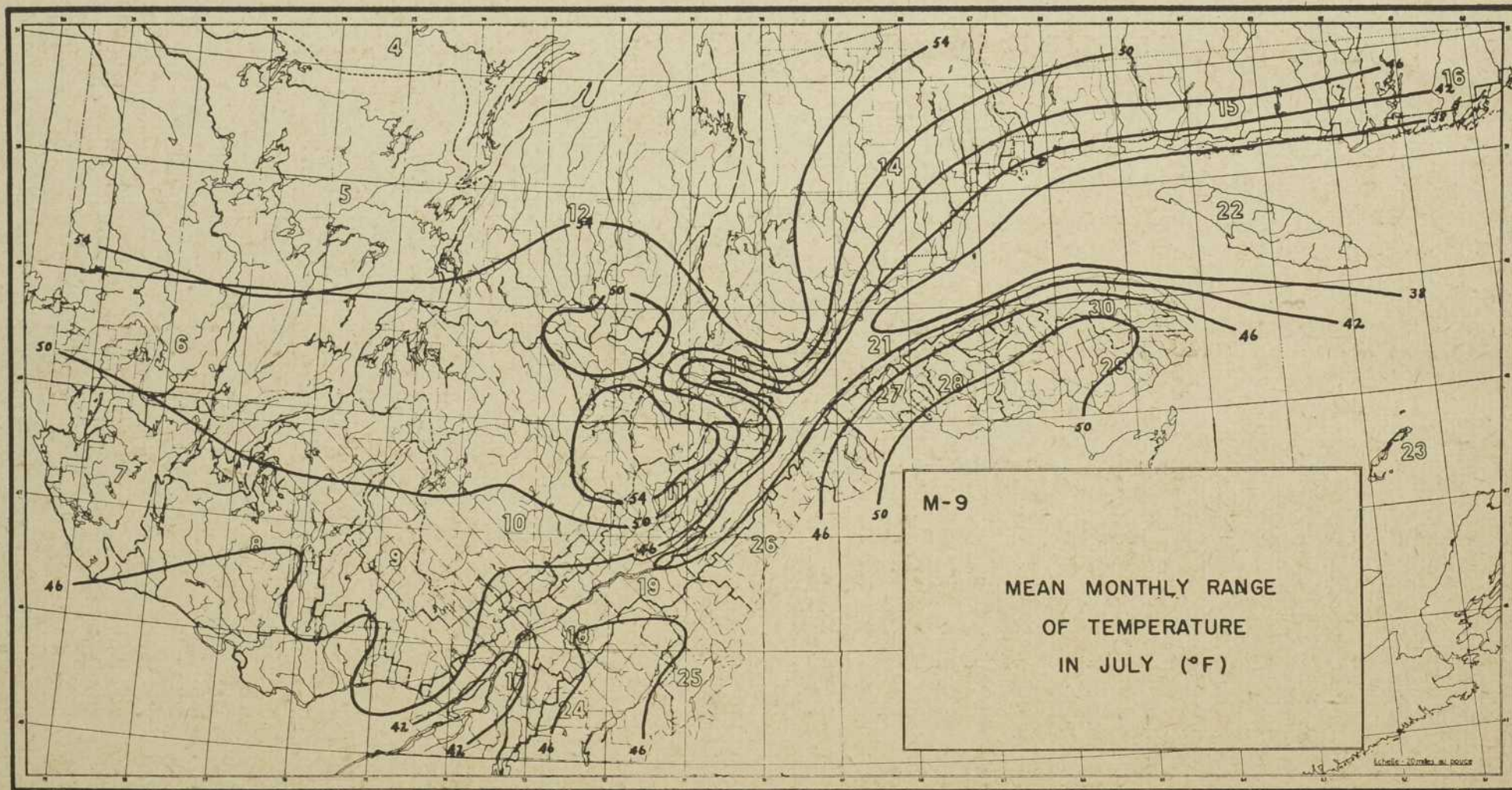


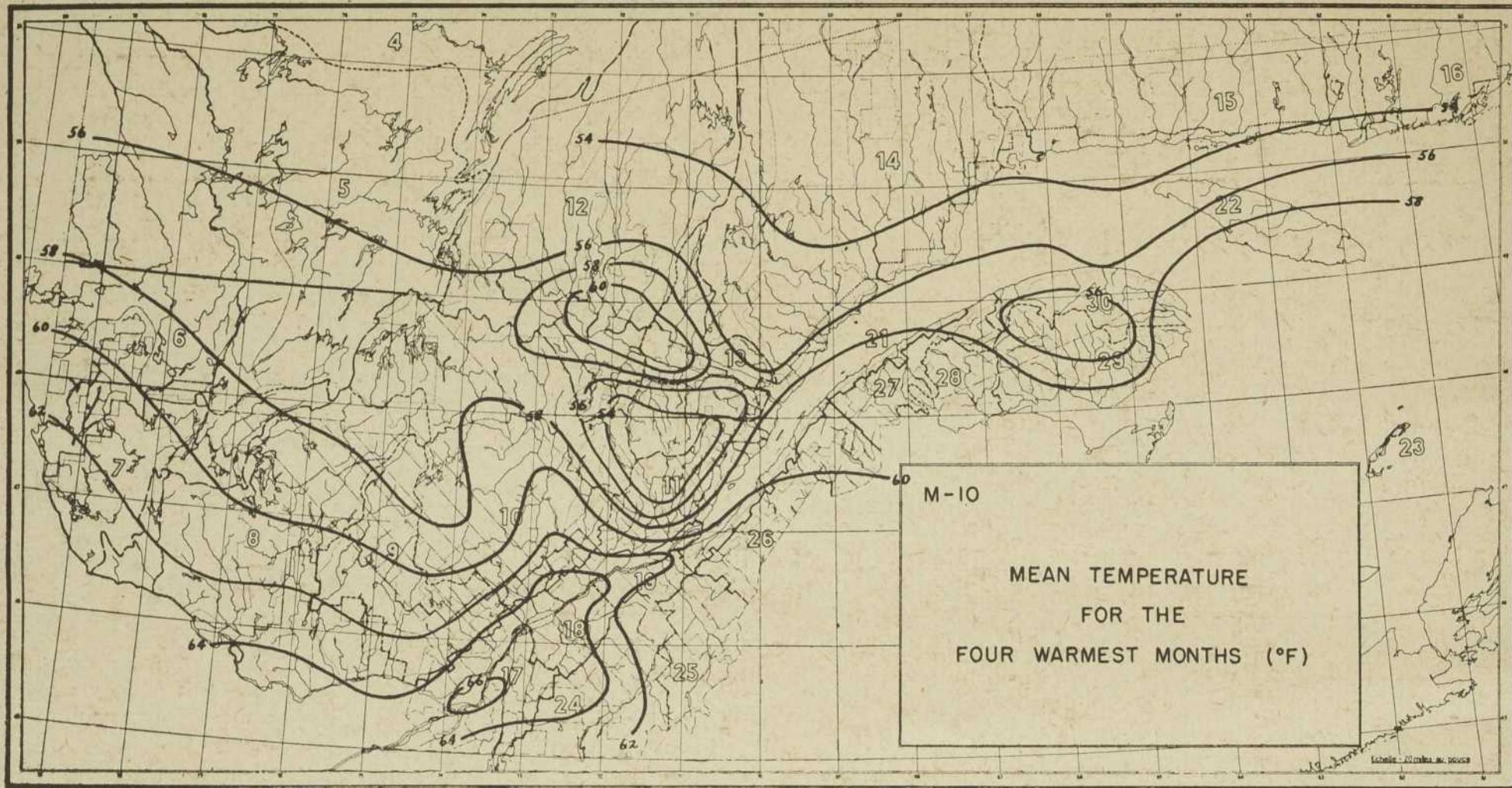


