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CLIMATOGRAPHY OF PUKASKWA NATIONAL PARK, ONTARIO

by

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Applications and Consultation Division
Atmospheric Environment Service
Toronto
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- a climatological inventory prepared for the National and Historic Parks Branch, Department of Indian Affairs and Northern Development -

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Abstract

The Pukaskwa Park is located in an area of Northern Ontario which is relatively inaccessible due to exceedingly rough topography. Physiographic and climatic characteristics are complex, and are complicated by the adjacent major water-body, Lake Superior. In the preparation of a report for such a vaguely known and ungauged district, regional climatological statistics are adjusted and vectored to fit park conditions. The results are inherently speculative and the final interpretation largely qualitative, but a significant compendium of figures and recommendations will give specific guidance to planners and users of the park.

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CLIMATOGRAPHY OF PUKASKWA NATIONAL PARK, ONTARIO

Introduction

"National Parks are areas of outstanding features "dedicated to the people of Canada for their benefit, education and enjoyment, ... and such parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations".

"Three major activities are involved in making a national park achieve its goals: resource conservation, planning and development and interpretation."

"Before the park area can be developed, the road network laid down, campsites located, etc., the planner must know the nature and distribution of the important resources in order that he may locate amenities in areas where development will not conflict with natural resources which are to be preserved unimpaired. Yet his road and trail network should be designed in such a way that outstanding resources are rendered accessible to the visitors. Similarly, the inventory will provide the interpreters with the basic information useful in determining the areas, features and subjects for interpretation. Climate is one of the basic physical resources to be inventoried."

From: National and Historic Parks Branch,
Information Bulletin 1972.

The above paragraphs outline the challenge to meteorology in aiding the development of recreational facilities. The forms by which this may be accomplished have not been well established.

In distinguishing it from other physiographic factors often discussed in environmental studies, Landsberg (1958 vii) has described climate as a "pulsing element". Though it is studied by similar scientific criteria, climatic character changes over short time periods, making generalizations. difficult. The weather affects everyone daily, and for recreational activities it is a governing factor in what to do, where to go, how long to stay and other decision-making. Crowe (1970) Crowe, McKay and Baker (1973) have distinguished threshold values of temperature, cloudiness, wind, etc., which affect tourism and recreation for sub-continental regions, but their data are not generally applicable to the smaller national park area until perti-

nent meteorological measurements are available.

National parks are, for inherent reasons, located in areas remote from population zones where economic activity may have stimulated the establishment of meteorological networks. A park climatic inventory must be derived from the sparse, often broken records measured in areas which are probably outside the park, in a landscape which may not be typical or representative. Much can be derived by physical climatological analysis, but the generated data have imperfections.

It is rare when man's activities can actually be halted by natural causes, but there are many instances when inconvenience and discomfort may be experienced. Meteorologically-induced limitations to park access and activity during the year are described in this report. Of course the degree of cold, wind or wetness that will be tolerable to one individual or group will not be acceptable to others. This problem has been avoided by limiting this report to a presentation of utilizable data and allowing the users to draw their own conclusions.

The report is organized into eight sections in which individual meteorological elements are presented, in terms of maps where possible, but otherwise by tables and descriptions. The collective effect of these elements is discussed in terms of recommendations for park activity areas. Finally, recommendations as to meteorological monitoring are made.

The essential source of data is the national meteorological archive. Figure 1 shows the locations of meteorological stations adjacent to the park. Two types of stations are common. Principal or first-order stations measure a wide range of meteorological parameters hourly with special observations taken as warranted by meteorological events. Other stations measure only temperature and precipitation, twice daily. In the published

literature the study of northern Ontario climates by Chapman and Thomas (1968), and the Great Lakes Basin report by Phillips and McCulloch (1972) are good general references. The national climatic maps (Canada Dept. Transport 1967-70) are useful too in depicting regional patterns. Though the literature has been frequently referred to in supporting the course of this report, there is a dearth of specific information on the immediate Pukaskwa area.

As there are no climatological records from within the park, nor are there readily obtainable sources of general physical information, the values generated for the area must be considered with great caution. This will become clearer as each element is discussed. Section one of this report is a topographic description which is followed by 2) temperature, 3) precipitation and hydrology, 4) winds and waves, 5) ice on water bodies, 6) sky cover, 7) comfort and 8) a concluding chapter including recommendations for a meteorological monitoring programme.

TOPOGRAPHY

The park occupies a unique promontory in the eastern shoreline of Lake Superior. (Figure 2) It is unique because the topography is rougher and higher than in surrounding regions. At one point the land rises 1500 feet in less than six miles. Most of the area is deeply dissected by swift, short rivers of limited drainage area, though on the eastern boundary most of the drainage is to the White River; the Bremner River is a principal tributary. The other principal streams, draining westward, in an irregular manner, through steep gorges, are the Pukaskwa, Cascade and Willow.

It is difficult to discern any general trend or grain to the landscape. In the north central region, which is in general the highest zone, the long axes of the major ridges seem north-south, but on closer

inspection there are northwest-southeast elements, and a significant number of smaller ridges are oriented northeast-southwest. On first inspection, the land slopes outward from the highest part of the plateau, but when a generalized slope map is constructed most aspects face westerly. It is a rugged landscape, inaccessible to foot travel, roads and canoes, and extremes of exposure and shelter are present. Areas above 1500 feet experience the brunt of strong winds and precipitation, abated little by the open woodland and rocky barren. Yet there are valleys nearby almost 500 feet deep where the airflow is light through a dense spruce forest. The shoreline is steep, and heavily forested with only narrow openings for the mouths of small rivers. However, relatively unmodified lake air is able in some instances to travel some miles inland along these stream courses. Nevertheless, in most cases the shore climate will be confined to a narrow zone.

TEMPERATURE

The mean annual temperature at the park ($36^{o}F$) is similar to Thunder Bay, Winnipeg and Quebec City, but is 4 degrees Fahrenheit cooler than Sault Ste. Marie and 10 degrees cooler than Toronto. However, there are wide variations on a shorter time scale within the park. Some idea of the regional differences may be obtained by examining the records from stations such as Marathon, Wawa and White River (see Appendix). Marathon, being strongly influenced by Lake Superior water temperatures, has cool summers, cold but not severely cold winters and a reduced annual, monthly and usually daily range when compared with White River. Wawa, being fairly close to the lake, but situated at a higher elevation, has intermediate characteristics.

There are three general rules applying to temperature distribution within this area. First, temperatures will usually decline with increasing elevation. In the standard lower atmosphere the rate is $3.6^{o}F$ per 1000

feet. Secondly, temperatures will change greatly moving inland from Lake Superior. In summer, temperatures increase with distance; in winter they decrease. At night except for brief periods in the intermediate seasons, the land-water contrasts are smaller, for on sunny days much solar energy is converted to sensible heat over the land whereas equivalent amounts are absorbed through a considerable depth of water. Finally, there will be a general temperature reduction to the north though this may be masked by local or mesoscale influences such as lake currents.

Elevation Effects

Rather than depend on standard atmosphere generalizations which are intended for sub-continental areas, the monthly mean temperature gradients between 950 and 850 millibars at Sault Ste. Marie (Michigan) Upper Air Station were used to adjust temperatures for altitude. Although the 950 mb height is about 1800 feet ASL, it was selected in preference to the surface value in order to avoid nocturnal inversion effects, common at the radiosonde release times, particularly in winter.

TABLE I

RATE OF TEMPERATURE CHANGE WITH HEIGHT AT SAULT STE. MARIE (MICH.)

(from average 950 mb and 850 mb values 1946-55)

Month	J	F	M	A	M	J	J	A	S	O	N	D
Gradient (°F/1000')	1.42	1.73	2.15	2.35	2.10	2.53	2.92	3.04	2.72	2.17	2.44	1.91

Lake Effect

Using the Table I values, monthly mean temperatures at several regional stations were adjusted to the level of Lake Superior (600 feet ASL). The adjusted values were plotted as departures from the Marathon means, (Figure 3). Marathon is at 620 feet, and as the range of the departure

increases, this is an index of greater continentality i.e. the influence of the lake becomes less. At this stage no correction has been made for latitude, but as will be subsequently shown, this is small. It may be seen from Figure 3 that a maritime climate does not extend much further inland than Wawa (eight miles). An arbitrary cut-off at 10 miles has been used here.

As water and land temperatures are sharply in contrast during much of the ice-free season, particularly in spring, the formation of a "marine inversion" may be expected. During this period, air crossing the lake is chilled in the lower layers by cold water and becomes very stable. This effect may be seen by contrasting Marathon and Wawa temperatures, once the stations have been adjusted to a similar latitude and elevation.

Latitude Effect and Mesoscale Influences

Several processes are concurrently active, and to avoid problems in separating causes from effects an empirical adjustment was obtained following an analysis of Montreal Falls and Wawa data. Both of these stations are at a similar elevation, equidistant from the water with same open exposure to the southwest; but Montreal Falls is 45 minutes of latitude south of Wawa and experiences warmer conditions. Mean monthly temperatures for a common period of record varying from 7 to 11 years were compared and Table 2 gives the adjustment applied here so that a vertical temperature

TABLE 2

MEAN VARIATION OF TEMPERATURE WITH 10' OF LATITUDE

(Deg. F.)

J	F	M	A	M	J	J	A	S	O	N	D
0.5	0.4	0.4	0.1	0.2	0.5	0.6	0.2	-0.1	0.1	0.5	0.3

gradient could be computed for the maritime zone. Marathon values were adjusted 20 minutes south and Wawa was moved 20 minutes north so that conditions at the central latitude of the park could be assessed. Table 3 gives the temperature gradients computed. Throughout the cold season, there

TABLE 3

VERTICAL TEMPERATURE GRADIENTS IN THE LAKESHORE ENVIRONMENT

Month	J	F	M	A	M	J	J	A	S	O	N	D
Gradient °F/1000'	2.1	3.6	1.8	0.6	-1.6	-2.3	-1.4	-0.6	-1.6	2.1	4.8	2.4

is a regular temperature decline with height with maximum gradients in late fall. The inversion is prevalent in spring and summer.

Temperature Model

In a general sense measurements at Marathon, Wawa and White River may be said to represent lakeshore, intermediate and interior conditions respectively, but greater precision is obtainable by using a station as an index and making adjustments as the terrain changes. Here the park was divided into 52 grid squares (four miles by four miles). A mean elevation was assigned to eachgrid and the prevailing slope aspect was estimated. Mean monthly temperatures were computed for each grid. White River values adjusted for elevation using the Sault Ste. Marie radiosonde gradients were applied to grids more than 10 miles inland from the shore or when the slope aspect faced inland. Grids located lakeward of the 10 mile limit were given Wawa values adjusted using the lakeshore environment vertical gradients. Those grids straddling the 10-mile boundary were assigned the averaged value of the two methods. Maps for each month were thereby produced, (Figures 4 - 15). It

must be again emphasized that these are based on synthesized values, and it should be pointed out that this method differs from other grid square techniques in which grid centre values are estimated by weighting surrounding stations. Unfortunately in this latter case the grid size would have been governed by the distance between stations and would have emerged too large to be sensitive to local characteristics.

In the cold season months of December, January, February and March there is a sharp cooling gradient inland from the shore of 7-8°F. The most rapid changes occur on crossing the 10 mile limit as might be expected. An isolated cool zone occurs on the highest area in the central region. In April the gradient weakens though a cold zone is evident over the east-central plateau. In May, inversion conditions allow for the warmest areas to be on higher ground, though inland where a more continental climate is postulated, the coolest area is on the plateau. The maritime influence seems stronger in June with the coolest part of the plateau being confined to the very highest area, and yet this region, with the addition of greater insolation, is 1 1/2° warmer than at the shore. In July the pattern may be summarized as: a cold belt along the shore; less cold on the high parts of the plateau; warmest in the valleys and low parts of the plateau. The August map clearly shows the declining influence of the now warmer lake. The greatest heat is 5 to 10 miles inland where nighttime temperatures are relatively high because conditions are poor for the formation of strong inversions. Cold areas are most frequently found on the greater elevations of the central-northeast zone where frosts are more likely in the drier air. The middle valley of the Pukaskwa River is warm. The September and October patterns are similar to those of August, though the contrasts between inland and lakeshore become increasingly greater. By November there is a 7°

difference, though the Pukaskwa Valley is still one degree warmer than the plateau; anomalous valley temperatures do not appear on the December map.

The incidence of sub-freezing temperatures is markedly greater in the zone inland from marine influence. White River has an average frost-free period of only 40 days, compared with 112 at Wawa and 115 at Marathon. In the shortest frost-free season on record, only five consecutive nights remained above 32° at White River, compared with 57 at Wawa, 83 at Marathon and 133 at Caribou Island. On the average frost has been absent from White River between June 25 and August 5, but the period is probably longer on sloping ground in major valleys which have a westerly exposure to the lake. The maps suggest this applies to the Pukaskwa and White River Valleys, but there is no indication in the Cascade Valley presumably on account of masking by very high topography.

Below 50°F some discomfort is usually felt by inadequately clothed persons. If the daytime outdoor traveller is willing to accept an 80 per cent chance of the mid-day temperature exceeding this limit, he should select the period May 7 - September 24. To obtain an impression of the variation between daytime and nighttime temperatures the user of the park maps may refer to Table 4 which lists the mean daily temperature range for each month. To obtain early afternoon conditions, add half the range value to the map value, and perform the reverse to estimate nighttime situations.

TABLE 4

MEAN DAILY RANGES IN TEMPERATURE

	J	F	M	A	M	J	J	A	S	O	N	D
Marathon	19	19	19	16	18	18	17	16	15	14	13	15
Wawa	17	17	17	16	18	19	18	17	16	14	12	14
White River	27	30	30	24	26	27	28	27	22	20	16	23

Local Variation

Standard meteorological stations measure temperatures in a well ventilated screen four and a half feet above the surface on sloping or flat ground. In depressions near rivers or marshes or on exposed plateau surfaces, conditions are much cooler. It should also be noted that on clear calm nights when the air is dry, there can be a strong temperature gradient from the thermometer shelter to the ground. Six to eight degrees may be expected, and once or twice a year it might be 15 to 25°. Similarly on sunny days it is much warmer near the ground. Forests offer shade during the day but are warmer at night. They are shelter zones at all times. Snow-free zones are warmer than snow-covered areas, but in mid-winter the insulation of deep snow drifts is enough to provide a refuge for many animals.

Extreme Values

Heat waves will not be a problem at Pukaskwa Park though agreeably warm weather is frequently experienced during July and early August. Crowe, McKay and Baker (in preparation) note that temperatures less than 51° do not occur on the average between July 1 to beyond August 10, and during this same period daytime temperatures above 77° occur at least 40 per cent of the time. The highest temperature recorded at White River over a 79-year period was 101°. However, very high temperatures will not last for more than a few hours.

The area is more renowned for its cold temperatures. Crowe et. al. loc. cit. demonstrate that the coldest 10-day period is January 21-30 when four per cent of the time the maximum temperature is below -9° and eight per cent of the time it is below -3°. Ten per cent of the time at White River the observed temperature in January is equal to or less than -27°; in December is equal to or less than -17° and in February is equal to or less than -23°.

The probability of a low temperature occurring may be expressed in terms of the return period for a particular value. For example, a 50-year return period means that, on the average, a specific temperature will be experienced once in 50 years. Figure 16 shows the return periods of extreme minimum temperatures for White River, Steep Hill Falls, Wawa and Marathon. The lines were constructed using the Gumbel technique (Kendall 1959) and in view of the scatter of points the 50-year return periods at White River and Marathon may be about 5° high.

PRECIPITATION

From year to year the average precipitation varies more widely than the mean temperature. In assessing the precipitation regime in the Pukaskwa Park area there are three basic principles. First, it is generally true that precipitation increases as the land surface rises and moist air undergoes forced lift to condensation levels. Winter precipitation (snowfall) from air moving over the lake generally increases at about the time of contact with the shoreline, but decreases at greater distances inland from the lake. On a progressively rising land surface very heavy precipitation may be expected particularly at abrupt elevation rises, and shadow effects are common on lee-ward sides of ridges though turbulent airflow may result in a "spillover" of snowfall into the valleys. In summer, the relatively cool lake water inhibits air convection near the lake; but precipitation is significantly greater where surface heating is more effective i.e., inland particularly over higher terrain.

Regional climatological stations indicate annual precipitation ranging from 29 to 43 inches with the lowest amounts being at the lakeshore and at distances of 40 miles or more inland, and the highest values being measured short distances inland on steeply-rising ground. The station expo-

sure is a critical factor in evaluating regional precipitation statistics, for when trees and buildings interfere with the airflow near a gauge, anomalous catches, particularly with snowfall, will result; usually a fraction of the true fall is missing. In addition to considering the immediate gauge environment, it is necessary to judge the area which the gauge might represent. This is a difficult and usually subjectively resolved problem, for it has been demonstrated that two gauges placed almost side-by-side will record differing amounts.

Although there are few stations along the east shore of Lake Superior, precipitation characteristics at the 600 foot level are not difficult to estimate. However, moving inland for the first 10 or more miles the pattern is evidently very complicated. Stations at Steep Hill Falls and Montreal Falls on the lip of the plateau have somewhat high annual values, and experience especially heavy snowfalls. Though Wawa is in a similar topographic situation, it strangely does not receive the same spectacular amounts. Some miles from the lake on the plateau precipitation tends to increase from north to south, but elevation effects are not as evident.

Water Balance

The validity of precipitation values and their representativeness can be checked by hydrological techniques. Over a year an approximate balance occurs between precipitation and the sum of run-off and evapotranspiration, when net changes in soil moisture and surface water detention are allowed for. Over several years the net changes approach zero when basin subterranean outflow is equal to inflow.

In Table 5 the mean monthly run-off from various drainage basins near the park is shown.