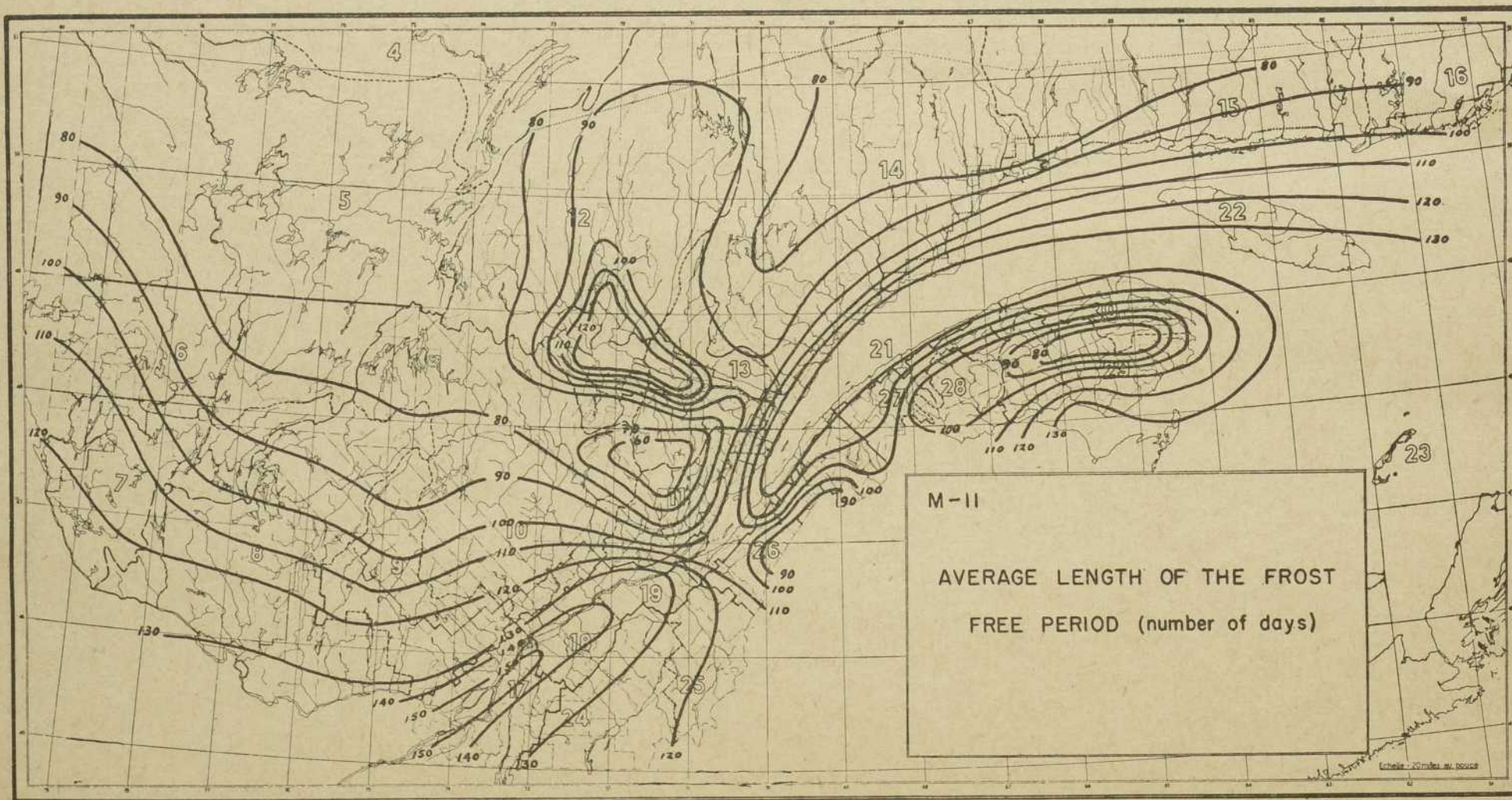


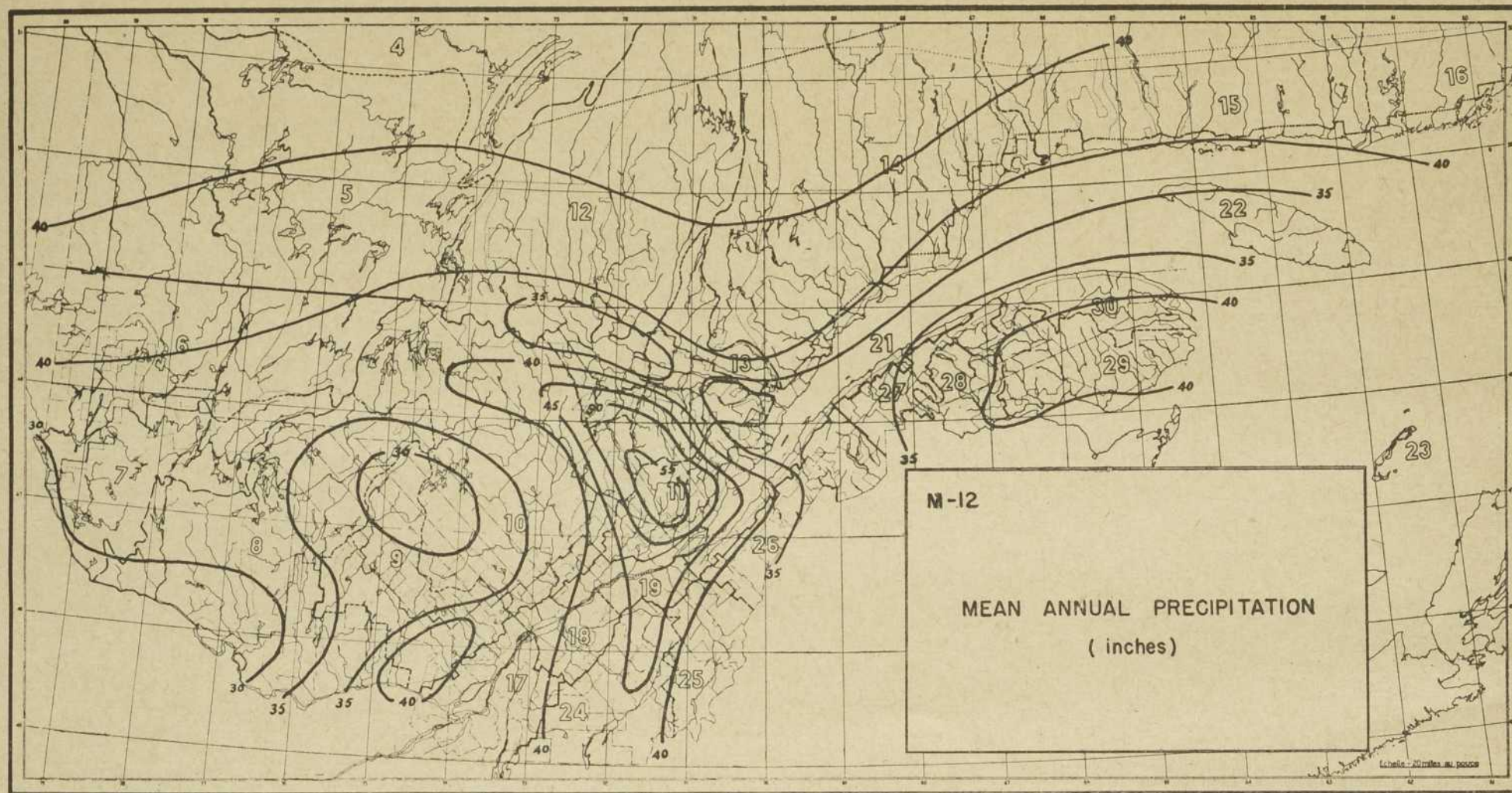


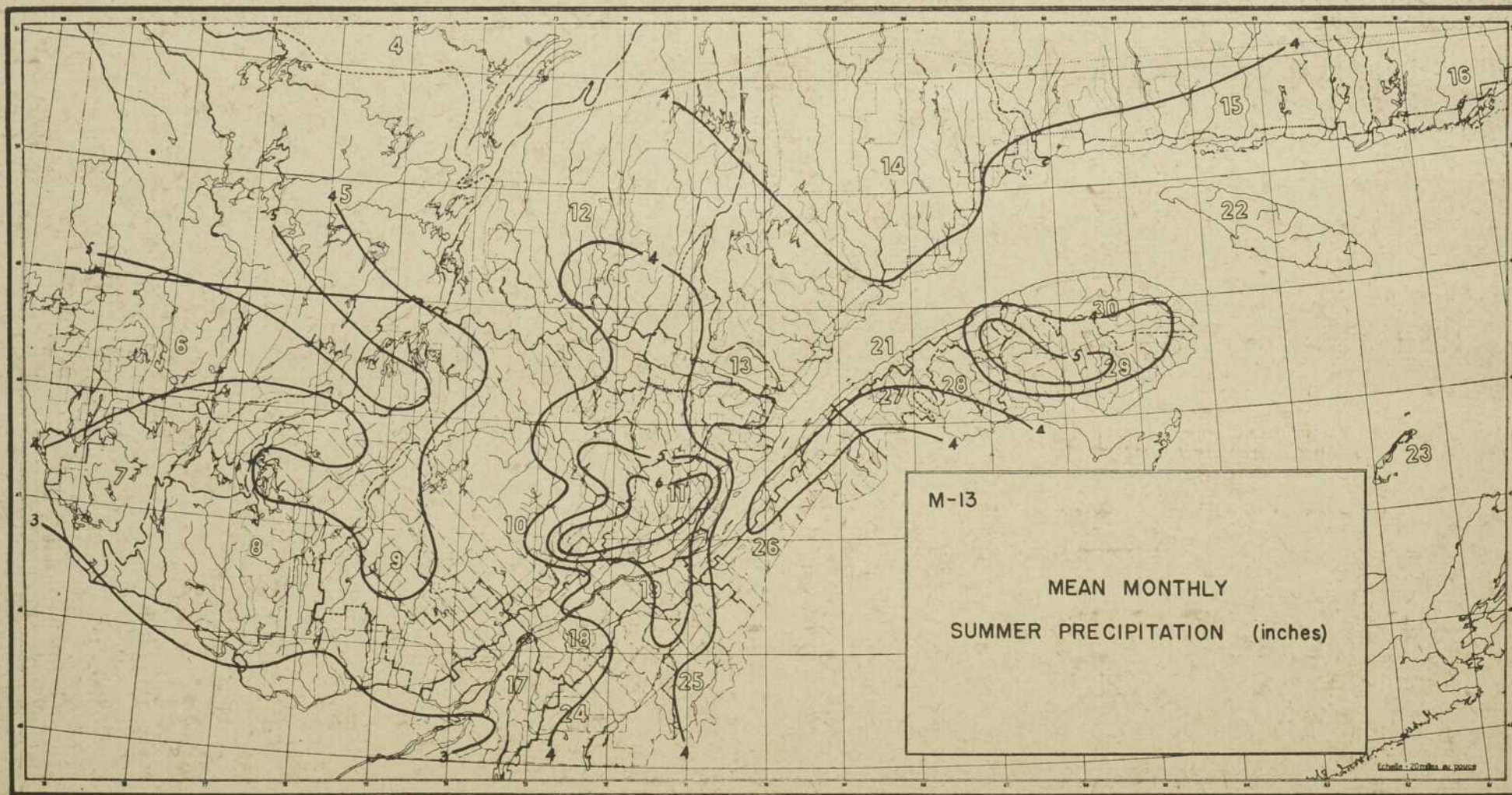


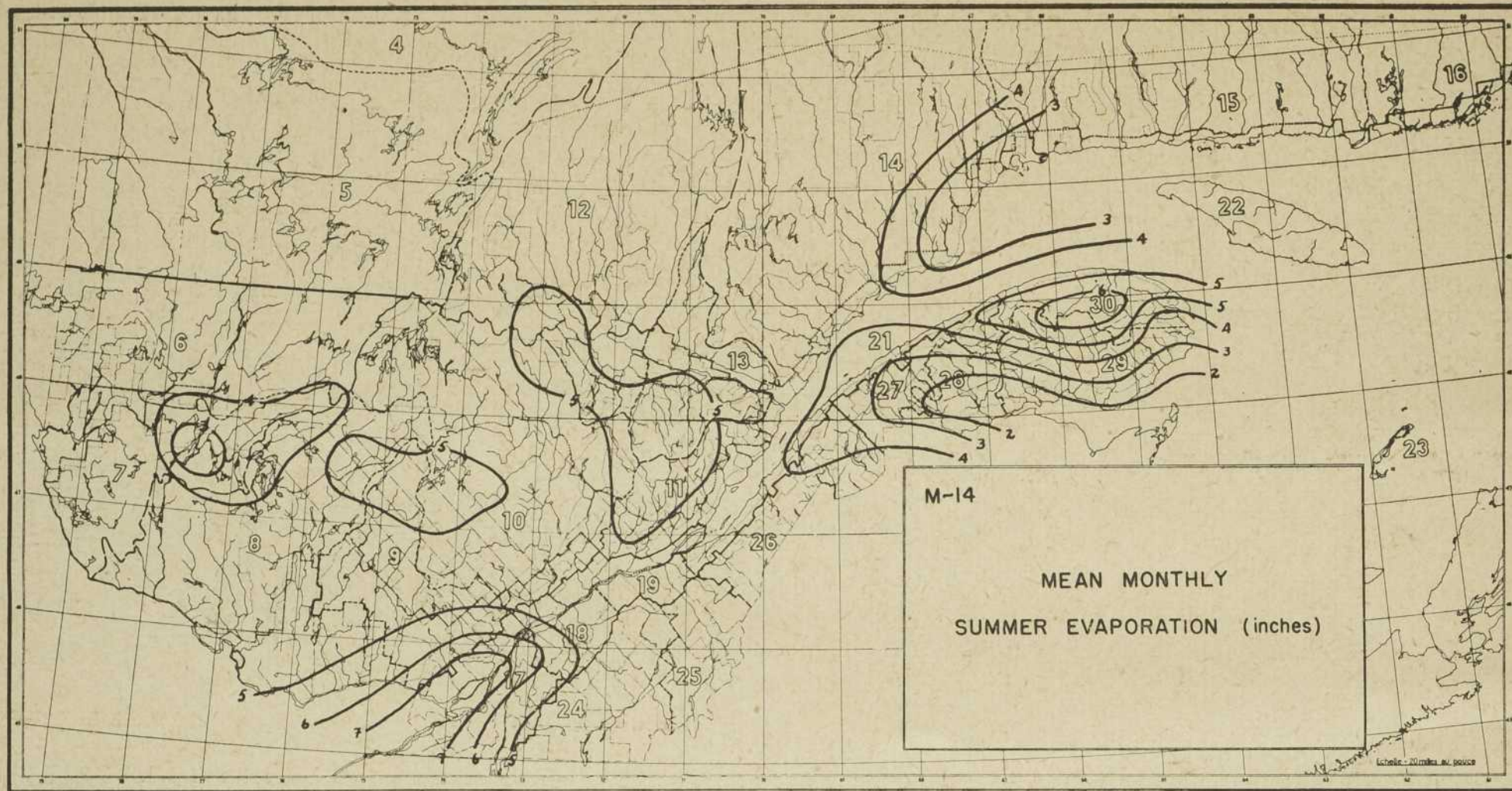