The two White River gauges taking in the larger part of the watershed (including White Lake drainage) have higher values than for that portion

TABLE 5

MEAN MONTHLY RUN-OFF PUKASKWA AREA
(Inches)

Watershed	J	F	M	A	M	J	J	A	S	O	N	D	Year Total	Period Used
White River below White Lake (1800 mi^2)	.63	.42	.40	1.05	3.82	2.43	1.21	.68	.60	1.28	1.24	.91	14.67	1959-68
at Regan (1800)	.54	.37	.38	.93	3.75	2.41	1.29	.63	.33	.79	1.18	.82	13.42	1949-55
at Bertrand (928)	.45	.32	.31	1.78	3.51	1.81	.86	.30	.30	.52	.65	.63	11.44	1953-58
Magpie River near Michipicoten (745)	.72	.49	.56	2.41	3.71	2.22	1.24	.74	.81	1.25	1.41	1.03	16.59	1941-70
at Steep Hill Falls (635)	.63	.32	.26	1.47	4.47	2.33	1.70	.84	.66	.89	1.16	.99	15.72	1920-39
Michipicoten River near Scott's Falls (2,070)	1.22	1.13	1.22	1.54	1.80	1.35	1.15	1.06	1.06	1.42	1.32	1.22	15.49	1956-70

of the watershed flowing northwest from Pokei and Negwazu Lakes through the town of White River to Bertrand. However, the latter record was measured during a short, dry period which when compared with long-term Magpie River records, an increase to an annual mean of 13.95 inches is suggested. Run-off is noticeably higher on the more southern Magpie and Michipicoten Basins. The gauge located near Michipicoten measures conditions in the nearshore part of the watershed in addition to that area formerly gauged by the Steep Hill Falls station. Unfortunately there is no common period of record, though when long-term precipitation values from White River are compared it appears that mean annual precipitation is 10 per cent higher in the 1941-70 period as compared with 1921-40. This suggests that streamflow in the area between Steep Hill Falls and the lake may not be higher than upstream from the Falls. Of course, the White River precipitation trend may not be typical of the lower Michipicoten area.

To estimate evapotranspiration several techniques may be used. Four methods were attempted here and three of these gave a value of 19 inches. The agreeing methods were: (a) the lake evaporation technique developed by Ferguson et al. (1970) and demonstrated in the Canadian climatological maps; (b) the Thornthwaite technique (Canada Department of Forestry and Rural Development 1966) and (c) a method developed largely by Robertson at the Canada Department of Agriculture. Values are reported in the agrometeorological Technical Bulletin, 68. The fourth method, the Turc formula, yielded a value of 13 inches which was considered too low.

The synthetic precipitation derived from the summation of mean run-off and evapotranspiration is in general agreement with the measured amounts. For example, the 1941-70 normal precipitation at Wawa (37 inches) may be compared with the Magpie watershed synthetic value of nearly 36 inches. However,

a 23-year aver ge precipitation of nearly 43 inches at Steep Hill Falls may be contrasted with a synthetic precipitation above the Falls during almost the same period of 35 inches. The anomaly is mainly snowfall, as the rain values are similar to the regional average.

The interpretation is that the anomalous snowfall is very limited in geographical extent; it evidently does not significantly affect regional streamflow. This concept is supported by Great Lakes snowbelt research. For example, Wiggin (1950) described theoretical reasons why the belt does not exceed 3 to 5 miles in width. This corresponds with the heavy snow zone on the Keweenaw Peninsula of Michigan described by Eichmeier (1951). Of course, we have no measurements of precipitation or streamflow strictly from the park area. In the north part of the park, moist air in winter might travel some distance up the White River Valley before heavy precipitation is released. But most of the shoreline has restricted penetration before air mass ascent is forced and it is concluded that heavy snowfall will occur on the upslope facing the lake. This rugged bastion will also stimulate rainfall in conditionally unstable air, but during the period of the marine inversion (late spring, early summer) it will have a lesser effect except during cyclonic storms.

Precipitation Model

(a) Snowfall

Once again the grid technicue is used. Here it is assumed that snowfall progressively increases with height. The rate of increase has been empirically determined using Whitefish Point, Michigan and Montreal Falls data. Whitefish Point ($46^{o}46'N$ $85^{o}57'W$) is at the tip of a well-exposed, low-lying peninsula. It is superior to Sault Ste. Marie, Ontario, for this model in that local orography will not influence the precipitation regime.

The means of a 53-year record at Whitefish Point and 15 year record at Montreal Falls have been used to construct Table 6.

TABLE 6

MEAN SNOWFALL VERTICAL GRADIENT EAST SHORE LAKE SUPERIOR

	J	F	M	A	O	N	D
Increase per 100' (inches)	1.4	2.4	2.0	1.1	0.6	1.4	1.4

Absolute values for the 600 foot level are those of Aguasabon which is north of Marathon, but has a better exposure and lacks urban influences. In the operation of the model, precipitation values are assigned to each grid according to the mean grid elevation. Where the slope faces away from the lake, however, a reduced value is assigned. This is because air moving downslope will be subjected to adiabatic heating which will induce evaporation rather than condensation. The reduction rate is based on the decline in snowfall between Steep Hill Falls and White River (a distance of 25 miles) computed on a monthly basis. As only three grid squares are affected this is a minor adjustment. However, in constructing isohyets a bias toward lower snowfall amounts in valleys is invoked. This may be fallaceous in the narrow, deep valleys of the park, for these may be heavy accumulation zones, trapping snow kept aloft by turbulence over high ground (spill-over). Certainly snow which falls on exposed hill country will soon be drifted to lower sheltered areas by the wind.

(b) Rainfall

Essentially the same technique has been used to generate rainfall

values. In this instance Caribou Island was originally considered for use as the lake level station on account of its similar latitude to Montreal Falls, but was rejected in favour of Whitefish Point because, firstly, turbulent mixing and precipitation stimulation would be greater at a true lee shoreline station, and secondly, convectional rainfall would be dampened by surrounding cold water at the island's location. In Table 7 the rainfall elevation adjustment is listed. Rainfall over areas facing away from the lake is adjusted in the same manner as that used for snowfall (Figures 17-30).

TABLE 7

MEAN RAINFALL VERTICAL GRADIENT EAST SHORE LAKE SUPERIOR

	M	J	J	A	S
Increase per 100' (inches)	.06	.11	.08	.18	.15

While the amount of precipitation at White River is considerably less that what we have postulated for the high part of Pukaskwa Park, the markedly increased number of days with measurably precipitation at the former site in comparison with other regional stations nearer the lake suggests that rough topography continues to stimulate the precipitation mechanism inland though amounts of precipitable water are less. At White River, there are 173 days per year with measurable precipitation compared with 132 days at Steep Hill Falls, 128 days at Marathon and 115 days at Wawa. At Hornepayne, eighty miles from the lake, there are only 112 days.

Snow Cover

The median date of the first occurrence of snow cover varies from late September to early November. Near the shores of Lake Superior, the most likely time for the occurrence of the first snow cover is in the first week

of November. The most likely date for the end of the snow cover season is near mid-April.

The maximum winter depths are usually greater than 40 inches. The maximum accumulation occurs during late February. The snow cover has varied from a winter maximum of nearly 5 feet in winters with heavy snowfall to about 20 inches in winters with light snowfall. The ratio of water equivalent to depth (snow density) has been measured at Franz for over 10 years and the 1961-70 means for late January, February and March are 0.19, 0.22 and 0.25 respectively. These are probably typical of the continental zone but would have to be increased one or two percentage points in the maritime zone.

Thunderstorms

Thunderstorms occur when condensation is accelerated in unstable air. The resulting cloud (cumulonimbus) marks the up-draught zone of the convection cell and though these clouds are massive and opaque, there are frequent breaks in the sky cover. This discontinuity is reflected in precipitation patterns, but whether a thunderstorm or shower results from convectional cloud depends on other factors such as relief. Thunderstorm frequency maps have been produced in areas where there is a dense observing network, but in this report only White River data are reliable and representative. Some notation of thunderstorm occurrences was made at Caribou Island in 1964, 1968 and 1969. In all, 48 days with thunderstorms were reported over 14 months. During the same period White River and Sault Ste. Marie reported 47 days and 61 days respectively. The incidence of unstable air masses is higher at the more southerly Caribou Island than at White River, but the cold water about the island dampens convective activity. Along the shoreline of Pukaskwa Park it is believed thunderstorms will be less frequent than a few miles inland. The interior pattern will be similar to White River.

TABLE 8
SNOW COVER

	OCCURRENCE OF SNOW COVER OF 1 INCH OR MORE			DEPTH OF SNOW COVER (INCHES)									
	Date of First Snow Cover	Days With Snow Cover	Date of Last Snow Cover	September 30	October 31	November 30	December 31	January 31	February 28	March 31	April 30	May 31	WINTER MAXIMUM
NAKINA A 50° 11'N 86° 42'W 1065 Ft.													
Earliest or Least	Sept. 24	150	Apr. 10	0	0	0	9	14	0	0	0	0	24
Latest or Greatest	Nov. 26	197	May 30	1	16	24	32	42	42	41	3	0	59
Median (Middle Value)	Oct. 29	168	May 2	0	0	12	21	30	30	21	0	0	39
Arithmetic Mean	Oct. 28	173	May 1				21	28				0	38
PAGWA A 50° 02'N 85° 16'W 620 Ft.													
Earliest or Least	Sept. 20	140	Apr. 16	0	0	2	3	11	20	0	0	0	21
Latest or Greatest	Nov. 12	203	May 31	5	4	24	30	38	43	40	18	0	50
Median (Middle Value)	Oct. 26	169	May 9	0	0	13	16	25	31	23	0	0	40
Arithmetic Mean	Oct. 26	170	May 8			12	16	25	31	22		0	38
WHITE RIVER 48° 35'N 85° 17'W 1243 Ft.													
Earliest or Least	Sept. 20	138	Mar. 13	0	0	1	4	8	11	0	0	0	19
Latest or Greatest	Nov. 26	188	May 29	0	9	17	23	32	30	33	2	0	37
Median (Middle Value)	Oct. 28	155	May 1	0	0	7	13	18	21	14	0	0	28
Arithmetic Mean.	Oct. 24	157	Apr. 27	0		7	13	18	21			0	27

(after Potter, 1965)

TABLE 9

AVERAGE THUNDERSTORM DAYS AT WHITE RIVER 1931-60

J	F	M	A	M	J	J	A	S	O	N	D	YEAR
0.0	0.0	0.2	0.7	1.6	3.5	3.6	4.1	2.1	0.7	0.0	0.0	16.5

Drought

Application of the Thornthwaite water balance at White River indicates that potential evapotranspiration usually equals actual evapotranspiration. The Canada Department of Agriculture (1969) has prepared an irrigation risk analysis for White River in which the user has water-need probability tables in eighteen different forms depending on the soil moisture storage and plant consumptive use factors he wishes to select. As the White River vicinity is a forested landscape interspersed with many lakes, the soil moisture storage capacity will be large regardless of whether the texture is sand or clay. Plant use of the stored water for transpiration is likely to be quite efficient, except perhaps in clearings where lichens form the vegetative cover. Given a soil storage of five inches, with no restriction on evaporation opportunity, there is 15-20 per cent chance that two inches of supplementary water may be required by the end of August, (Table 10). The Park, however, experiences a greater precipitation and lower summer temperatures than at White River, and the five inch soil moisture storage value may be too low, since Thornthwaite suggests there is a soil moisture storage of 10-16 inches in a mature forest, meaning presumably a broad-leaf deciduous forest in a more southern latitude.

This aspect of the moisture regime may also be described following a technique developed by McKay and Chaîné (1971), in which a treatment of the probability of accumulated precipitation with time is presented. A reasonable time for the beginning of the accumulation period at White River

TABLE 10

WHITE RIVER: WEEKLY AND SEASONAL IRRIGATION REQUIREMENTS FOR A GIVEN RISK

STORAGE CAPACITY 5.00 IN. CONSUMPTIVE USE FACTOR 1.00

WEEK BEGINNING		LOWEST ESTIMATE	75	50	25	20	15	10	5	1	HIGHEST ESTIMATE
MONTH	DAY										
4	30	.0	-	-	-	-	-	-	-	-	.0
5	7	.0	-	-	-	-	-	-	-	-	.0
5	14	.0	-	-	-	-	-	-	-	-	.0
5	21	.0	-	-	-	-	-	-	-	-	.0
5	28	.0	-	-	-	-	-	-	-	-	.0
6	4	.0	-	-	-	-	-	-	-	-	.0
6	11	.0	-	-	-	-	-	-	-	.1	.2
6	18	.0	-	-	-	-	-	-	.1	.1	.2
6	25	.0	-	-	-	-	.1	.1	.1	.2	.5
7	2	.0	-	-	.1	.1	.1	.2	.2	.4	.4
7	9	.0	-	-	.1	.1	.2	.3	.4	.6	.4
7	16	.0	--	-	.1	.2	.3	.4	.6	.9	1.2
7	23	.0	-	-	.1	.2	.3	.5	.7	1.1	1.0
7	30	.0	-	-	.2	.3	.4	.5	.7	1.1	.9
8	6	.0	-	-	.2	.3	.4	.5	.7	1.2	.9
8	13	.0	-	-	.1	.2	.3	.4	.6	1.0	1.0
8	20	.0	-	-	.1	.1	.2	.3	.4	.7	.5
8	27	.0	-	-	-	.1	.1	.1	.2	.4	.4
9	3	.0	-	-	-	-	-	.1	.1	.2	.5
9	10	.0	-	-	-	-	-	-	-	.1	.0
9	17	.0	-	-	-	-	-	-	-	-	.0
9	24	.0	-	-	-	-	-	-	-	-	.0
SEASONAL		.0	-	-	1.4	1.7	2.2	2.7	3.4	4.9	4.3

(after Canada Dept. Agriculture (1969))

would be May 15, when the snow has melted but soil moisture levels are still high. Figure 31 shows the means by which the return period for amounts of accumulated precipitation up to 100 inches can be estim ted. Estimates of return-period values for a specific dur tion may be readily obtained from normally distributed information if the mean and the standard deviation are known using the equation

$$P = \overline{P} + K\,\sigma$$

where:

P is an estimated value having

$\overline{P}$ as the mean value and

K is the frequency factor and

σ is the standard deviation.

In this diagram the 50 per cent probability curve is used as the mean; the D_w and D_D curves correspond to the standard deviations required to estimate precipitation excess and deficiency respectively. Examples of the K factor are shown in Table II which correspond to various return periods.

TABLE II

APPROXIMATE FREQUENCY FACTOR (K) VALUES

Return Period in Years	Frequency factor K for moisture excess	for drought
3	0.43	-0.43
4	0.67	-0.67
5	0.85	-0.85
10	1.28	-1.28
20	1.65	-1.65
25	1.75	-1.75
50	2.05	-2.05
100	2.33	-2.33

WIND

An analysis of winds above the 950-mb level (1800 feet) indicates a predominant westerly (onshore) flow occurring about 75% of the time in all seasons. Prevailing surface wind directions may differ because of topographic blocking and channeling. In addition, there are lake-breezes and land-breezes generated by local pressure differences formed over differentially heated surfaces.

Standard measurements of surface winds are at 10 metres above ground, and there are four stations near the park which yield useful information. Wind roses have been constructed for February, May, August and November for White River, Caribou Island (partial), Thunder Bay and Sault Ste. Marie (Figures 32, 33, 34, 35, 36).

The strong easterly component at Sault Ste. Marie is topographically induced. Similarly, at Thunder Bay the southeast component is blocked by Mt. McKay. There is a great variation in wind speed from the exposed Caribou Island site to the shelter of White River. In Table 12, the mean monthly speeds have been reproduced as well as the ratios of the two land stations to Caribou Island.

Munn (1969) compared strong winds at Caribou Island with the Thunder Bay Airport values. He noted particularly high frequencies of strong winds on the open lake during autumn. While it is rare to experience prolonged winds above 35 mph at the Airport, such conditions occur at rates of 30 hours per 10 day period in October and November at Caribou Island.

TABLE 12

MEAN MONTHLY WIND SPEEDS (M.P.H.)

Caribou Isl. 1942-54					18.0	16.6	15.3	15.7	18.2	20.2	22.3	
Thunder Bay 1941-54	9.5	9.3	10.0	10.4	9.7	8.9	8.3	7.8	8.6	9.2	9.6	9.5
Ratio Car./T.B.					1.85	1.86	1.84	2.01	2.12	2.20	2.32	
White River 1937-54	4.4	4.8	5.1	5.4	5.4	5.0	4.5	4.1	4.6	5.1	5.0	4.5
Ratio Car./W.R.					3.34	3.32	3.40	3.83	3.96			
Great Lakes Lake-land Wind Ratio (Richards and Phillips 1970)	1.96	1.94	1.88	1.81	1.71	1.31	1.16	1.39	1.78	1.99	2.09	1.98

TABLE 13

LAKE SUPERIOR
ANALYSIS OF OVER-LAKE WINDS
PERCENTAGE FREQUENCY OF WIND BY DIRECTION AND SPEED CLASS
(Calculated from Lakehead A 1957-1966)
SUMMER

Wind Direction	Speed Class (Knots)						Totals %
	1-5	6-10	11-15	16-20	21-25	26-30	
JULY							
CALM	11.76						11.76
N	.87	2.53	.72	.06			4.18
NE	2.04	8.82	.72	.03			11.61
E	1.75	12.73	1.75	.07			16.30
SE	.40	2.02	.14				2.56
S	1.05	5.63	1.89	.30			8.87
SW	3.51	14.60	1.37	.13	.06		19.67
W	2.08	9.76	3.70	.72	.06	.03	16.35
NW	.99	3.53	3.56	.48	.10		8.66
TOTAL	24.45	59.62	13.85	1.79	.22	.03	100.00
AUGUST							
CALM	11.88						11.88
N	.67	2.80	2.24	.46	.01		6.18
NE	1.09	5.97	2.62	.13			9.81
E	.86	7.60	6.57	.14	.02		15.19
SE	.30	1.92	1.13				3.35
S	.86	4.81	2.97	.13			8.77
SW	1.92	13.96	4.26	.47	.10		20.71
W	1.52	8.01	4.44	.97	.11		15.05
NW	.61	2.74	4.47	1.00	.09		8.91
TOTAL	19.71	47.81	28.70	3.30	.33		100.00
SEPTEMBER							
CALM	10.71						10.71
N	.33	1.48	2.53	1.50	.17	.08	6.09
NE	.62	2.87	4.26	.95	.13	.04	8.87
E	.55	3.16	6.50	2.04	.04		12.29
SE	.22	1.02	1.70	.34	.02		3.30
S	.44	1.86	4.69	2.34	.22	.04	9.59
SW	1.63	6.30	10.16	2.92	.25	.10	21.36
W	.84	4.63	7.07	3.96	1.69	.59	.08	18.86
NW	.34	1.46	2.79	2.72	1.21	.40	.04	8.96
TOTAL	15.68	22.78	39.70	16.77	3.73	1.25	.12	100.00

TABLE 13 (CONT'D)