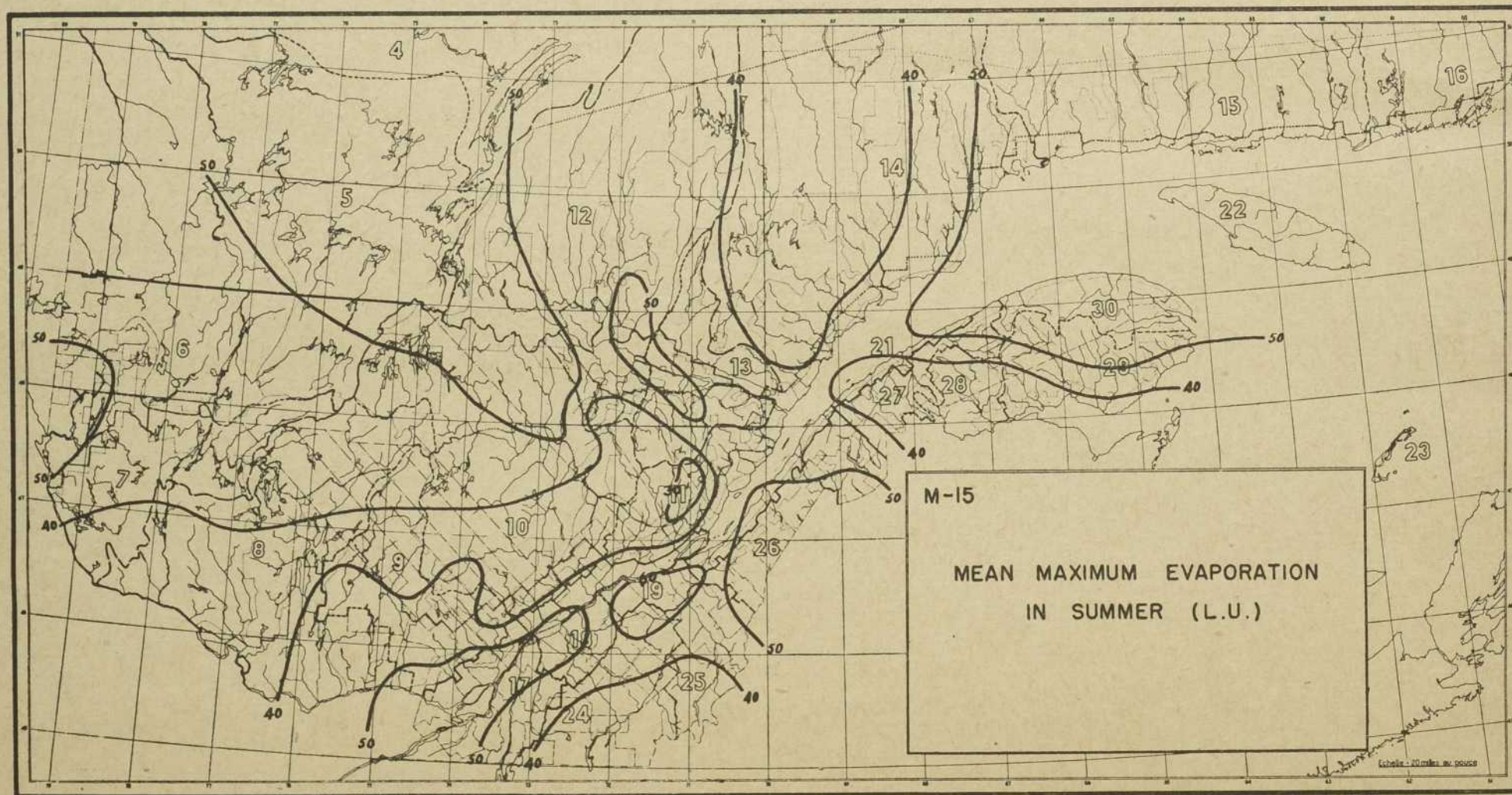


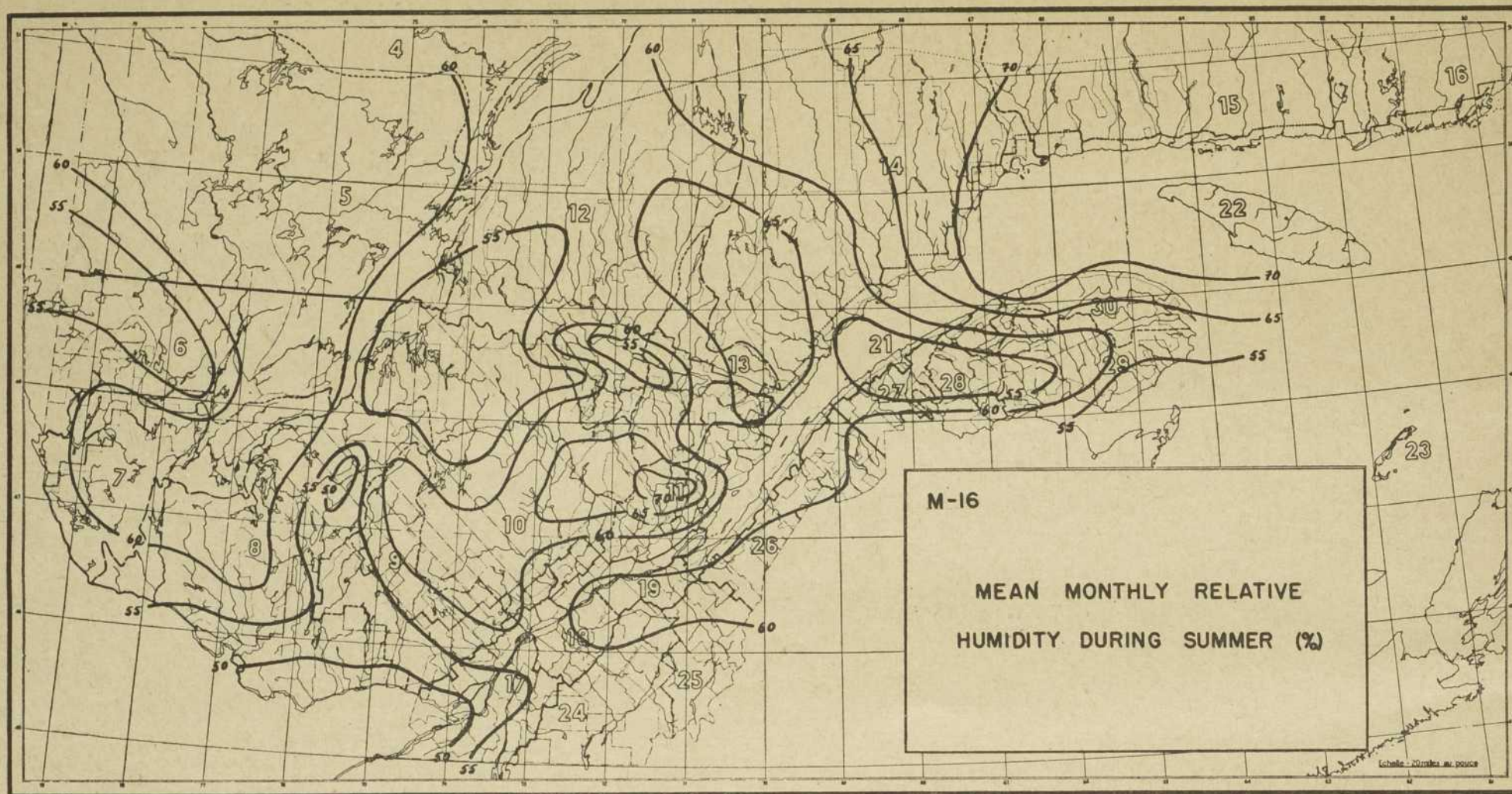