LAKE SUPERIOR
ANALYSIS OF OVER-LAKE WINDS
PERCENTAGE FREQUENCY OF WIND BY DIRECTION AND SPEED CLASS
(Calculated from Lakehead A 1957-1966)
FALL

Wind Direction	Speed Class (Knots)										Totals %
	1-5	6-10	11-15	16-20	21-25	26-30	31-35	3640	41-45	4650	
OCTOBER											
CALM	9.92										9.92
N	.30	1.29	2.51	2.38	.61	.30	.10	.04			7.53
NE	.51	2.23	4.86	2.08	.20	.04					9.92
E	.34	1.35	4.91	3.33	.59	.04					10.56
SE	.14	.68	1.29	.67	.06						2.84
S	.33	1.16	2.70	1.93	.48	.08					6.68
SW	1.14	4.86	9.41	3.34	.83	.22	.08				19.88
W	.60	3.29	6.91	4.64	2.17	.60	.52	.30	.15		19.08
NW	.45	1.42	3.30	4.20	2.62	.97	.49	.15			13.60
TOTAL	13.73	16.28	35.79	22.57	7.56	2.25	1.19	.49	.15		100.00
NOVEMBER											
CALM	8.96										8.96
N	.24	1.10	2.35	2.70	1.22	.45	.07	.02			8.15
NE	.34	1.44	2.41	2.11	1.41	.39	.24	.10			8.44
E	.16	.64	1.63	2.07	.73	.16	.15	.08	.07	.04	5.75
SE	.09	.42	.97	.84	.25	.02	.01				2.60
S	.19	.96	2.50	1.95	.65	.03	.02				6.30
SW	1.01	3.46	8.58	5.04	1.73	.29	.07				20.18
W	.70	2.51	6.07	7.19	4.89	2.09	.91	.49	.28	.07	25.20
NW	.17	.97	2.39	4.29	3.70	1.55	.76	.42	.17	.03	14.45
TOTAL	11.86	11.50	26.90	26.19	14.58	4.98	2.23	1.11	.52	.14	100.00
DECEMBER											
CALM	7.69										7.69
N	.14	.89	2.17	2.23	.65	.08					6.16
NE	.24	.99	1.95	1.31	.63	.31	.17	.02			5.62
E	.17	.67	1.40	.99	.51	.16	.05	.02	.01		3.98
SE	.05	.22	.68	.65	.23	.07					1.90
S	.27	1.39	2.60	1.03	.18	.02					5.49
SW	.88	4.55	13.09	6.78	.96	.16					26.42
W	.56	2.39	8.15	11.90	4.23	1.60	.88	.10	.06		29.87
NW	.30	.95	2.61	5.44	2.38	.80	.23	.15			12.86
TOTAL	10.30	12.05	32.65	30.33	9.77	3.20	1.33	.29	.07		100.00

TABLE 13 (CONT'D

LAKE SUPERIOR
ANALYSIS OF OVER-LAKE WINDS
PERCENTAGE FREQUENCY OF WIND BY DIRECTION AND SPEED CLASS
(Calculated from Lakehead A 1957-1966)
WINTER

Wind Direction	Speed Class (Knots)									Totals %
	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	
JANUARY											
CALM	9.35										9.35
N	.33	.77	1.37	1.45	.20	.07	.07	.04	.02		4.32
NE	.31	1.28	2.18	1.46	.25	.10	.02				5.60
E	.29	.79	1.20	.55	.16	.04					3.03
SE	.12	.23	.39	.29	.07						1.10
S	.26	.85	1.87	.40	.11						3.49
SW	1.13	4.30	12.67	5.52	.49						24.11
W	.64	2.85	9.58	12.67	5.39	1.98	.64	.04	.04		33.83
NW	.31	1.15	3.60	6.06	2.85	.91	.27	.02	.02		15.19
TOTALS	12.74	12.22	32.86	28.40	9.52	3.10	1.00	.10	.08		100.00
FEBRUARY											
CALM	8.81										8.81
N	.23	.94	2.92	2.71	.30	.04					7.14
NE	.59	2.26	4.67	1.66	.24						9.42
E	.45	1.97	3.23	1.84	.22	.02					7.73
SE	.08	.43	.80	.37	.05						1.73
S	.27	.88	2.06	1.25	.22						4.68
SW	.73	4.06	11.78	4.23	.81	.10	.06				21.77
W	.55	2.66	7.58	8.52	3.60	1.09	.24	.08			24.32
NW	.32	.93	4.15	5.55	2.41	.81	.20	—	—		14.37
TOTALS	12.03	14.14	37.19	26.13	7.85	2.06	.50	.08			100.00
MARCH											
CALM	11.16										11.16
N	.32	.97	3.08	3.48	1.42	.45	.20	.04			9.96
NE	.97	3.41	4.98	3.36	.69	.37	.32	.23	.04		14.37
E	.42	2.62	7.41	4.00	.75	.33	.21				15.74
SE	.12	.60	.98	.36	.08						2.14
S	.23	1.27	2.59	.91	.21	.06					5.27
SW	.71	4.54	9.95	1.27	.16						16.63
W	.57	2.81	4.80	2.82	1.29	.30	.11	.08	.04		12.82
NW	.23	.92	2.88	4.81	2.15	.61	.19	.07	.03		11.88
TOTALS	14.73	17.14	36.67	21.00	6.75	2.12	1.03	.42	.11		100.00

TABLE 13 (CONT'D)

LAKE SUPERIOR
ANALYSIS OF OVER-LAKE WINDS
PERCENTAGE FREQUENCY OF WIND BY DIRECTION AND SPEED CLASS
(Calculated from Lakehead A 1957-1966)
SPRING

Wind Direction	Speed Class (Knots)									Totals %
APRIL										
CALM	7.99									7.99
N	.33	1.39	2.55	3.27	.74	.23	.02			8.53
NE	.71	3.73	6.87	3.55	.35	.09				15.30
E	.54	2.44	8.49	5.24	.73	.54	.18			18.16
SE	.17	.60	1.22	.69	.06	.02				2.76
S	.17	1.12	2.58	1.40	.20	.04				5.51
SW	.63	3.71	5.45	1.18	.47	.40	.08			11.92
W	.57	2.89	4.64	3.34	2.28	1.25	.61	.19	.04	15.81
NW	.28	1.43	4.04	5.30	2.26	.55	.15	.04		14.05
TOTALS	11.39	17.31	35.84	23.97	7.09	3.12	1.04	.23	.04	100.00
MAY										
CALM	7.85									7.85
N	.26	1.35	3.17	2.40	.81	.17	.04			8.20
NE	.48	3.29	6.22	4.32	1.64	.48				16.43
E	.57	3.99	11.87	5.32	.57	.28				22.60
SE	.15	.63	1.50	.43	.04					2.75
S	.15	1.21	2.19	1.77	.34	.20				5.86
SW	.73	4.31	4.64	1.09	.48	.24	.04			11.53
W	.53	2.98	4.45	2.90	1.72	.74	.20	.08		13.60
NW	.46	1.25	3.50	3.84	1.58	.50	.08			11.21
TOTALS	11.18	19.01	37.54	22.07	7.18	2.61	.36	.08		100.00
JUNE										
CALM	10.46									10.46
N	.92	2.58	1.60	.14	.01					5.25
NE	1.56	10.35	4.05	.23						16.19
E	1.83	12.10	7.64	.31						21.88
SE	.44	1.72	.72	.01						2.89
S	.51	3.81	3.33	.29						7.94
SW	1.48	9.56	3.01	.35	.05					14.45
W	1.25	5.82	3.98	1.20	.51					12.76
NW	.35	2.46	4.05	1.16	.13	.03				8.18
TOTALS	18.80	48.40	28.38	3.69	.70	.03				100.00

Richards and Phillips (1970) have synthesized over-lake winds and significant wave heights for the Great Lakes using the ratio technique. Their ratios (see Table 12) were formulated from careful analyses of ship data, but have some bias toward the lower Lakes. Here, however, we have reproduced their synthesized Lake Superior wind data generated from Thunder Bay Airport observations with the recommendation that some subjective bias be given to the higher adjacent speed groups (Table 13). In addition, their monthly histograms of significant wave heights, the wave height probability diagram and maximum significant waves (Figures 37, 38 - Table 14), are shown. A "significant wave height" is the average height of the highest one-third of all waves sampled. Again, it may be expedient to adjust the probability values for higher waves slightly upward. It may be seen that relatively calm water exists from June to August with wave heights greater than five feet occurring only about two per cent of the time in July. On contrast, during November, waves over five feet occur more than 50 per cent of the time. In mid-winter, high waves will be dampened by ice cover.

Table 14

Heights of Maximum Significant Waves on Lake Superior

	J	F	M	A	M	J	J	A	S	O	N	D
Max. Wave (ft.)	31	27*	32	32	27	15	16	12	21	31	37	32
Wind Direction	W	W	W	W	W	NW	W	W	W	W	W	W
Probability (%)	.04	.08	.04	.04	.08	.03	.03	.11	.08	.15	.07	.06

* not valid because of high probability of ice cover

TABLE 15

WHITE RIVER — FREQUENCY OF DURATIONS OF WINDS 0-7 MPH — COMP'D 05/04/71 — PROJECT #05370

	HOURS	6 TO 8	9 TO 11	12 TO 14	15 TO 17	18 TO 20	21 TO 23	24 TO 26	27 TO 29	30 TO 32	33 TO 35	36 TO 41	42 TO 47	48 TO 59	60 TO 71	72 TO 95	96 TO 119	120 TO 143	144 TO 167	168 OR GTR
57–66	JAN	23	20	19	13	21	16	7	4	3	4	8	7	10	6	5	2	2	2	2
	FEB	15	20	12	26	17	11	8	2	1	5	9	6	3	11	6	3	2		
	MAR	16	14	19	37	26	15	9	2	1	1	8	10	4	5	2	6	2	2	1
	APR	27	24	46	43	19	16	8	2	1	3	8	6	4	7	1				
	MAY	25	26	62	42	20	9	8	3	2	1	6	7	3	6	1				
	JUN	30	29	65	48	24	9	6	2	2	1	6	2	4	4	5				1
	JUL	24	20	46	61	31	16	11	2			9	10	5	6	1		1	1	
	AUG	25	22	26	54	27	13	7	4	2	4	7	15	7	6	4	2	1	1	1
	SEPT	27	16	27	44	27	15	4		2	5	9	8	4	6	4	2			2
	OCT	32	18	20	41	33	5	4	4	4	5	5	6	4	3	5	4			2
	NOV	37	25	15	24	26	15	5	1	3	2	10	7	10	3	4	1	1		1
	DEC	33	19	13	14	9	16	7	7	2	4	9	6	8	6	8	4	1	2	3

TABLE 16

THUNDER BAY A — FREQUENCY OF DURATIONS OF WINDS 0-7 MPH — COMP'D 05/04/71 — PROJECT #05370

	HOURS	6 TO 8	9 TO 11	12 TO 14	15 TO 17	18 TO 20	21 TO 23	24 TO 26	27 TO 29	30 TO 32	33 TO 35	36 TO 41	42 TO 47	48 TO 59	60 TO 71	72 TO 95	96 TO 119	120 TO 143	144 TO 167	168 OR GTR
57–66	JAN	46	32	32	8	13	15	1	4	1	2	3	2		2	1				
	FEB	46	32	29	26	12	6	1	3	1	2	2	4	1						
	MAR	67	46	37	52	20	7	3			1	2	1	2						
	APR	61	54	37	31	10														
	MAY	61	51	57	21	7		2												
	JUN	62	42	59	50	19	7	2		1										
	JUL	63	55	54	51	24	12	3		1	1		1							
	AUG	78	39	44	54	29	9	3	2		1	4	2	1						
	SEP	64	50	36	41	19	4	3	1	3		1	2		1					
	OCT	63	32	32	37	31	11				2	2	3		1					
	NOV	36	29	21	19	20	12	7	5	3	1			2		1				
	DEC	51	42	26	15	14	7	5	4	1	2	3	1	1	1					

50 30 50 10 50 30 10

At White River winds are often light. True calms occur 31 per cent of the time in February, 21 in May, 34 in August and 24 in November. However, when the anemometer was higher (1937-54 - 46 feet) the percentage of calms was 10, 6, 10, and 6 respectively. Table 15 indicates that low wind speeds persist for long periods. This diagram shows the number of occasions in a 10-year period when winds remained at 7 mph or less for varying lengths of time. Similar data are shown for Thunder Bay (Table 16). It may be noted that there are occasions exceeding 10 for periods lasting over 60 hours in February and 42 hours in July and August and that occasions occur in all months where light winds last over 72 hours. At Thunder Bay the 10 or greater frequency does not last beyond 20 hours in all months and there is a high concentration of 50 or more occurrences in the warm months reaching 15 to 17 hours in June, July and August. In terms of a simple count of occasions when winds are light there is a greater frequency in summer at Thunder Bay, but during the rest of the year conditions are similar at the two stations or slightly greater at White River. Persistent light winds mean that advective cooling or wind-chill effects are ameliorated. However, conditions governing the formation of nocturnal inversions, during which radiational heat loss from the earth is high, are favourable.

In summary, areas exposed to the lake will experience frequent strong westerly winds with the greatest blow in late fall (see the Caribou Island data). Those regions in valleys parallel to the shoreline will have long periods of calm, particularly in summer, but in valleys which are perpendicular to the shore, air penetration will occur for varying distances. The temperature maps indicate that the middle valley of the Pukaskwa River is affected in autumn. The White River data are suitable for use in the interior.

In terms of wind-chill, high exposed areas will receive, on the average, values of an equivalent temperature of less than -30°F in mid-winter.

For further information on wind characteristics the reader may refer to the Hourly Data Summaries (HDS) for White River and Thunder Bay (Lakehead) (Nos. 38, 5, respectively).

ICE COVER

Rivers and Small Lakes

Ice conditions on lakes and streams near the White River meteorological stations have been observed since 1952. In addition, break-up dates at Oba Lake were noted continuously 1930-55. These data are tabulated below (Table 17). Many factors influence the formation and wastage of lake ice (e.g. surface area, depth, shape); but with no limnological information available, the evaluation must be very general. The Picnic Lake and Tookenay Lake records are fairly complete, and the data may be representative of Birch and Lurch Lakes within the Park. Picnic Lake appears somewhat shallower than Tookenay, for the ice season occurs earlier at the former, in closer harmony with land temperatures. The White River freezes later than the lakes but is ice-free earlier. Toward the lake the ice season should be shorter though at higher elevations in the park this effect will be minimized.

Lake Superior

Recently the U.S. Army, Corps of Engineers (1969) published an atlas of ice cover on the Great Lakes. Here we quote directly from their text and have reproduced six of their maps (Figures 39, 40, 41, 42, 43, 44).

TABLE 17

INLAND ICE SUMMARY
(from Allen and Cudbird (1971))

	Lake Sites				River Sites		
	White River at Little Lake 1952-60 (some misg)	White River at Oba Lake 1930-55 (complete)	White River at Picnic Lake 1952-69 (some misg)	White River at Tookenay Lake 1952-69 (some misg)	White River at townsite 1952-69 (some misg)	White River at Regan	Fort William Harbour
First Permanent Ice	Oct. 21 - Dec. 6		Oct. 15 - Nov. 23	Nov. 3 - Dec. 1	Nov. 5 - Dec. 12 M Nov. 24		Nov. 7 - Dec. 22 M Nov. 30
Complete Freeze-Over	Nov. 7 - Dec. 8		Oct. 28 - Nov. 27 M Nov. 16	Nov. 20 - Dec. 12	Nov. 18 - Dec. 14 M Dec. 2		Nov. 30 - Feb. 2 M Dec. 13
Ice safe for vehicular traffic*	Nov. 20 - Dec. 20		Nov. 25 - Jan. 8	Dec. 15 - Jan. 8	Nov. 30 - Jan. 2		Closed to Navigation Dec. 4 - Dec. 24 M Dec. 13
Maximum ice thickness (inches)			22 - 36	26 - 35	14 - 36		18 - 38 M 29
Ice unsafe for vehicular traffic	Apr. 12 -29		Apr. 7 - May 12	Mar. 31 - May 6	Apr. 1 - 18		Mar. 17 - Apr. 7
First deterioration of Ice	Apr. 16 - May 6		Apr. 10 - May 17	Apr. 10 - May 15	Apr. 1 - Apr. 28 M Apr. 15		Mar. 2 - Apr. 18 M Mar. 27
Water clear of ice	Apr. 20 - May 4 M May 2	Apr. 26 - May 25 M May 11	Apr. 20 - May 6 M May 16	Apr. 28 - May 22 M May 12	Apr. 12 - May 5 M Apr. 21	Apr. 17 - May 6	
						At White Lake (lake site) Apr. 28 - May 16	Open to Navigation Mar. 27 - May 5 M Apr. 17

* Indicators of safe ice have varied from year to year and site to site. In some cases a safe surface refers to one which will take take light snowmobile traffic; in others air craft have been used. At Picnic and Tookenay Lake most dates refer to light aircraft landings. Similar criteria apply to the "ice unsafe" category.

"Lake Superior is the largest and deepest of the Great Lakes with an extremely large heat storage capacity. In this lake wind, waves and currents has a more pronounced effect upon the ice cover than in any other lake. Wind and currents produce upwelling of lake water, bring warm water into contact with the ice, and thus cause melting of the ice cover even though air temperatures are below freezing. Upwelling currents not only change the extent but also the distribution of ice cover. The largest extent of ice cover observed on Lake Superior was approximately 95 per cent and occurred on 30 March 1965. The per cent of lake surface area that can be expected to become ice covered is 40 per cent during a severe winter."

"The initial lake ice formation other than that forming in harbors and bays takes place along the north shore and in the Duluth, Minnesota and Apostle Island areas in the western portion of the lake. As the ice season progresses the ice cover is increased so that the entire lake perimeter becomes covered with the ice sheet extending many miles out into the lake. Except during severe winters the area of the lake between Stannard Rock and Caribou Island remains ice free except for isolated areas of drift ice. The average dates of maximum accumulation of freezing degree-days will vary on Lake Superior from March 30 on the southeastern shore (Marquette to Sault Ste. Marie) to April 10 on the north shore in the Marathon, Ontario area. Because of the season duration, ice thickness, and the textural changes which take place in the drifting floes on this most northern of the Great Lakes, the ice cover here most resembles and acts as an arctic ice pack." (page 4).

CLOUDINESS, FOG AND SUNSHINE

In Table 18 the average number of days lacking sun 1963-70 at White River and Caribou Island is shown. Dark days during winter are overwhelmingly noticeable, occurring 50 per cent of the time. In summer few days are fully overcast, but the chances increase slightly along the shore due to fog. An indication of the increased maritime fogginess is shown by Table 19. Fog in this instance refers to a reduction of the horizontal visibility to less than six miles, but it must be noted that these data are not entirely reliable as Caribou Island does not officially measure fog. In winter fog only occurs one day a month at White River.

TABLE 18

AVERAGE DAYS WITH NO SUN 1963-70

	J	F	M	A	M	J	J	A	S	O	N	D
White River	13	5	6	7	4	3	2	3	6	10	15	16
Caribou Island			3	6	3	3	5	8	16			

TABLE 19

SUMMER DAYS WITH FOG

	M	J	J	A	S	C	N
White River 1957-66	2	2	3	4	4	4	3
Caribou Island 1961-70	10	12	12	11	10	7	4

The actual sunniness expressed as a percentage of the theoretical maximum is presented in Table 20. It is assumed that the instrument undermeasurement at low sun angles is compensated by overmeasurement at mid-day.

TABLE 20

SUNSHINE

	J	F	M	A	M	J	J	A	S	O	N	D
White River												
Mean Hours	2.4	3.9	4.6	5.4	6.3	7.5	7.7	6.5	4.3	2.6	1.4	1.5
Per Cent Max.	27	38	39	40	43	48	50	46	35	24	15	18
Caribou Isl.												
Mean Hours					7.8	7.5	8.4	8.2	5.6	3.9	1.4	
Per Cent Max.					53	48	55	58	45	36	15	

At White River the annual sunshine is 1649 hours. This is lower than the Canadian average but comparable to the Quebec North Shore Region, mountainous districts in north central British Columbia, the treeline zones of the Keewatin and Mackenzie Districts. Worse conditions exist in Newfoundland, northern Quebec and the Arctic Archipelego. The regional pattern is similar even in July, the sunniest month in terms of total hours.

In summary, sunshine is not to be expected frequently in fall and winter. Only 15 per cent of the daytime hours throughout the park are sunny in November. In summer, with the exception of June, there is an advantage in locating

near the shore. Advantage should also be taken of south west facing slopes where solar energy is most efficient in heating the air and soil. The park is fortunate in having a considerable exposure to the southwest. In November, however, these same regions will receive heavy snowfall and fog.

COMFORT

During the snow-free season (mid-May to the end of September) the park visitor can be comfortable in light warm clothing, providing he selects shelter from wind and rain occasionally. However, in winter special clothing and behaviour are required. Auliciems et al. (1972) have studied Canadian winter clothing requirements, indicating regional patterns diagramatically. Figures 45. 46 show the insulation required by the human body at White River and Thunder Bay during each month for various levels of activity. Insulation is expressed in terms of clo units and activity is referred to by metabolic rates. A clo is the amount of insulation required to keep a sitting-resting subject indefinitely comfortable in a steady state at 21°C, 50 per cent relative humidity and a wind of 6.6 metres per minute. One clo is approximately equivalent to a business suit.

Typical activities for metabolic rates of 80, 100, 150, 300 and 450 are: standing, walking 2 mph, cycling 3.5 mph, walking 3 mph with a 45 lb. load, and hand-sawing hardwood, respectively. Sample clothing items corresponding to clo values would be (in progressive layers) heavy underwear and wool socks (0.5), wool shirt and trousers (1.0), woolen coveralls, gloves and cap (1.0), hooded parka, mitts and fur-lined boots (1.5). The total clo value in this instance is 4.0, corresponding to an insulation thickness of one inch.

As the calculation of the clo is more scientific and has a greater relation to physiological behaviour it is considered preferable to wind-chill as an index of physiosystem requirements. However, since the concept of wind-chill

is in frecuent use, particularly when expressed in terms of equivalent temperatures, some remarks are appropriate.

Wind-chill is an expression of convective (advective cooling). It was developed by Siple who measured the freezing of cylinders of water in Antarctica. Other forms of cooling which are not measured by Siple's formula are evaporative cooling, radiative cooling and conductive cooling. Evaporative cooling is an expecially important means of cooling a perspiring body. In summer it is a beneficial process, but in winter it can lead to dangerous repercussions. Of course, evaporation is accelerated to a maximum rate by the wind.

Wind-chill is usually measured in terms of kilogram-calories of heat loss per square metre per hour, but equivalent temperature tables have been prepared (Table 21). Here the user selects an "equivalent temperature" corresponding to the ambient air temperature and wind. These values may be related to human activity. At <u>equivalent</u> temperatures of less than -55°F outdoor travellers are easily fatigued and extreme caution must be used. Below -15°F adequate face protection is required and persons should not travel alone. At less than 5°F, unprotected skin can freeze in one minute. Below 20°F the freezing of unprotected skin takes several minutes but heavy outer clothing is mandatory.

RECOMMENDATIONS

Monthly maps showing activity zones and areas to be avoided have been constructed (Figures 47-56). Figure 47 is the combined January and February map. The best areas for use are in deep valleys perpendicular to the prevailing wind. This would include the Lurch and Birch Lake areas where ice fishing could take place, and in the middle section of the Pukaskwa Valley, though the river ice will not be solid near rapids or where snow is deeply drifted. The coastal area and high ground will be unpleasant on account of strong cold winds and frequent snowfall or fog which will often reduce visibilities to zero. Skiing is

TABLE 21

WIND CHILL TEMPERATURES
Air Temperatures Reduced to a 5 Mile per Hour Wind Speed

TEMPERATURE 32°F to 16°F

WIND (mph)	32°F	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
5	32	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
10	22	20	19	18	17	16	14	13	12	11	10	8	7	6	5	4
12	19	17	16	15	14	13	11	10	9	8	7	5	4	3	2	0
14	17	14	13	12	11	10	8	7	6	5	4	2	1	0	-2	-3
16	15	12	11	10	9	8	6	4	3	2	1	-1	-2	-3	-5	-6
18	13	10	9	8	7	6	4	2	1	0	-2	-3	-4	-6	-7	-8
20	11	8	7	6	5	4	2	0	-1	-2	-4	-5	-6	-8	-9	-10
25	7	5	4	3	1	0	-2	-3	-5	-6	-8	-9	-10	-12	-13	-14
30	5	3	1	0	-2	-3	-5	-6	-8	-9	-11	-12	-14	-15	-16	-17
35	3	1	-1	-2	-4	-5	-7	-8	-10	-11	-13	-14	-16	-17	-19	-20
40	2	-1	-2	-4	-5	-7	-8	-9	-11	-13	-15	-16	-17	-19	-21	-22
45	1	-2	-3	-5	-6	-8	-9	-10	-12	-14	-16	-17	-18	-20	-22	-23
50	0	-2	-4	-6	-7	-9	-10	-11	-13	-15	-17	-18	-20	-21	-23	-24

TEMPERATURE 15°F To 0°F

WIND (mph)	15°F	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
5	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
10	2	1	0	-1	-2	-4	-5	-6	-7	-8	-10	-11	-12	-13	-14	-15
12	-2	-3	-4	-5	-6	-8	-9	-10	-11	-12	-14	-15	-16	-17	-18	-20
14	-5	-6	-8	-9	-10	-11	-13	-14	-15	-16	-17	-19	-20	-21	-22	-24
16	-8	-9	-11	-12	-13	-14	-16	-17	-18	-19	-20	-22	-23	-25	-26	-27
18	-10	-12	-13	-14	-16	-17	-18	-19	-20	-22	-23	-24	-26	-28	-29	-30
20	-12	-14	-15	-16	-18	-19	-20	-21	-22	-24	-25	-26	-28	-30	-31	-32
25	-16	-18	-19	-20	-22	-24	-25	-26	-27	-29	-30	-31	-33	-35	-36	-37
30	-19	-21	-22	-24	-26	-27	-28	-30	-31	-33	-34	-35	-37	-38	-40	-41
35	-22	-24	-25	-26	-28	-29	-30	-32	-34	-36	-37	-38	-40	-41	-43	-44
40	-24	-25	-27	-28	-29	-31	-32	-34	-36	-37	-38	-40	-42	-43	-45	-46
45	-25	-26	-28	-29	-30	-32	-34	-35	-37	-38	-39	-41	-43	-45	-46	-47
50	-26	-27	-29	-30	-31	-33	-35	-36	-38	-39	-40	-42	-44	-46	-47	-48

TABLE 21 (Cont'd) WIND CHILL TEMPERATURES

Air Temperatures Reduced to a 5 Mile per Hour Wind Speed

TEMPERATURE -1°F to -19°F

WIND (mph)	-1°F	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14	-15	-16	-17	-18	-19
5	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14	-15	-16	-17	-18	-19
6	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14	-15	-16	-17	-18	-19	-20	-21	-22	-23
8	-11	-12	-13	-14	-15	-16	-18	-19	-20	-21	-22	-23	-24	-25	-27	-28	-29	-30	-31
10	-16	-17	-18	-20	-21	-23	-24	-25	-26	-27	-28	-29	-30	-32	-33	-35	-36	-37	-38
12	-21	-22	-23	-25	-26	-27	-29	-30	-31	-32	-33	-34	-35	-37	-38	-39	-40	-41	-43
14	-25	-27	-28	-29	-30	-31	-32	-34	-35	-36	-37	-38	-39	-41	-42	-43	-44	-46	-48
16	-28	-30	-31	-32	-33	-34	-35	-37	-38	-40	-41	-42	-43	-44	-46	-47	-48	-50	-52
18	-31	-32	-33	-35	-36	-37	-38	-40	-41	-43	-44	-45	-46	-48	-49	-51	-52	-53	-55
20	-33	-34	-35	-37	-39	-40	-42	-43	-44	-46	-47	-48	-49	-50	-52	-54	-55	-56	-58
25	-39	-40	-41	-43	-44	-45	-47	-48	-49	-51	-53	-54	-55	-56	-58	-59	-60	-62	-64
30	-43	-44	-45	-47	-48	-49	-51	-52	-54	-56	-58	-59	-61	-62	-63	-64	-65	-67	-69
35	-46	-47	-48	-50	-51	-52	-54	-55	-57	-59	-61	-62	-64	-65	-66				
40	-48	-49	-50	-51	-53	-54	-56	-57	-59	-61	-63	-64	-66	-67	-68				
45	-49	-50	-51	-52	-54	-56	-57	-59	-60	-62									
50	-50	-51	-52	-54	-56	-57	-58	-60	-61	-63									

TEMPERATURE -20°F to -45°F

WIND (mph)	-20°F	-21	-22	-23	-24	-25	-26	-27	-28	-29	-30	-31	-32	-33	-34	-35	-40	-45
5	-20	-21	-22	-23	-24	-25	-26	-27	-28	-29	-30	-31	-32	-33	-34	-35	-40	-45
6	-24	-25	-26	-27	-28	-29	-30	-32	-33	-34	-35	-36	-37	-38	-39	-40	-45	-50
8	-32	-33	-34	-36	-37	-38	-39	-40	-41	-42	-43	-44	-45	-47	-48	-49	-54	-60
10	-39	-40	-42	-43	-44	-45	-46	-47	-48	-49	-50	-51	-52	-53	-54	-56	-62	-68
12	-44	-45	-47	-48	-49	-50	-51	-52	-53	-54	-56	-57	-58	-60	-61	-62	-69	
14	-49	-50	-51	-52	-54	-55	-56	-57	-58	-59	-61	-63	-64	-66	-67	-68		
16	-53	-54	-55	-56	-58	-59	-60	-61	-63	-64	-66							
18	-56	-58	-59	-60	-62	-63	-64	-65	-67	-68	-70							
20	-59	-61	-62	-63	-65	-66												
25	-65																	
30	-70																	

a reasonable activity when air temperatures are above -20°F. Snowshoeing is reliable in all temperatures.

In March, favourable areas occur immediately inland from the shore and in the secluded valley regions described above. As spring approches, heavy precipitation is stimulated in progressively higher terrain and sunny periods are longer. With greater sunshine travellers must carry goggles to protect their eyes from glare off the snow.

During April, travellers in river valleys, on lakes and near the shore must cautiously assess ice conditions. On the high ground near the shore there should be many pleasant, sunny days, particularly on bare, southwest-facing slopes, though travel across snow-covered areas becomes increasingly difficult as air temperatures become warmer.

In May, surface water levels are high, but precipitation is relatively low on account of contrasting water - land temperature differences and the northward migration of cyclonic storms. Some of the warmest areas are in the high zone of the "lake-effect belt", but the coastal area experiences a higher frequency of cloud and fog. Thus favourable activity zones occur on inland dry areas above the valley bottoms.

The June map (Figure 51) indicates that the cold shore area will be least pleasant. In highland areas it will be somewhat cooler and wetter. The best regions are in the sheltered valleys and lake district. Conditions in July will be favourable for park use in all areas, and though the relatively cool Lake Superior shore will not entice many swimmers, the ease of access, stable weather, light winds, reduced insect population, and natural beauty of the area will draw concentrations of visitors. August and September are similar to July, but the greater precipitation and risk of frost in highland areas will dampen public interest. Near the shore, however, the gap between water and land temperatures

is reduced to its narrowest point. September and early October will be especially attractive here, though bright mornings may be obscured by fog off the lake.

Real changes occur during October as snow accumulates on the inland highlands toward the end of the month. The lake keeps the shore area and the Pukaskwa Valley relatively warm, though cloudiness increases markedly.

November is an inhospitable month, dark and wet. Freeze-over of lakes and rivers is accomplished, but the ice is usually not safe for transportation.

December is suitable for limited activity in the inland lake and valley district. Bad weather is more severe in the maritime belt, but heavy snowfalls occur in all areas, to the delight of ski enthusiasts.

Meteorological Monitoring

The present analysis is wholly based on data from outside the park. No verification of the adjustments made to simulate conditions is possible without some type of meteorological measurement programme. In addition, local data permit more precise planning to meet environmental demands.

Initially a central station is required at the base of park operations. With staff available it is possible to measure a number of useful parameters; the exact nature, however, would depend on the types of operational demands, but temperature, precipitation and wind should be noted at least twice daily. If the observation and reporting standards of the Atmospheric Environment Service are met these data become readily comparable with regional information, thus allowing a reasonable interpretation of public weather forecasts for the park locality.

There is a need to discover climatic variation away from the central station as the terrain and type of park activity changes. Much can be

learned from carefully sited climatological stations to monitor forested and open areas, river valleys, slopes, and hilltops, but in an area as large as the park it is more important to first know the general variation with elevation and distance from the shore. In this vein we would recommend a line of stations running east-west, five miles apart, at about the latitude of Tip-Top Mountain. Perhaps near this latter feature station two stations at differing elevations could be placed. In general, the exposure should be good to the southwest. The locations of such stations would depend on the road network or whether a helicopter could be used. The frequency of monitoring would be preferably weekly, but even monthly visits would yield useful data. While such stations would not meet the requirements of the Atmospheric Environment Service network, the use of hygrothermographs and autographic rain gauges permits daily comparisons to be made.

A five-year monitoring period should be sufficient to realize adjustments required for the provisional maps, but there is an on-going demand for ecological evaluation and nature interpretation.

The specific siting of stations, monitoring programme, standards, data processing should be discussed by members of the Atmospheric Environment Service and the National Parks Planning Staff.

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APPENDIX I

TEMPERATURE AND PRECIPITATION 1941 - 1970

ONTARIO

This volume contains monthly and annual values of temperature and precipitation elements from 336 stations in the Province of Ontario. The stations are arranged in alphabetical order and data are listed for stations with an appreciable period of record over the period from 1941 to 1970. The actual period of record used to compute the means of temperature and precipitation may be determined through the use of code numbers which appear in the column labelled "Type of Normal".

The code is as follows:

1 30 years between 1941 and 1970
2 25 to 29 years between 1941 and 1970
3 20 to 24 years between 1941 and 1970
4 15 to 19 years between 1941 and 1970
5 10 to 14 years between 1941 and 1970
6 less than 10 years
7 combined data from 2 or more stations
8 adjusted
9 estimated

Temperature

In order to obtain representative observations, all temperature reporting stations are equipped with standard shelters in which the thermometers are housed. The thermometers are self-registering mercury maximum and spirit minimum thermometers which are hung four feet above the surface of the ground, and are usually read two or four times daily. Ideally each shelter is located in the most representative location possible, and is installed over level grassy terrain, where practicable, in a spot away from the sheltering influence of trees and buildings.

At most stations the maximum thermometer is read twice daily but at some only once daily. Because mercury freezes at -38°F such thermometers cannot be used at temperatures below this value. At most climatological stations the maximum temperature is based on a day ending with the morning observation, usually about 8 a.m. the next day. The minimum temperature for the day is based on a day ending with the evening observation, usually about 5 p.m. the same day.

The mean daily maximum temperature for any month is the mean of all daily maximum temperatures recorded in that particular month for the period of record. The mean daily minimum temperature is similarly derived from all daily minimum temperature observations. The mean daily temperature is the average of the monthly maximum and monthly minimum temperatures and may not be exactly equal to the mean of the normal maximum and minimum temperatures.

The temperature extremes are the absolute maximum and minimum values observed over the entire period of record at each station up to and including 1970. In each case the number of years are given below the extreme.

Precipitation

Mean Rainfall - The official Canadian rain gauge is a small cylinder with a cross section area of ten square inches. The gauge is placed in such a position that it is free from all obstructions which might interfere with the catch of rainfall. The gauge is usually located on a level grassy plot, and the rim of the gauge is one foot above the surface of the ground. The rain is funnelled into an inner gauge and then measured to 1/100 of an inch in a glass graduate. The total rainfall for any month is the accumulated total of the daily rainfall amounts. To obtain the mean values of the total rainfall for a particular month over several years, the monthly totals are added and averaged.

Mean Snowfall - In Canada, freshly fallen snow is measured in inches and tenths as it lies on the ground. Observations are made as representative as possible by averaging several measurements and by avoiding snow drifts and wind-swept bare spots. The daily totals of freshly fallen snow are added to give the total snowfall for any month. These monthly totals are then averaged over the period to give the mean monthly amount of snowfall.

Mean Precipitation - The total precipitation for any month is obtained by adding together the total rainfall and the water equivalent of the total snowfall. Since 1960 about 300 stations have been equipped with snow gauges in order to obtain the actual water content, but at the other stations the depth of water resulting from melting newly fallen snow has been taken as one tenth of the depth of the snowfall. Therefore mean total precipitation will not necessarily be equal to the total summation of the total rainfall and one tenth the snowfall.