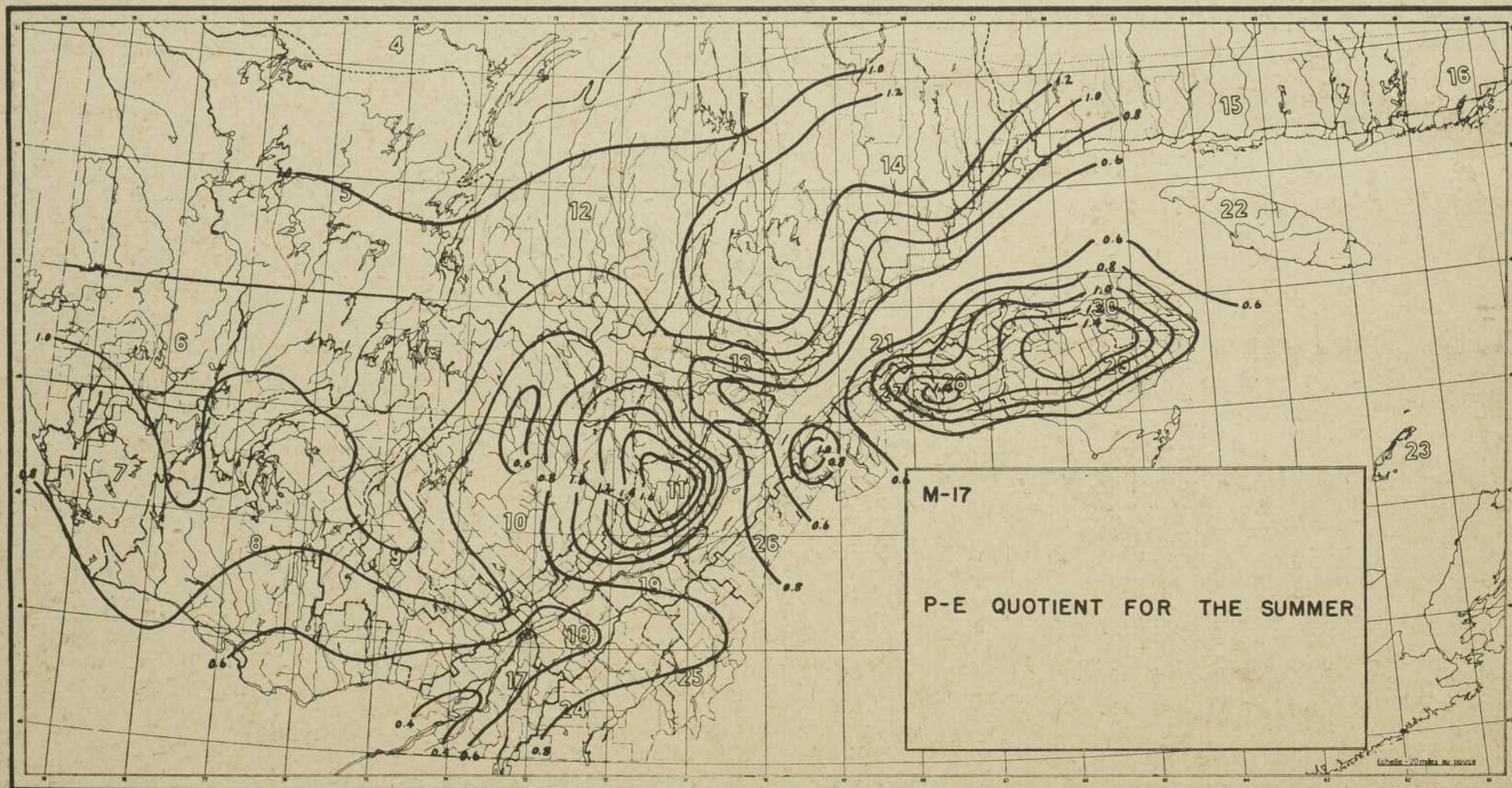


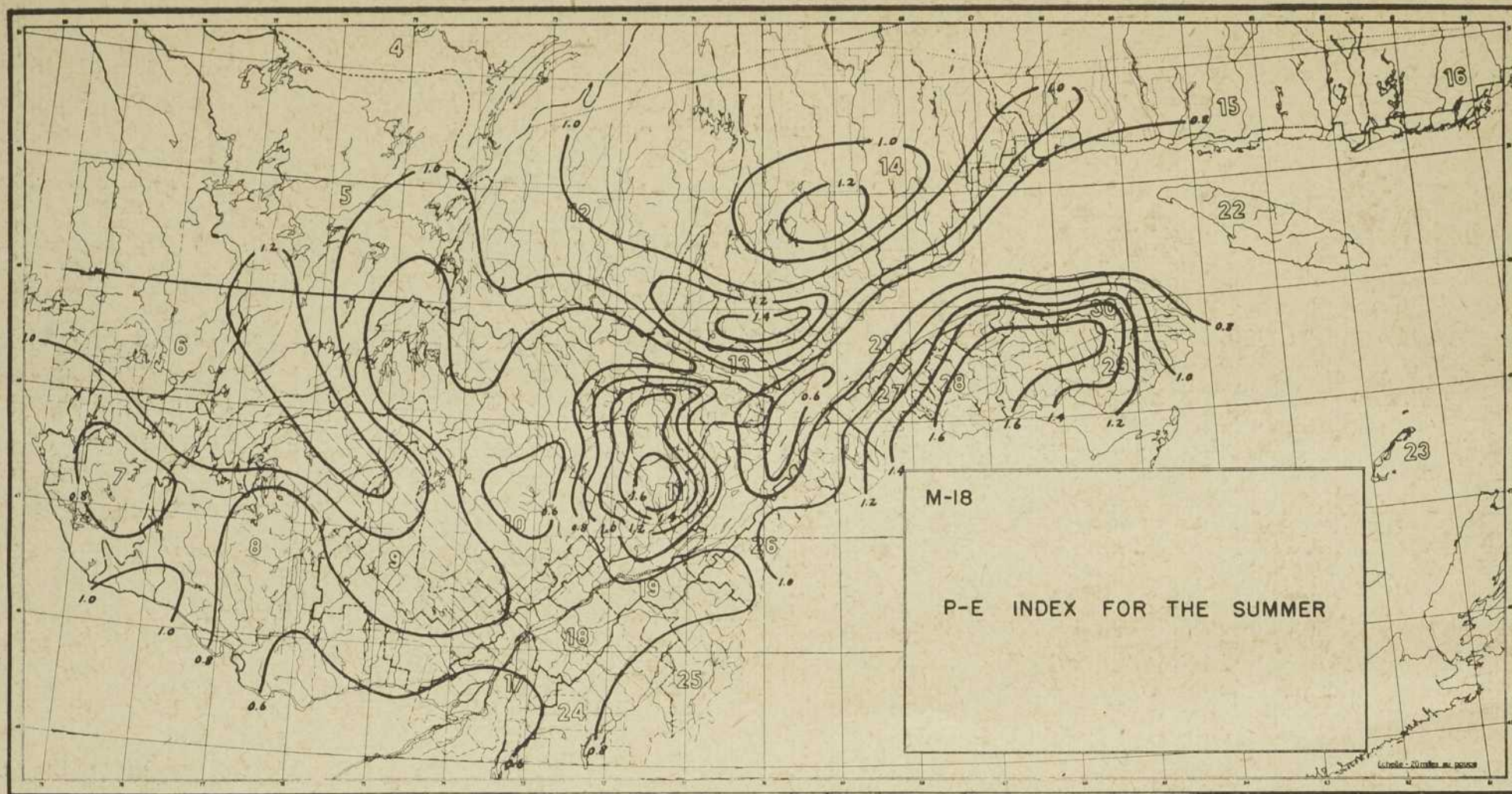