All mean values were plotted on large scale maps and where short period normals seemed to be out of line with nearby station values were adjusted by comparing the means for the identical period at the nearest long period station. Means adjusted in this way are a much better approximation to the standard period normals than unadjusted short period means, the closeness of the approximation depending upon the length of overlapping period for which data were available. Short period means published without adjustment have at least been checked for spatial continuity by the mapping procedure and were considered to be reasonable. Some short period values failed in this test and where no reasonable adjustment could be made, were discarded.

In three cases, all at airports, the available period of record was short, consisting of a few recent years only but for operational reasons it was desirable to have normal values of temperature and precipitation elements available. Adjusted values were prepared but they were classified as type 9 - estimated - to alert users to the fact that their reliability is less than that of the other values shown.

Days with Measurable Rain, Snow or Precipitation

A day with measurable rain is one on which 1/100 of an inch or more has fallen. A day with measurable snow is one on which at least one tenth of an inch of snow falls. A day with measurable precipitation is one on which 1/100 of an inch of water equivalent is recorded.

Days with Frost

A day with frost is a day on which the daily minimum temperature recorded is 32°F or lower.

Identification

Some station names are followed by abbreviations which assist in defining the location of the station, especially when there is more than one station with the same geographical name. Abbreviations used in these tables are as follows:

A - Airport

CDA - Canada Dept. of Agriculture

OWRC - Ontario Water Resources Commission

ONTARIO

ELEMENT and STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR	Type of Normal
□□□ AGUASABON	LATITUDE 48 47 N LONGITUDE 87 10 W ELEVATION 620 FT ASL													
MEAN DAILY TEMPERATURE (DEG F)	7.4	9.7	19.9	34.8	44.1	51.9	57.3	58.3	51.5	43.0	29.0	14.9	35.2	3
MEAN DAILY MAXIMUM TEMPERATURE	17.6	20.6	30.3	43.2	52.6	60.8	66.1	66.4	58.8	49.9	35.7	23.6	43.8	3
MEAN DAILY MINIMUM TEMPERATURE	- 2.9	- 1.3	9.6	26.4	35.5	42.9	48.6	50.2	44.1	36.2	22.4	6.2	26.5	3
EXTREME MAXIMUM TEMPERATURE	41	43	57	71	76	79	83	84	84	71	62	53	84	3
NO. OF YEARS OF RECORD	19	19	20	19	20	18	18	20	21	20	21	21		
EXTREME MINIMUM TEMPERATURE	-41	-37	-32	-12	16	28	34	30	22	14	-14	-31	-41	3
NO. OF YEARS OF RECORD	20	19	20	19	20	19	21	20	20	19	20	21		
NO. OF DAYS WITH FROST	31	28	30	24	11	*	0	*	2	10	24	30	190	3
MEAN RAINFALL (INCHES)	0.01	0.06	0.40	2.07	3.19	3.37	2.93	3.55	3.39	2.85	1.39	0.37	23.58	3
MEAN SNOWFALL	26.2	16.5	15.2	4.7	1.0	0.0	0.0	0.0	T	0.9	12.6	21.9	99.0	3
MEAN TOTAL PRECIPITATION	2.63	1.72	1.92	2.54	3.29	3.37	2.93	3.55	3.39	3.04	2.66	2.56	33.60	3
GREATEST RAINFALL IN 24 HRS	0.20	0.58	1.41	1.69	1.70	3.13	2.45	2.36	3.41	2.08	2.38	0.75	3.41	3
NO. OF YEARS OF RECORD	20	19	20	19	20	19	21	20	21	19	21	21		
GREATEST SNOWFALL IN 24 HRS	12.0	12.0	12.0	8.0	5.5	0.0	0.0	0.0	T	4.0	13.0	18.0	18.0	3
NO. OF YEARS OF RECORD	20	19	20	19	20	19	21	20	21	19	21	21		
GREATEST PRECIPITATION IN 24 HRS	1.20	1.20	1.61	1.69	1.70	3.13	2.45	2.36	3.41	2.08	2.38	1.80	3.41	3
NO. OF YEARS OF RECORD	20	19	20	19	20	19	21	20	21	20	21	21		
NO. OF DAYS WITH MEASURABLE RAIN	*	*	1	7	10	11	10	11	12	10	6	1	79	3
NO. OF DAYS WITH MEASURABLE SNOW	11	8	7	3	1	0	0	0	0	1	6	9	46	3
NO. OF DAYS WITH M. PRECIPITATION	11	8	8	9	11	11	10	11	12	11	11	10	123	3
□□□ CARIBOU ISLAND	LATITUDE 47 20 N LONGITUDE 85 50 W ELEVATION 612 FT ASL													
TEMP. MOYENNE QUOTIDIENNE (DEG F)	41.2	46.4	52.2	57.0	52.8	45.3	35.3							1
TEMPERATURE MAX. QUOTIDIENNE MOYENNE	46.2	52.3	58.1	61.6	56.8	49.1	39.5							1
TEMPERATURE MIN. QUOTIDIENNE MOYENNE	36.1	40.5	46.3	52.4	48.7	41.4	31.0							1
TEMPERATURE MAXIMALE	67	68	78	78	74	66	55							1
NOMBRE D'ANNEES EN RECORD	30	36	36	36	36	35	36							
TEMPERATURE MINIMALE	24	30	35	41	32	22	4							1
NOMBRE D'ANNEES EN RECORD	30	35	36	36	36	36	35							
NOMBRE DE JOURS DE GEL	3	*	0	0	*	2	17							1
HAUTEUR DE PLUIE MOYENNE (POUCES)	2.73	2.82	2.22	2.73	3.08	2.40	2.32							1
CHUTE DE NEIGE MOYENNE	0.4	0.0	0.0	0.0	0.0	1.4	14.9							1
PRECIPITATION TOTALE MOYENNE	2.73	2.82	2.22	2.73	3.08	2.55	3.81							1
PLUIE MAXIMUM EN 24 HEURES	1.50	2.46	2.45	3.10	1.91	1.84	1.83							1
NOMBRE D'ANNEES EN RECORD	28	33	34	34	35	36	33							
CHUTE DE NEIGE MAXIMUM EN 24 HEURES	3.0	0.0	0.0	0.0	T	14.0	17.0							1
NOMBRE D'ANNEES EN RECORD	29	35	36	36	36	35	32							
PRECIPITATION MAXIMUM EN 24 HEURES	1.50	2.46	2.45	3.10	1.91	2.80	1.83							1
NOMBRE D'ANNEES EN RECORD	28	33	34	34	35	35	33							
NOMBRE DE JOURS AVEC PLUIE MESURABLE	10	10	8	9	12	11	9							1
NOMBRE DE JOURS AVEC NEIGE MESURABLE	*	0	0	0	0	1	6							1
NBRE DE JRS AVEC PRECIPITATION MBLE.	10	10	9	9	12	11	14							1
□□□ CHAPLEAU	LATITUDE 47 50 N LONGITUDE 83 26 W ELEVATION 1405 FT ASL													
TEMP. MOYENNE QUOTIDIENNE (DEG F)	1.9	6.8	16.8	33.8	47.6	57.8	61.9	58.7	50.3	40.1	26.0	8.8	34.2	9
TEMPERATURE MAX. QUOTIDIENNE MOYENNE	14.9	19.9	30.4	45.5	59.8	70.5	74.5	71.0	60.9	50.3	33.7	19.6	45.9	9
TEMPERATURE MIN. QUOTIDIENNE MOYENNE	-11.3	- 7.2	2.0	21.7	34.6	44.5	49.0	46.2	39.6	30.5	18.1	- 2.4	22.1	9
TEMPERATURE MAXIMALE	46	58	74	82	95	103	103	96	96	81	67	53	103	9
NOMBRE D'ANNEES EN RECORD	47	46	46	48	49	49	50	49	49	48	50	45		
TEMPERATURE MINIMALE	-52	-52	-47	-28	8	19	31	18	14	- 2	-35	-53	-53	9
NOMBRE D'ANNEES EN RECORD	48	46	48	49	49	49	49	49	48	47	51	45		
NOMBRE DE JOURS DE GEL	31	28	31	26	15	3	*	2	8	20	27	30	221	9
HAUTEUR DE PLUIE MOYENNE (POUCES)	0.14	0.04	0.27	1.34	2.70	3.31	3.06	3.69	4.20	2.30	1.20	0.24	22.49	9
CHUTE DE NEIGE MOYENNE	17.4	16.8	15.5	6.6	0.4	0.0	0.0	0.0	0.1	3.2	16.4	17.7	94.1	9
PRECIPITATION TOTALE MOYENNE	1.88	1.72	1.82	2.02	2.74	3.31	3.06	3.69	4.21	2.62	2.94	2.04	32.05	9
PLUIE MAXIMUM EN 24 HEURES	0.70	0.50	1.00	1.77	2.01	3.10	2.65	3.71	4.10	2.17	2.00	0.95	4.10	9
NOMBRE D'ANNEES EN RECORD	51	52	49	49	50	52	54	55	54	52	48	46		
CHUTE DE NEIGE MAXIMUM EN 24 HEURES	20.5	14.0	12.5	8.0	8.0	T	0.0	0.0	4.0	18.0	15.0	12.0	20.5	9
NOMBRE D'ANNEES EN RECORD	51	52	44	48	47	53	53	55	54	52	51	45		
PRECIPITATION MAXIMUM EN 24 HEURES	2.05	1.40	1.50	1.90	2.01	3.10	2.65	3.71	4.10	2.17	2.40	1.20	4.10	9
NOMBRE D'ANNEES EN RECORD	51	52	44	48	49	52	54	55	54	52	49	44		
NOMBRE DE JOURS AVEC PLUIE MESURABLE	*	*	1	6	12	11	11	12	14	10	4	1	82	9
NOMBRE DE JOURS AVEC NEIGE MESURABLE	11	10	7	4	*	0	0	0	*	2	8	11	53	9
NBRE DE JRS AVEC PRECIPITATION MBLE.	11	10	8	9	12	11	11	12	14	11	12	12	133	9

▫▫▫ FRANZ — LATITUDE 48 28 N LONGITUDE 84 25 W ELEVATION 1225 FT ASL

TEMP. MOYENNE QUOTIDIENNE (DEG F)	2.2	6.6	16.7	33.5	46.3	57.6	61.5	60.3	50.2	41.5	25.3	7.7	34.1	4
TEMPERATURE MAX. QUOTIDIENNE MOYENNE	15.8	20.3	30.7	46.0	59.4	71.3	75.3	73.2	61.6	51.9	34.3	18.6	46.5	4
TEMPERATURE MIN. QUOTIDIENNE MOYENNE	-11.3	- 7.1	2.8	21.0	32.9	43.9	47.7	47.4	38.8	30.8	16.3	- 3.4	21.7	4
TEMPERATURE MAXIMALE	47	53	74	84	93	101	101	94	90	78	68	53	101	1
NOMBRE D'ANNEES EN RECORD	39	39	40	40	38	37	38	35	35	35	34	38		
TEMPERATURE MINIMALE	-59	-50	-45	-29	5	22	30	25	15	- 5	-35	-55	-59	1
NOMBRE D'ANNEES EN RECORD	41	40	41	40	36	37	39	36	36	37	36	39		
NOMBRE DE JOURS DE GEL	31	28	30	26	15	4	*	1	9	18	28	31	221	4
HAUTEUR DE PLUIE MOYENNE (POUCES)	0.12	0.01	0.29	1.33	3.16	3.31	2.82	3.29	3.98	2.45	1.18	0.12	22.06	8
CHUTE DE NEIGE MOYENNE	24.2	19.6	20.2	9.8	0.7	0.0	0.0	0.0	0.8	2.9	20.7	22.2	121.1	4
PRECIPITATION TOTALE MOYENNE	2.54	2.01	2.26	2.31	3.23	3.31	2.82	3.29	4.07	2.74	3.25	2.34	34.17	8
PLUIE MAXIMUM EN 24 HEURES	0.60	0.95	1.13	1.42	2.36	1.79	2.40	2.26	2.17	2.45	2.07	1.05	2.45	1
NOMBRE D'ANNEES EN RECORD	39	40	38	35	33	33	36	37	31	31	32	38		
CHUTE DE NEIGE MAXIMUM EN 24 HEURES	17.0	12.0	16.0	14.5	5.0	T	T	0.0	5.0	7.0	15.0	11.5	17.0	1
NOMBRE D'ANNEES EN RECORD	31	34	31	33	37	38	40	41	38	35	32	32		
PRECIPITATION MAXIMUM EN 24 HEURES	1.70	1.20	1.60	1.45	2.36	1.79	2.40	2.26	2.17	2.45	2.07	1.25	2.45	1
NOMBRE D'ANNEES EN RECORD	31	33	29	32	33	33	36	37	30	28	31	32		
NOMBRE DE JOURS AVEC PLUIE MESURABLE	1	*	1	6	12	11	12	12	13	10	5	1	84	4
NOMBRE DE JOURS AVEC NEIGE MESURABLE	13	11	9	5	1	0	0	0	*	2	11	13	65	4
NBRE DE JRS AVEC PRECIPITATION MBLE.	14	11	9	10	12	11	12	12	13	11	15	13	143	4

▫▫▫ HORNEPAYNE — LATITUDE 49 14 N LONGITUDE 84 48 W ELEVATION 1080 FT ASL

MEAN DAILY TEMPERATURE (DEG F)	- 1.8	1.8	14.3	32.3	44.9	55.8	60.7	57.7	49.1	39.1	23.5	5.6	31.9	2
MEAN DAILY MAXIMUM TEMPERATURE	9.8	15.1	27.9	43.5	56.9	68.4	73.8	70.5	59.7	47.7	30.4	14.9	43.2	2
MEAN DAILY MINIMUM TEMPERATURE	-13.4	-12.0	0.6	21.0	32.6	43.0	48.0	45.5	38.5	30.4	16.6	- 3.9	20.6	2
EXTREME MAXIMUM TEMPERATURE	44	55	66	84	90	99	98	94	89	89	64	50	99	1
NO. OF YEARS OF RECORD	43	44	45	46	46	49	46	46	44	45	44	44		
EXTREME MINIMUM TEMPERATURE	-57	-62	-47	-35	5	10	15	19	10	-17	-40	-62	-62	1
NO. OF YEARS OF RECORD	43	44	45	46	46	48	45	44	42	44	43	42		
NO. OF DAYS WITH FROST	31	28	30	26	17	4	1	2	9	20	28	31	227	2
MEAN RAINFALL (INCHES)	0.03	0.01	0.17	0.96	2.52	2.99	2.99	2.81	3.28	1.94	0.52	0.15	18.37	2
MEAN SNOWFALL	18.2	15.5	15.5	9.8	2.1	0.1	0.0	0.0	0.2	5.4	21.7	17.1	105.6	2
MEAN TOTAL PRECIPITATION	1.83	1.56	1.72	1.93	2.82	3.00	2.99	2.81	3.31	2.48	2.69	1.83	28.97	2
GREATEST RAINFALL IN 24 HRS	0.40	0.20	0.54	1.50	1.90	1.95	3.25	2.75	2.43	1.57	1.13	0.74	3.25	1
NO. OF YEARS OF RECORD	46	47	44	42	44	42	38	38	39	41	44	47		
GREATEST SNOWFALL IN 24 HRS	11.2	10.5	14.0	10.0	11.0	0.6	0.0	0.0	3.0	12.0	14.8	12.0	14.8	1
NO. OF YEARS OF RECORD	41	40	39	39	46	49	47	47	47	40	42	38		
GREATEST PRECIPITATION IN 24 HRS	1.12	1.05	1.40	1.68	1.90	1.95	3.25	2.75	2.43	1.57	1.48	1.20	3.25	1
NO. OF YEARS OF RECORD	40	40	39	38	43	42	38	38	39	37	40	38		
NO. OF DAYS WITH MEASURABLE RAIN	*	*	1	4	7	9	10	10	12	7	2	1	63	2
NO. OF DAYS WITH MEASURABLE SNOW	9	8	6	5	1	*	0	0	*	3	9	9	50	2
NO. OF DAYS WITH M. PRECIPITATION	9	8	7	8	8	9	10	10	12	10	11	10	112	2

▫▫▫ MARATHON — LATITUDE 48 45 N LONGITUDE 86 22 W ELEVATION 620 FT ASL

MEAN DAILY TEMPERATURE (DEG F)	7.6	11.8	20.5	35.3	44.4	52.1	56.9	58.3	51.8	43.4	29.7	15.0	35.6	4
MEAN DAILY MAXIMUM TEMPERATURE	17.2	21.4	29.9	43.2	53.2	61.3	65.6	66.3	59.1	50.2	36.1	22.7	43.9	4
MEAN DAILY MINIMUM TEMPERATURE	- 1.7	2.3	11.1	27.4	35.6	42.9	48.2	50.2	44.3	36.5	23.4	7.3	27.3	4
EXTREME MAXIMUM TEMPERATURE	40	47	54	76	76	86	90	86	78	73	63	49	90	4
NO. OF YEARS OF RECORD	17	18	19	19	20	18	18	20	21	19	20	17		
EXTREME MINIMUM TEMPERATURE	-30	-33	-28	- 6	16	30	35	34	21	15	-18	-30	-33	4
NO. OF YEARS OF RECORD	16	18	20	20	20	19	20	21	20	20	20	17		
NO. OF DAYS WITH FROST	31	28	30	22	10	1	0	0	2	10	23	30	187	4
MEAN RAINFALL (INCHES)	0.21	0.16	0.66	2.07	2.81	3.07	2.58	3.09	3.47	2.56	1.49	0.47	22.64	4
MEAN SNOWFALL	23.8	16.2	13.2	3.9	0.6	0.0	0.0	0.0	0.0	0.8	10.8	18.6	87.9	4
MEAN TOTAL PRECIPITATION	2.59	1.77	1.99	2.46	2.87	3.07	2.58	3.09	3.47	2.66	2.57	2.33	31.45	4
GREATEST RAINFALL IN 24 HRS	0.72	0.60	1.10	1.40	1.73	2.10	1.74	2.06	1.92	1.62	1.52	0.94	2.10	4
NO. OF YEARS OF RECORD	15	16	18	18	19	21	21	22	22	19	18	18		
GREATEST SNOWFALL IN 24 HRS	12.6	14.4	13.5	6.0	3.0	0.0	0.0	0.0	T	2.2	10.8	12.0	14.4	4
NO. OF YEARS OF RECORD	15	16	17	18	19	21	21	22	22	18	18	17		
GREATEST PRECIPITATION IN 24 HRS	1.26	1.44	1.35	1.40	1.73	2.10	1.74	2.06	1.92	1.62	1.52	1.20	2.10	4
NO. OF YEARS OF RECORD	15	16	18	18	19	21	21	22	22	18	18	17		
NO. OF DAYS WITH MEASURABLE RAIN	1	1	2	7	11	11	9	11	12	11	6	2	84	4
NO. OF DAYS WITH MEASURABLE SNOW	10	8	7	2	1	0	0	0	0	1	6	9	44	4
NO. OF DAYS WITH M. PRECIPITATION	11	9	9	9	12	11	10	11	12	12	12	10	128	4

▫▫▫ MONTREAL FALLS — LATITUDE 47 15 N LONGITUDE 84 24 W ELEVATION 1340 FT ASL

MEAN RAINFALL (INCHES)	0.24	0.19	0.57	1.62	3.25	4.26	3.30	4.15	4.69	3.26	2.45	0.27	28.25	8
MEAN SNOWFALL	32.0	26.4	23.4	11.4	1.3	0.0	0.0	0.0	T	5.9	23.6	35.5	159.5	8
MEAN TOTAL PRECIPITATION	3.44	2.83	2.91	2.76	3.38	4.26	3.30	4.15	4.69	3.85	4.81	3.82	44.20	8
GREATEST RAINFALL IN 24 HRS	1.10	0.50	0.97	1.11	1.40	2.10	1.55	1.71	2.38	2.34	1.80	0.71	2.38	5
NO. OF YEARS OF RECORD	14	14	15	15	13	13	13	10	8	9	12	13		
GREATEST SNOWFALL IN 24 HRS	8.5	12.0	14.0	7.0	2.7	0.0	0.0	0.0	T	10.0	15.0	13.0	15.0	5
NO. OF YEARS OF RECORD	13	13	13	14	14	14	14	11	11	11	12	13		
GREATEST PRECIPITATION IN 24 HRS	1.10	1.20	1.40	1.11	1.40	2.10	1.55	1.71	2.38	2.34	1.80	1.30	2.38	5
NO. OF YEARS OF RECORD	12	13	13	14	13	13	13	10	8	9	12	13		
NO. OF DAYS WITH MEASURABLE RAIN	1	1	2	4	8	11	9	10	13	9	5	1	74	6
NO. OF DAYS WITH MEASURABLE SNOW	13	11	10	6	1	0	0	0	0	3	9	13	66	6
NO. OF DAYS WITH M. PRECIPITATION	13	12	11	9	9	11	9	10	13	11	14	13	135	6

□□□ SAULT STE MARIE LATITUDE 46 32 N LONGITUDE 84 30 W ELEVATION 675 FT ASL

TEMP. MOYENNE QUOTIDIENNE (DEG F)	15.0	15.1	23.5	37.0	46.9	57.3	62.7	62.3	54.0	45.6	33.3	19.4	39.3	5
TEMPERATURE MAX. QUOTIDIENNE MOYENNE	23.6	24.0	32.9	45.9	58.0	69.3	74.5	73.7	64.4	54.8	39.8	26.8	49.0	5
TEMPERATURE MIN. QUOTIDIENNE MOYENNE	6.3	6.2	14.1	28.1	35.8	45.4	50.8	50.9	43.6	36.3	26.8	12.0	29.7	5
TEMPERATURE MAXIMALE	45	46	70	79	85	90	93	97	92	80	71	54	97	5
NOMBRE D'ANNEES EN RECORD	13	13	13	13	12	12	14	15	15	14	13	13		
TEMPERATURE MINIMALE	-38	-34	-29	- 4	16	22	32	26	17	14	-13	-34	-38	5
NOMBRE D'ANNEES EN RECORD	13	13	12	13	12	12	14	15	15	14	13	14		
NOMBRE DE JOURS DE GEL	31	28	30	22	12	3	*	1	4	11	22	30	194	5

□□□ SAULT STE MARIE 2 LATITUDE 46 32 N LONGITUDE 84 20 W ELEVATION 695 FT ASL

TEMP. MOYENNE QUOTIDIENNE (DEG F)	13.9	14.9	24.7	38.8	49.4	58.4	63.8	63.1	56.1	46.2	33.2	19.7	40.2	5
TEMPERATURE MAX. QUOTIDIENNE MOYENNE	21.4	23.4	32.9	47.6	59.4	69.1	74.3	72.6	64.5	53.6	38.9	26.5	48.7	5
TEMPERATURE MIN. QUOTIDIENNE MOYENNE	6.3	6.3	16.5	30.0	39.3	47.7	53.2	53.5	47.7	38.7	27.5	12.9	31.6	5
EXTREME MAXIMUM TEMPERATURE	40	44	52	77	88	90	92	88	88	80	62	50	92	5
NO. OF YEARS OF RECORD	11	10	10	12	13	13	11	13	13	14	14	13		
EXTREME MINIMUM TEMPERATURE	-29	-26	-16	12	20	29	37	35	28	19	- 7	-16	-29	5
NO. OF YEARS OF RECORD	11	10	10	11	13	13	12	13	13	14	13	12		
NO. OF DAYS WITH FROST	31	28	30	20	7	*	0	0	1	8	22	29	176	5
MEAN RAINFALL (INCHES)	0.56	0.10	0.99	2.08	3.35	3.71	2.92	3.20	4.41	2.94	2.74	1.40	28.40	8
MEAN SNOWFALL	26.2	20.2	15.0	2.9	0.9	0.0	0.0	0.0	0.1	2.2	15.7	21.8	105.0	8
MEAN TOTAL PRECIPITATION	3.18	2.12	2.49	2.37	3.44	3.71	2.92	3.20	4.42	3.16	4.31	3.58	38.90	8
GREATEST RAINFALL IN 24 HRS	0.62	0.83	0.82	1.04	3.19	3.34	1.65	3.75	2.24	2.11	1.64	0.89	3.75	5
NO. OF YEARS OF RECORD	12	10	9	12	13	12	11	13	13	14	13	13		
GREATEST SNOWFALL IN 24 HRS	7.4	9.0	8.0	5.0	2.0	T	0.0	0.0	1.0	5.1	7.6	9.0	9.0	5
NO. OF YEARS OF RECORD	10	9	9	12	13	13	13	13	13	14	13	12		
GREATEST PRECIPITATION IN 24 HRS	0.74	0.90	0.87	1.05	3.19	3.34	1.65	3.75	2.24	2.21	1.84	0.90	3.75	5
NO. OF YEARS OF RECORD	10	10	9	12	13	12	11	13	13	14	13	12		
NO. OF DAYS WITH MEASURABLE RAIN	2	1	2	9	12	11	10	11	13	14	9	3	97	5
NO. OF DAYS WITH MEASURABLE SNOW	17	14	11	4	1	0	0	0	*	2	12	17	78	5
NO. OF DAYS WITH M. PRECIPITATION	18	15	12	11	12	11	10	11	13	15	18	19	165	5

□□□ SAULT STE MARIE A LATITUDE 46 29 N LONGITUDE 84 30 W ELEVATION 620 FT ASL

MEAN DAILY TEMPERATURE (DEG F)	12.7	10.8	22.9	37.9	48.5	58.2	63.6	62.2	55.8	46.6	33.7	20.0	39.4	6
MEAN DAILY MAXIMUM TEMPERATURE	21.4	21.7	32.9	46.9	59.4	69.9	75.0	72.4	64.8	54.6	39.9	27.3	48.9	6
MEAN DAILY MINIMUM TEMPERATURE	4.0	- 0.2	12.9	28.8	37.6	46.4	52.2	51.9	46.7	38.6	27.4	12.6	29.9	6
EXTREME MAXIMUM TEMPERATURE	41	43	55	76	89	90	95	89	85	80	63	58	95	6
NO. OF YEARS OF RECORD	9	9	9	9	9	9	9	10	10	10	10	10		
EXTREME MINIMUM TEMPERATURE	-30	-31	-24	- 3	20	26	36	36	27	21	- 1	-17	-31	6
NO. OF YEARS OF RECORD	9	9	9	9	9	9	9	10	10	10	10	10		
NO. OF DAYS WITH FROST	31	28	30	21	8	*	0	0	1	8	22	29	178	6
MEAN RAINFALL (INCHES)	0.64	0.13	0.75	1.80	3.24	3.48	2.83	2.62	3.73	2.93	2.39	1.52	26.06	8
MEAN SNOWFALL	25.6	20.2	15.0	4.1	1.1	T	0.0	0.0	0.1	1.8	17.8	21.8	107.5	8
MEAN TOTAL PRECIPITATION	3.20	2.15	2.25	2.21	3.35	3.48	2.83	2.62	3.74	3.10	4.17	3.70	36.80	8
GREATEST RAINFALL IN 24 HRS	0.50	0.61	1.10	1.14	4.59	3.04	1.48	2.19	2.53	1.22	1.27	0.88	4.59	6
NO. OF YEARS OF RECORD	9	9	9	9	9	9	9	10	10	10	10	10		
GREATEST SNOWFALL IN 24 HRS	11.9	15.9	10.9	4.6	4.0	0.3	0.0	0.0	0.6	2.5	9.8	9.0	15.9	6
NO. OF YEARS OF RECORD	9	9	9	9	9	9	9	10	10	10	10	10		
GREATEST PRECIPITATION IN 24 HRS	1.13	1.49	1.16	1.14	4.59	3.04	1.48	2.19	2.53	1.22	1.27	0.91	4.59	6
NO. OF YEARS OF RECORD	9	9	9	9	9	9	9	10	10	10	10	10		
NO. OF DAYS WITH MEASURABLE RAIN	2	1	4	9	11	11	9	11	13	14	9	3	97	6
NO. OF DAYS WITH MEASURABLE SNOW	19	14	9	4	1	*	0	0	*	3	11	17	78	6
NO. OF DAYS WITH M. PRECIPITATION	20	14	12	11	12	11	9	11	13	15	16	19	163	6

□□□ SCHREIBER LATITUDE 48 49 N LONGITUDE 87 16 W ELEVATION 990 FT ASL

MEAN DAILY TEMPERATURE (DEG F)	5.8	8.7	19.5	34.0	44.5	53.7	58.7	58.2	49.9	41.0	26.6	12.8	34.5	1
MEAN DAILY MAXIMUM TEMPERATURE	15.0	18.5	29.0	42.2	53.4	62.9	67.9	66.7	57.3	47.7	32.6	20.5	42.8	1
MEAN DAILY MINIMUM TEMPERATURE	- 3.5	- 1.1	10.0	25.8	35.5	44.4	49.5	49.7	42.5	34.3	20.6	5.1	26.1	1
EXTREME MAXIMUM TEMPERATURE	46	54	57	71	83	91	87	84	83	76	64	53	91	1
NO. OF YEARS OF RECORD	60	59	59	60	58	60	62	61	56	55	60	60		
EXTREME MINIMUM TEMPERATURE	-43	-45	-32	- 9	11	28	30	30	20	4	-18	-36	-45	1
NO. OF YEARS OF RECORD	60	58	58	61	59	59	61	62	57	56	60	60		
NO. OF DAYS WITH FROST	31	28	30	24	11	1	0	*	4	14	26	30	199	2
MEAN RAINFALL (INCHES)	0.08	0.12	0.40	1.80	3.41	3.63	3.10	3.75	3.73	2.86	1.41	0.36	24.65	2
MEAN SNOWFALL	19.1	14.5	10.9	5.8	0.5	0.0	0.0	0.0	0.2	1.7	10.7	16.2	79.6	2
MEAN TOTAL PRECIPITATION	1.99	1.56	1.48	2.39	3.46	3.63	3.10	3.75	3.75	3.03	2.48	2.00	32.62	2
GREATEST RAINFALL IN 24 HRS	1.47	1.29	1.45	2.17	2.20	3.35	2.90	3.66	2.86	3.38	2.20	1.38	3.66	1
NO. OF YEARS OF RECORD	69	68	68	64	62	67	68	65	59	57	66	68		
GREATEST SNOWFALL IN 24 HRS	18.0	16.0	14.0	11.0	4.0	T	0.0	0.0	3.5	8.0	14.0	27.0	27.0	1
NO. OF YEARS OF RECORD	69	65	68	64	66	69	69	68	62	61	64	65		
GREATEST PRECIPITATION IN 24 HRS	1.80	1.60	1.45	2.17	2.20	3.35	2.90	3.66	2.86	3.38	2.20	2.70	3.66	1
NO. OF YEARS OF RECORD	69	65	67	63	62	67	68	65	59	57	65	65		
NO. OF DAYS WITH MEASURABLE RAIN	*	*	1	5	9	10	9	9	11	8	4	1	67	2
NO. OF DAYS WITH MEASURABLE SNOW	9	8	7	3	*	0	0	0	*	1	6	9	43	2
NO. OF DAYS WITH M. PRECIPITATION	10	8	7	8	9	10	9	9	11	9	10	9	109	2

□□□ THUNDER BAY A LATITUDE 48 22 N LONGITUDE 89 19 W ELEVATION 644 FT ASL

TEMP. MOYENNE QUOTIDIENNE (DEG F)	5.4	8.6	20.9	36.3	46.9	56.9	63.5	61.7	52.4	42.9	27.5	12.6	36.3	2
TEMPERATURE MAX. QUOTIDIENNE MOYENNE	16.0	20.8	32.0	46.6	58.7	68.8	75.5	73.2	63.0	52.9	35.2	21.9	47.1	2
TEMPERATURE MIN. QUOTIDIENNE MOYENNE	- 5.2	- 3.5	9.9	25.9	35.1	45.0	51.4	50.1	41.7	32.8	19.7	3.4	25.5	2
TEMPERATURE MAXIMALE	47	49	73	83	93	96	95	96	87	83	67	54	96	2
NOMBRE D'ANNEES EN RECORD	29	28	29	29	29	29	29	30	30	30	30	30		
TEMPERATURE MINIMALE	-42	-40	-34	- 8	16	27	32	31	17	8	-19	-31	-42	2
NOMBRE D'ANNEES EN RECORD	29	29	29	29	29	29	29	30	30	30	30	30		
NOMBRE DE JOURS DE GEL	31	28	30	24	12	1	*	*	6	16	26	31	205	2
HAUTEUR DE PLUIE MOYENNE (POUCES)	0.05	0.06	0.41	1.44	2.77	3.26	2.80	3.46	3.28	2.10	1.10	0.24	20.97	2
CHUTE DE NEIGE MOYENNE	20.3	12.2	13.9	7.9	1.7	0.0	0.0	0.0	T	1.4	12.1	17.9	87.4	2
PRECIPITATION TOTALE MOYENNE	1.89	1.19	1.72	2.22	2.94	3.26	2.80	3.46	3.29	2.24	2.25	1.81	29.07	2
PLUIE MAXIMUM EN 24 HEURES	0.68	0.42	1.05	2.73	2.13	1.94	1.74	2.75	3.86	1.88	2.07	1.68	3.86	2
NOMBRE D'ANNEES EN RECORD	29	29	29	29	29	29	29	30	30	30	30	30		
CHUTE DE NEIGE MAXIMUM EN 24 HEURES	20.3	13.2	14.9	9.5	8.5	T	0.0	0.0	0.3	6.4	13.6	12.2	20.3	2
NOMBRE D'ANNEES EN RECORD	29	29	29	29	29	29	29	30	30	30	30	30		
PRECIPITATION MAXIMUM EN 24 HEURES	2.03	1.32	1.65	2.73	2.13	1.94	1.74	2.75	3.86	1.88	2.07	1.68	3.86	2
NOMBRE D'ANNEES EN RECORD	29	29	29	29	29	29	29	30	30	30	30	30		
NOMBRE DE JOURS AVEC PLUIE MESURABLE	1	*	2	7	12	13	12	12	12	9	5	2	87	2
NOMBRE DE JOURS AVEC NEIGE MESURABLE	14	11	9	5	1	0	0	0	*	1	9	13	63	2
NBRE DE JRS AVEC PRECIPITATION MBLE.	13	11	10	11	12	13	12	12	12	10	12	13	141	2

□□□ WAWA LATITUDE 48 04 N LONGITUDE 84 45 W ELEVATION 1410 FT ASL

MEAN DAILY TEMPERATURE (DEG F)	7.9	10.5	20.7	35.2	46.5	55.9	60.4	59.6	52.7	42.1	27.9	14.3	36.1	3
MEAN DAILY MAXIMUM TEMPERATURE	16.2	19.2	29.4	43.4	55.5	65.4	69.5	67.9	60.3	48.9	33.6	21.1	44.2	3
MEAN DAILY MINIMUM TEMPERATURE	- 0.5	1.8	11.9	27.0	37.4	46.5	51.1	51.3	44.6	35.3	22.1	7.2	28.0	3
EXTREME MAXIMUM TEMPERATURE	43	48	68	81	80	85	88	88	68	77	67	58	88	2
NO. OF YEARS OF RECORD	24	24	24	24	25	24	27	27	23	25	26	25		
EXTREME MINIMUM TEMPERATURE	-38	-42	-28	-10	16	25	26	32	23	10	-17	-30	-42	2
NO. OF YEARS OF RECORD	24	24	24	24	25	25	27	27	23	27	26	22		
NO. OF DAYS WITH FROST	31	28	30	22	9	1	0	*	3	13	26	30	193	3
MEAN RAINFALL (INCHES)	0.21	0.20	0.50	2.01	3.15	3.16	2.67	3.89	4.25	3.20	1.64	0.58	25.46	2
MEAN SNOWFALL	25.6	24.0	16.9	5.9	1.1	0.0	0.0	0.0	0.2	3.0	16.2	21.8	114.7	2
MEAN TOTAL PRECIPITATION	2.78	2.60	2.28	2.59	3.17	3.16	2.67	3.89	4.32	3.50	3.26	2.73	36.95	2
GREATEST RAINFALL IN 24 HRS	0.80	1.15	1.00	1.70	2.98	2.08	2.03	2.22	2.40	3.00	3.95	1.89	3.95	2
NO. OF YEARS OF RECORD	25	24	22	25	25	27	27	26	26	27	26	25		
GREATEST SNOWFALL IN 24 HRS	12.0	12.0	8.0	9.0	4.0	T	0.0	0.0	2.3	8.0	9.5	12.0	12.0	2
NO. OF YEARS OF RECORD	24	23	24	26	24	27	28	27	25	26	26	23		
GREATEST PRECIPITATION IN 24 HRS	1.20	1.20	1.50	1.70	2.98	2.08	2.03	2.22	2.40	3.00	3.95	1.89	3.95	2
NO. OF YEARS OF RECORD	24	22	24	26	24	27	27	26	27	27	26	23		
NO. OF DAYS WITH MEASURABLE RAIN	1	*	1	6	9	9	8	10	11	8	5	2	70	2
NO. OF DAYS WITH MEASURABLE SNOW	11	10	7	3	1	0	0	0	*	1	7	9	49	2
NO. OF DAYS WITH M. PRECIPITATION	11	10	8	8	9	9	8	10	12	9	11	10	115	2