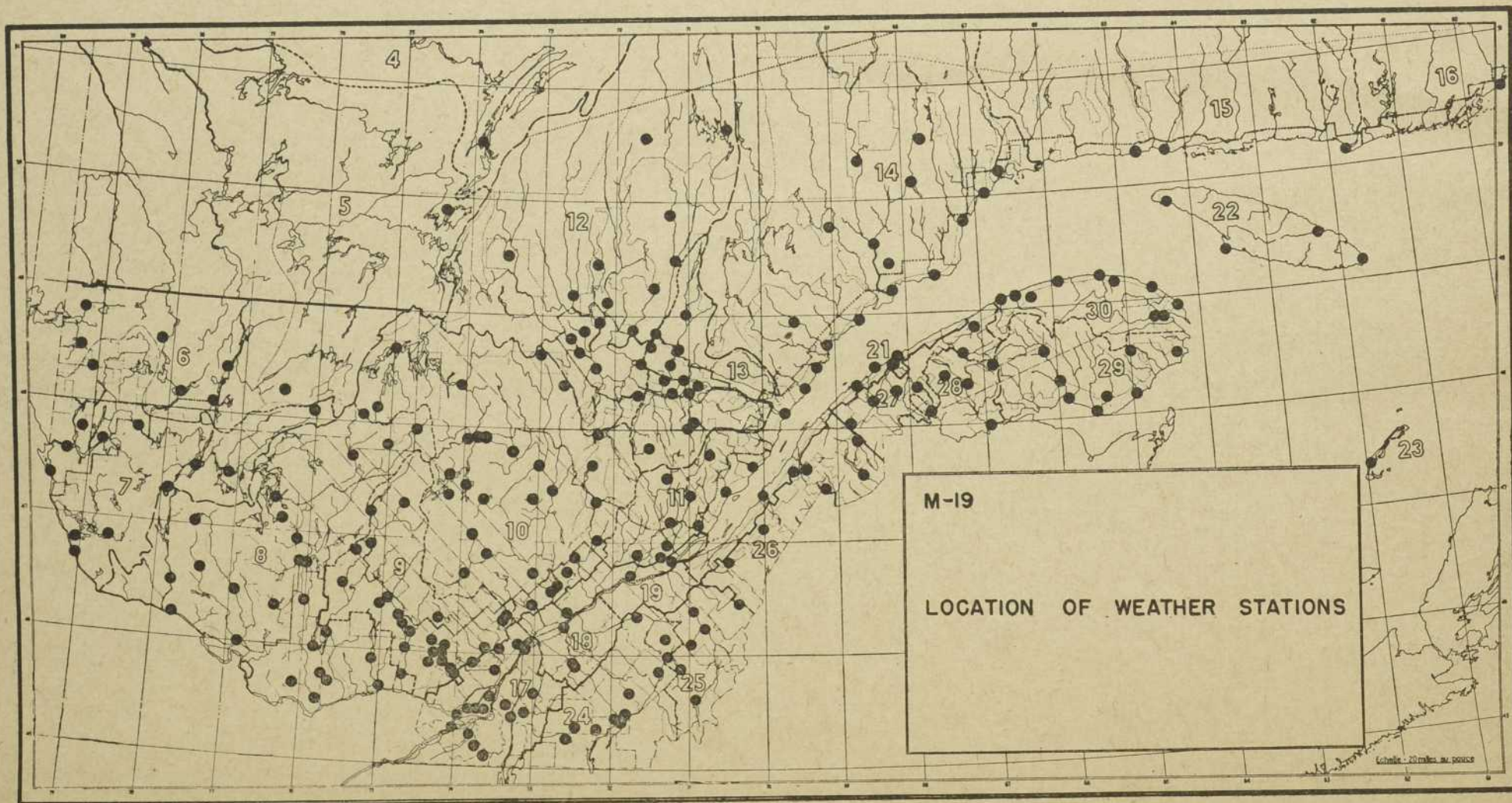


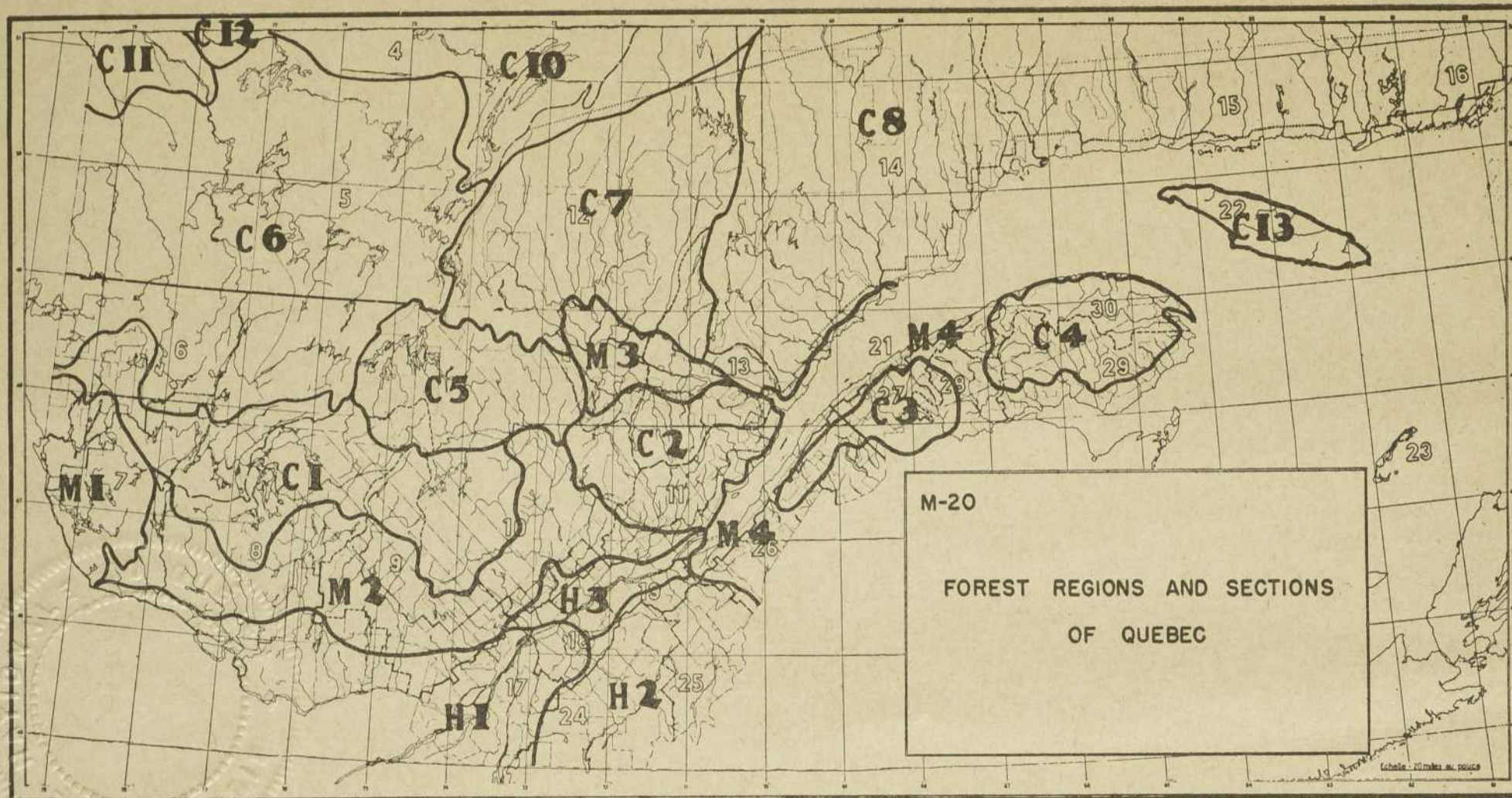