□□□ WHITE RIVER LATITUDE 48 36 N LONGITUDE 85 17 W ELEVATION 1243 FT ASL

TEMP. MOYENNE QUOTIDIENNE (DEG F)	0.6	3.8	14.9	32.7	45.6	56.0	60.6	58.2	49.5	40.1	24.3	7.3	32.8	1
TEMPERATURE MAX. QUOTIDIENNE MOYENNE	14.2	18.5	30.0	44.8	58.5	69.5	74.4	71.4	60.5	49.9	32.1	19.2	45.3	1
TEMPERATURE MIN. QUOTIDIENNE MOYENNE	-13.1	-11.0	- 0.2	20.4	32.7	42.5	46.8	44.9	38.4	30.2	16.5	- 3.7	20.4	1
TEMPERATURE MAXIMALE	46	52	75	81	93	101	100	97	91	82	69	54	101	1
NOMBRE D'ANNEES EN RECORD	82	82	81	82	81	79	81	82	82	82	81	80		
TEMPERATURE MINIMALE	-61	-60	-50	-31	-11	18	24	21	14	- 8	-38	-55	-61	1
NOMBRE D'ANNEES EN RECORD	82	82	81	82	81	79	80	82	82	82	81	80		
NOMBRE DE JOURS DE GEL	31	28	30	27	17	5	1	3	10	21	28	31	232	1

□□□ WHITE RIVER LATITUDE 48 36 N LONGITUDE 85 17 W ELEVATION 1243 FT ASL

MEAN RAINFALL (INCHES)	0.07	0.06	0.35	1.28	2.71	3.06	2.88	3.17	3.77	2.21	0.99	0.21	20.76	1
MEAN SNOWFALL	21.4	17.8	17.1	10.9	2.2	T	0.0	0.0	1.0	5.1	20.8	20.0	116.3	1
MEAN TOTAL PRECIPITATION	2.10	1.81	2.02	2.40	2.94	3.06	2.88	3.17	3.87	2.74	3.05	2.18	32.22	1
GREATEST RAINFALL IN 24 HRS	0.60	0.70	1.04	1.81	1.69	2.30	3.01	4.01	3.62	1.84	2.83	0.75	4.01	1
NO. OF YEARS OF RECORD	82	83	82	82	82	82	82	83	85	84	83	82		
GREATEST SNOWFALL IN 24 HRS	12.4	9.0	13.1	12.0	7.5	1.2	0.0	0.0	5.3	13.5	12.1	19.1	19.1	1
NO. OF YEARS OF RECORD	82	83	82	82	82	82	83	83	85	84	82	82		
GREATEST PRECIPITATION IN 24 HRS	1.20	0.90	1.30	1.81	1.69	2.30	3.01	4.01	3.62	1.84	2.84	1.91	4.01	1
NO. OF YEARS OF RECORD	82	83	82	82	82	82	82	83	85	84	82	82		
NO. OF DAYS WITH MEASURABLE RAIN	1	1	2	6	12	12	12	13	15	11	6	1	92	1
NO. OF DAYS WITH MEASURABLE SNOW	18	15	12	8	3	*	0	0	1	5	15	17	94	1
NO. OF DAYS WITH M. PRECIPITATION	18	15	13	12	13	12	12	13	15	14	18	18	173	1

TOTAL PRECIPITATION

MICHIGAN

WHITEFISH POINT

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
1952	-	-	-	-	-	-	-	-	2.01	2.13	2.18	1.83	-
1953	E 2.17	3.05	1.55	3.44	3.17	4.08	4.89	4.27	3.09	1.26	2.07	2.98	36.02
1954	2.03	2.13	E 2.95	4.79	2.85	2.90	.26	2.24	4.11	3.35	E .80	E .78	29.19
1955	E 1.73	E 1.13	E 3.18	1.84	1.23	1.95	2.17	3.51	1.28	2.54	2.01	1.75	24.32
1956	.69	.45	E 1.24	.92	2.90	2.99	5.96	2.38	2.58	.86	E 3.24	E 1.68	25.89
1957	-	-	E .65	-	1.95	2.87	-	1.38	-	-	-	-	-
1958	E 1.45	-	-	-	-	2.88	3.09	-	-	-	-	5.06	-
1959	3.39	1.60	E 2.01	1.95	1.18	E 3.21	4.79	5.74	4.68	4.58	E 2.18	E 1.53	36.84
1960	-	2.63	1.15	5.08	-	-	-	-	-	-	-	2.49	-
PERIOD YEARS	1.91 6	1.83 6	1.82 7	3.00 6	2.21 6	2.98 7	3.53 6	3.25 6	2.96 6	2.45 6	2.08 6	2.26 8	30.20
RECORD YEARS	2.65 53	1.86 52	2.12 52	2.17 51	2.72 53	2.90 52	2.69 52	2.48 53	3.42 54	3.17 53	3.04 52	3.02 53	32.30

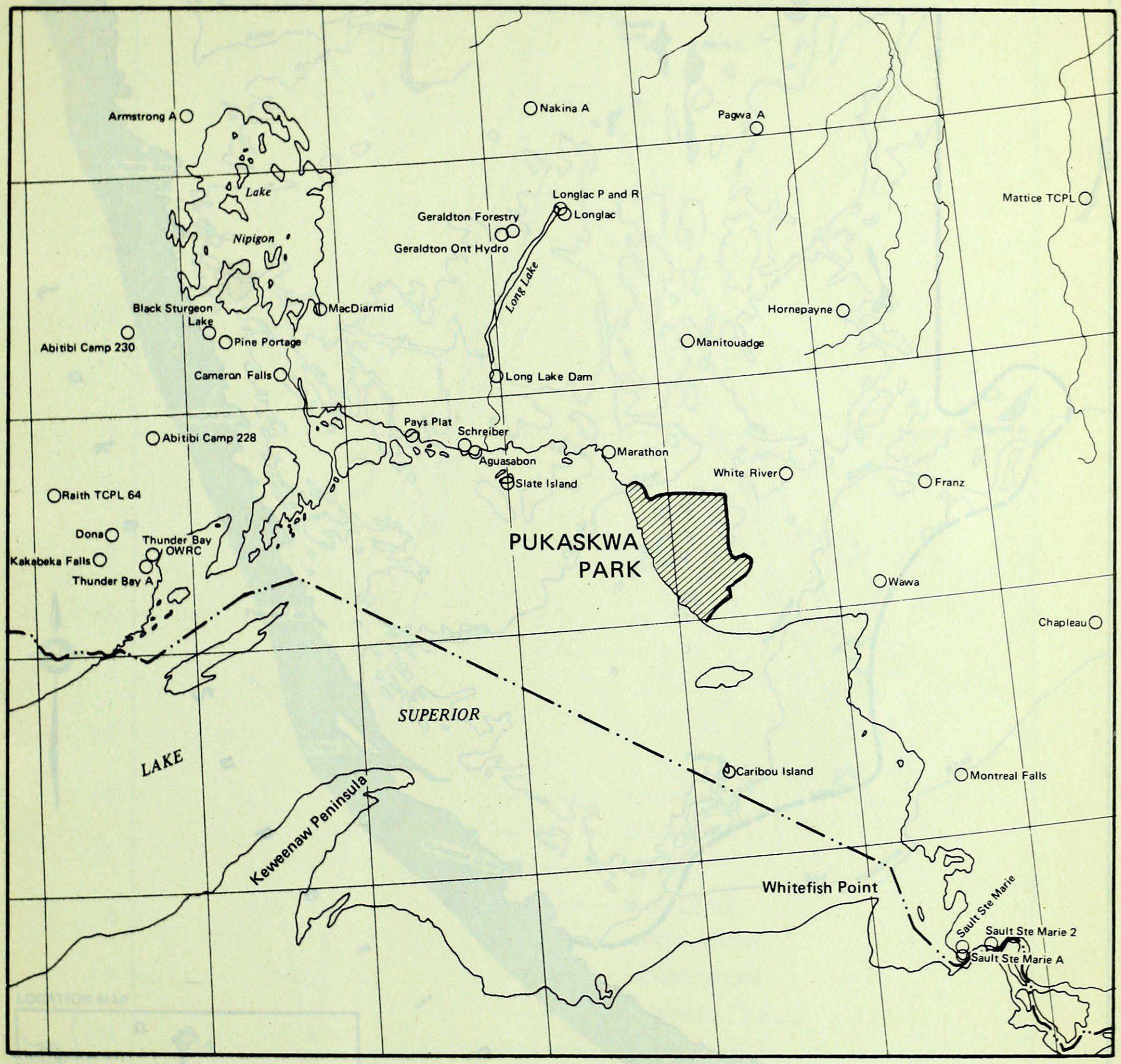


Figure 1. Meteorological Stations in the Eastern Lake Superior Area.

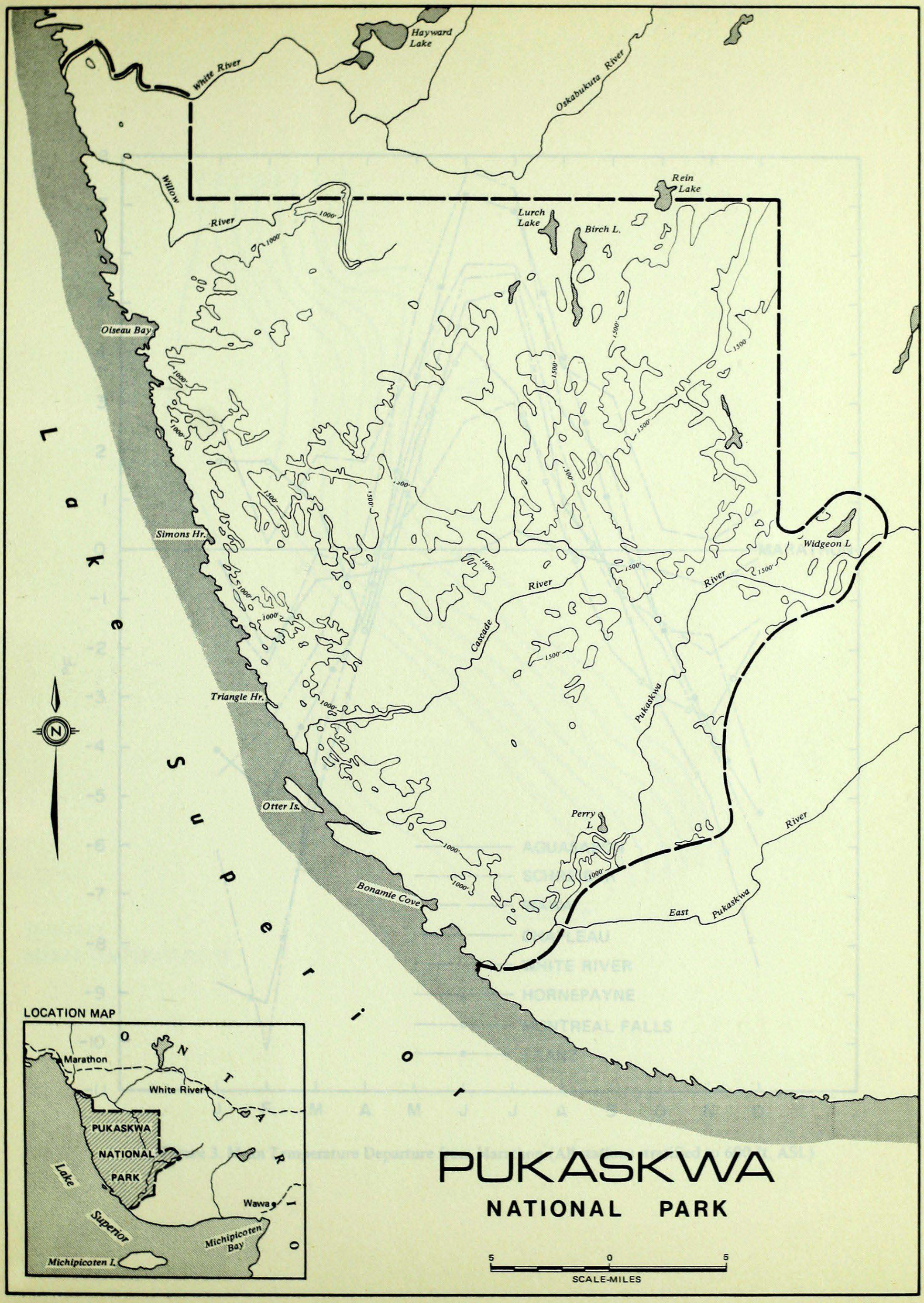

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
1000'
1500'
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
Perry L
Widgeon L
East Pukaskwa River
Lake Superior
N
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 2.

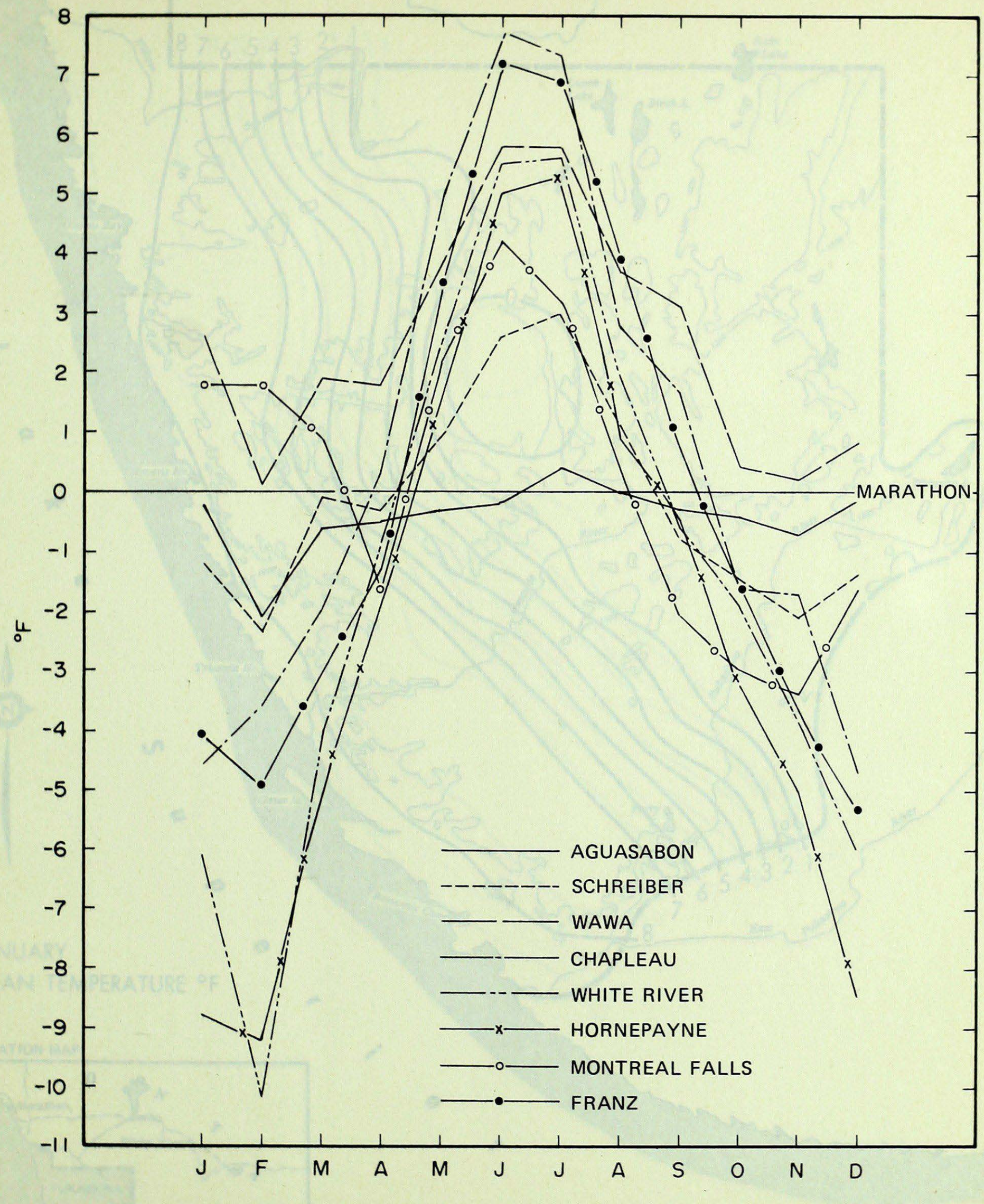


Figure 3. Mean Temperature Departure from Marathon (All stations stratified to 600 ft. ASL)