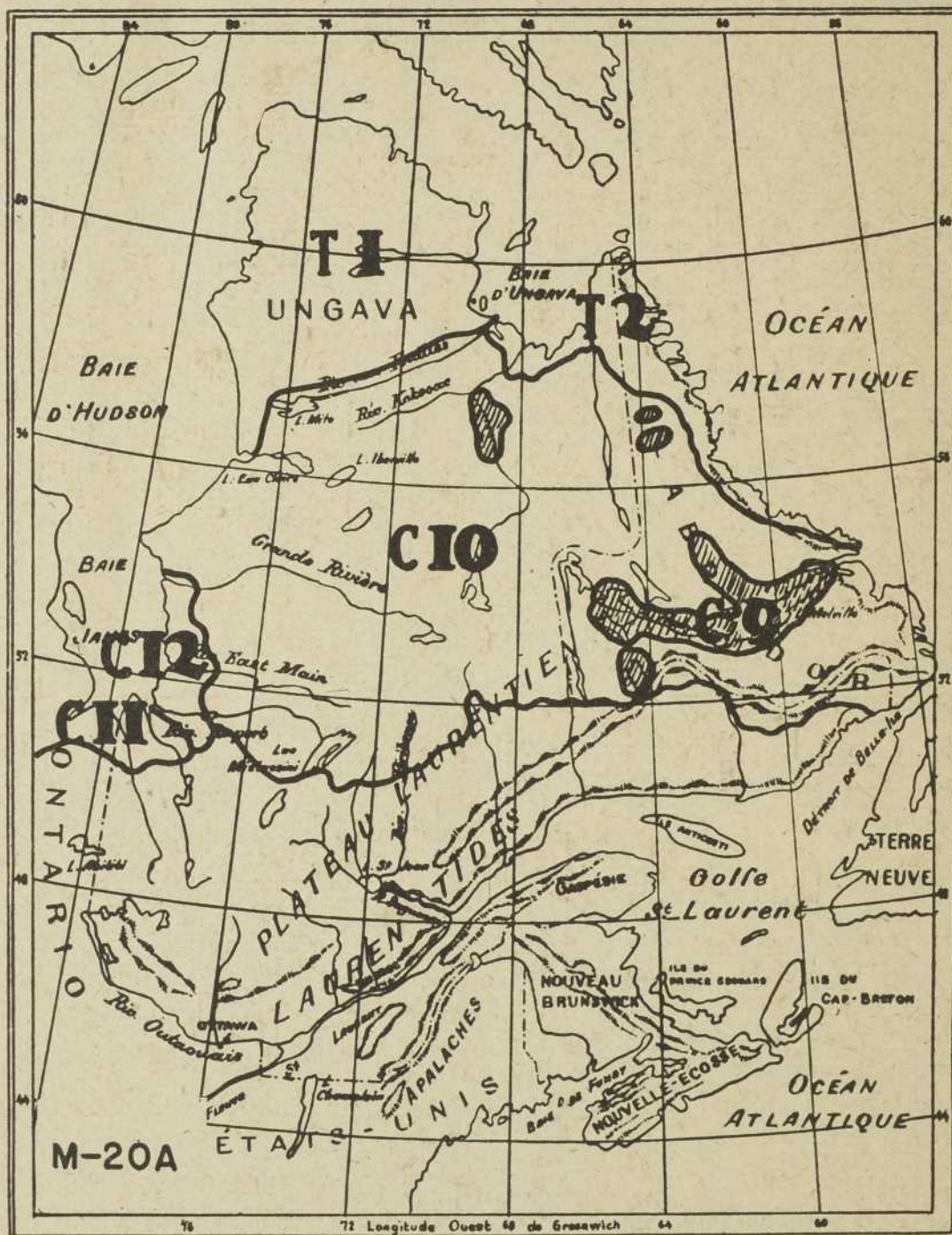




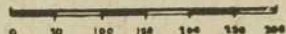








FOREST REGIONS AND SECTIONS OF QUEBEC





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