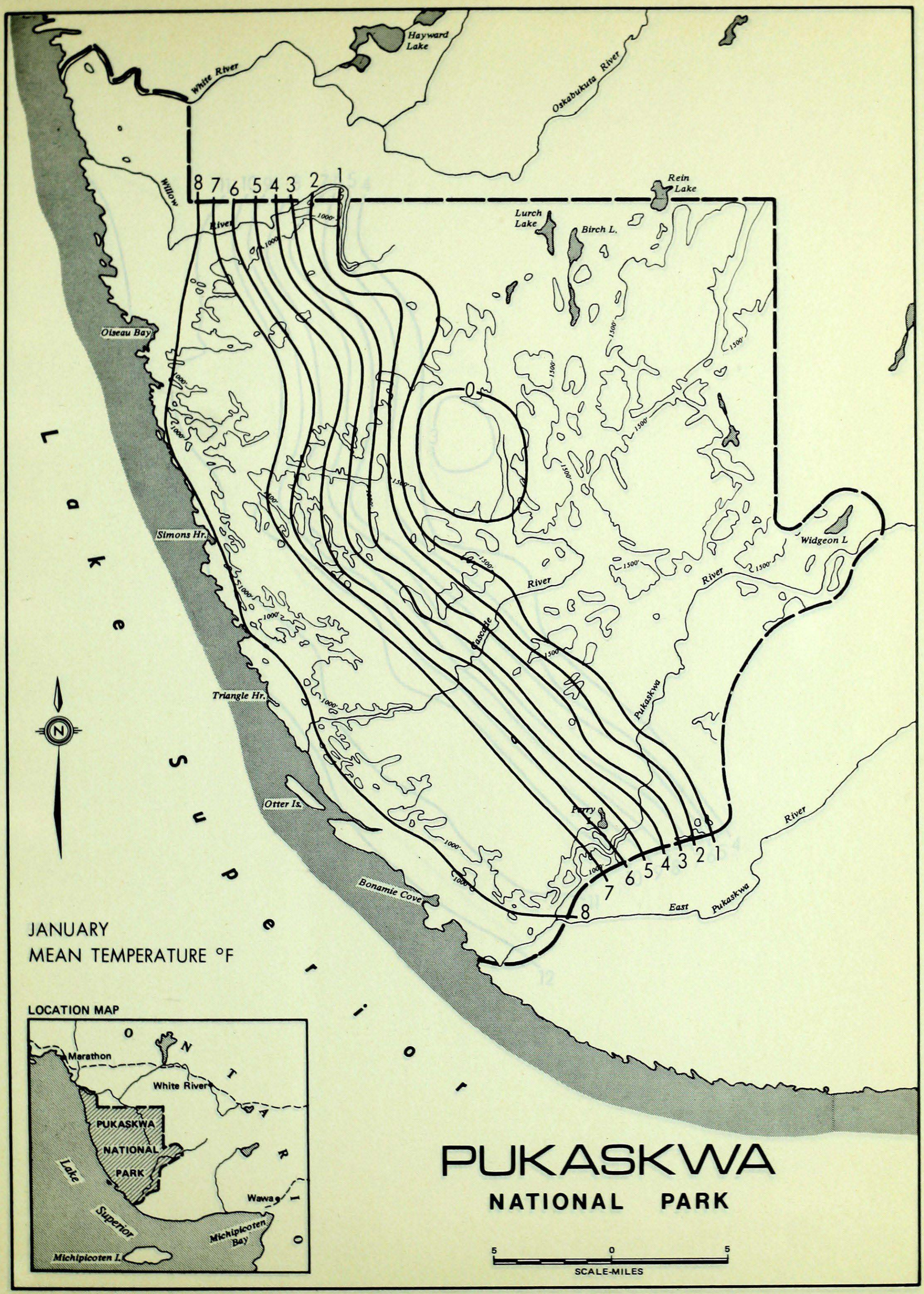
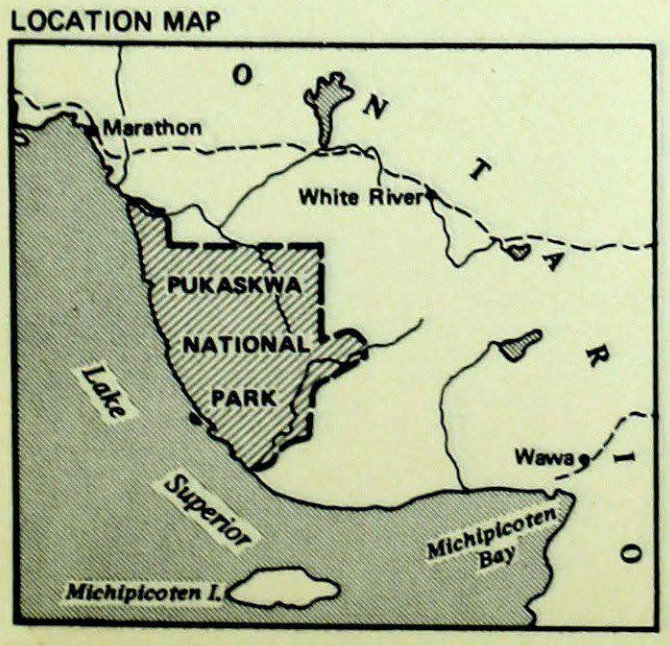

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Gascoigne River
Pukaskwa River
East Pukaskwa River
Perry
Widgeon L
Lake Superior
8 7 6 5 4 3 2 1
1000'
1500'
0
JANUARY
MEAN TEMPERATURE °F
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 4.

Hayward Lake
White River
Oskabukuta River
Rein Lake
Lurch Lake
Birch L.
Willow River
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Widgeon L
Cascade River
Pukaskwa River
Perry L
East Pukaskwa River
Lake Superior
1000'
1500'
12
11
10
9
8
7
6
5
4
3
2
1
0
FEBRUARY
MEAN TEMPERATURE °F

LOCATION MAP



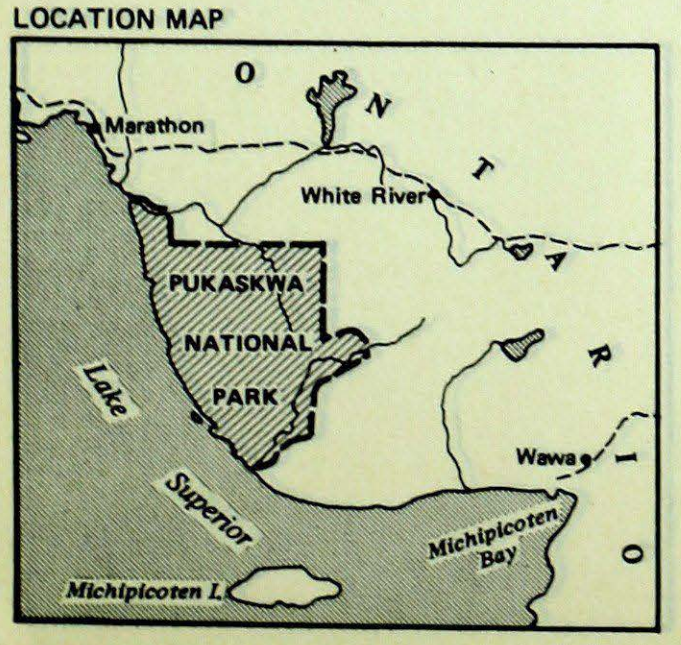
PUKASKWA
NATIONAL PARK

5 0 5
SCALE-MILES

Figure 5.

MARCH
MEAN TEMPERATURE °F

LOCATION MAP



PUKASKWA
NATIONAL PARK

SCALE-MILES 5 0 5

Figure 6.

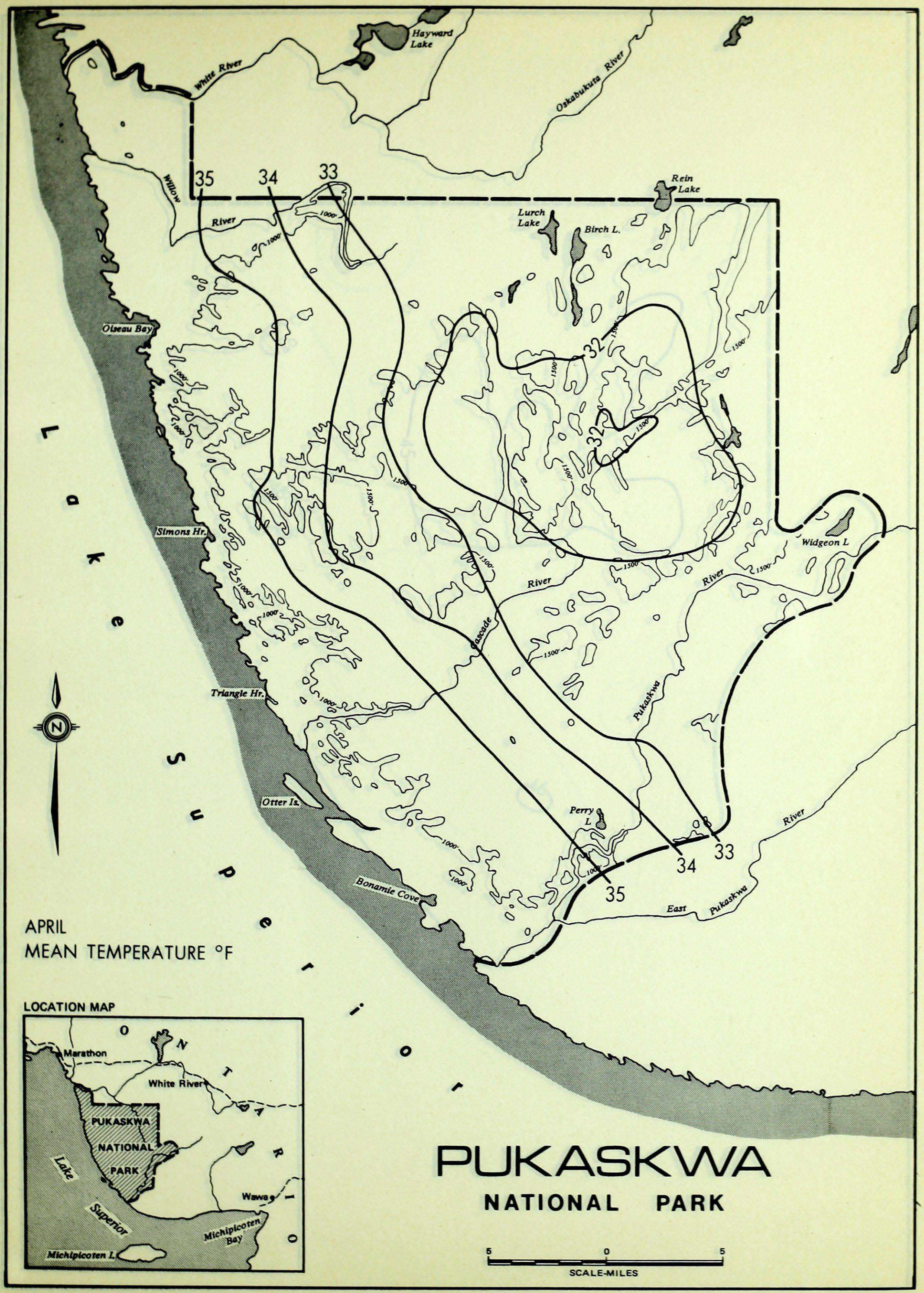

Hayward Lake
White River
Oskabukuta River
Willow River
35
34
33
32
Rein Lake
Lurch Lake
Birch L.
1000'
1500'
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
Widgeon L
Perry L
East Pukaskwa River
Lake Superior
N
APRIL
MEAN TEMPERATURE °F
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 7.

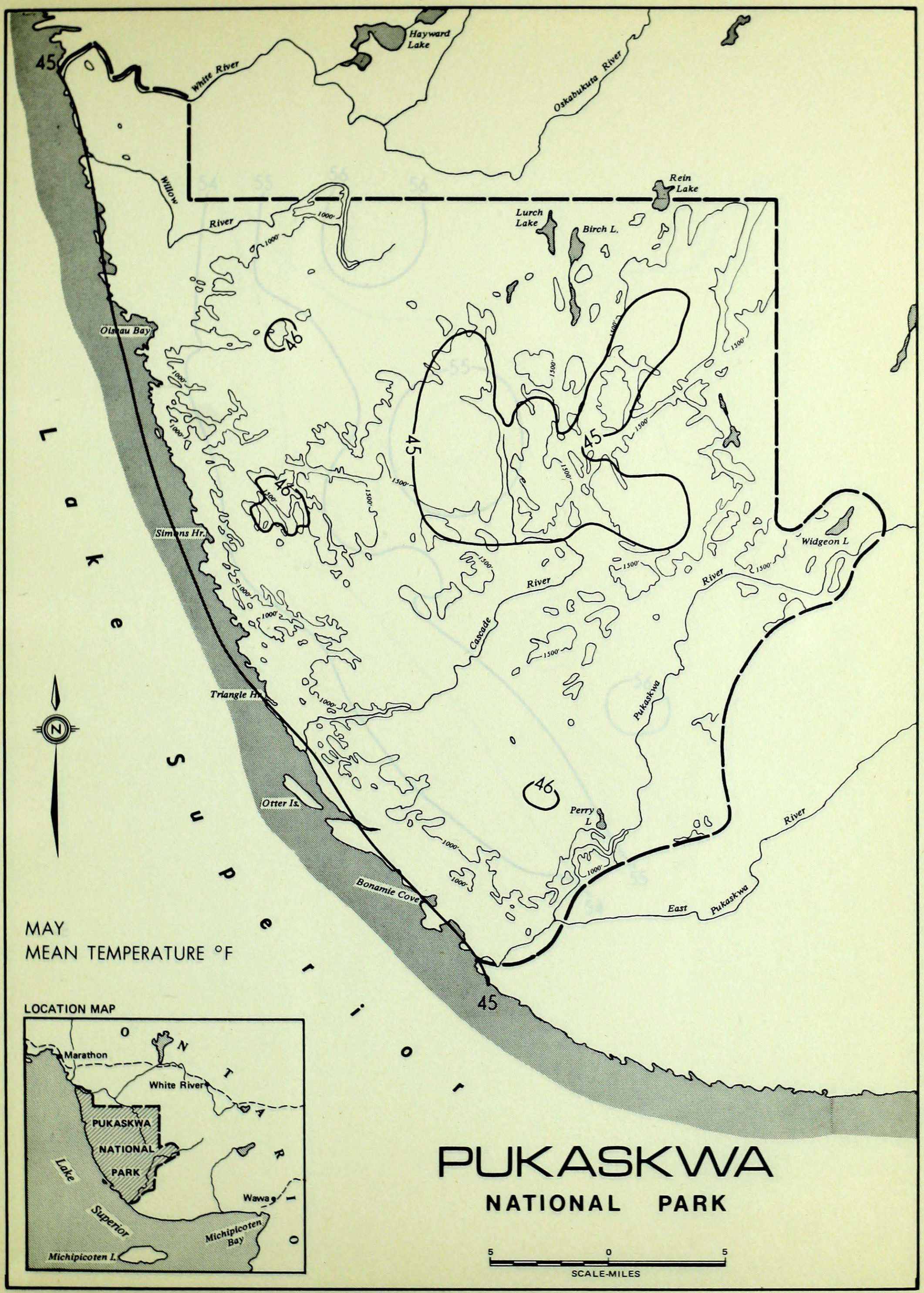

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
East Pukaskwa River
Perry L
Widgeon L
Lake Superior
1000'
1500'
45
46
MAY
MEAN TEMPERATURE °F
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 8.

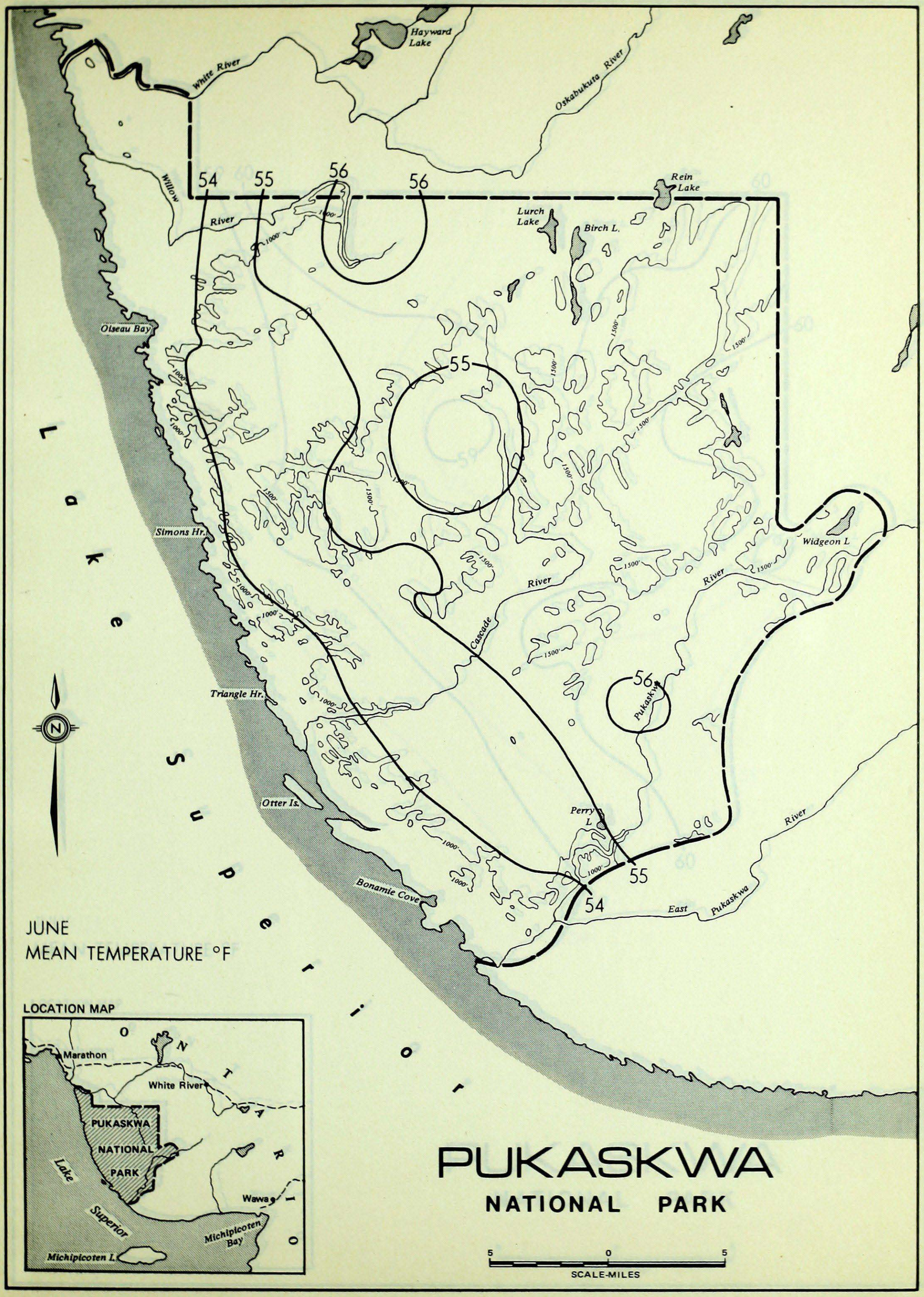

Hayward Lake
White River
Oskabukuta River
Willow River
54
55
56
56
Rein Lake
Lurch Lake
Birch L.
1000'
1500'
Oiseau Bay
55
Simons Hr.
Widgeon L
River
Cascade
Triangle Hr.
56
Pukaskwa
Otter Is.
Perry L
Bonamie Cove
55
54
East Pukaskwa
River
JUNE
MEAN TEMPERATURE °F
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 9.

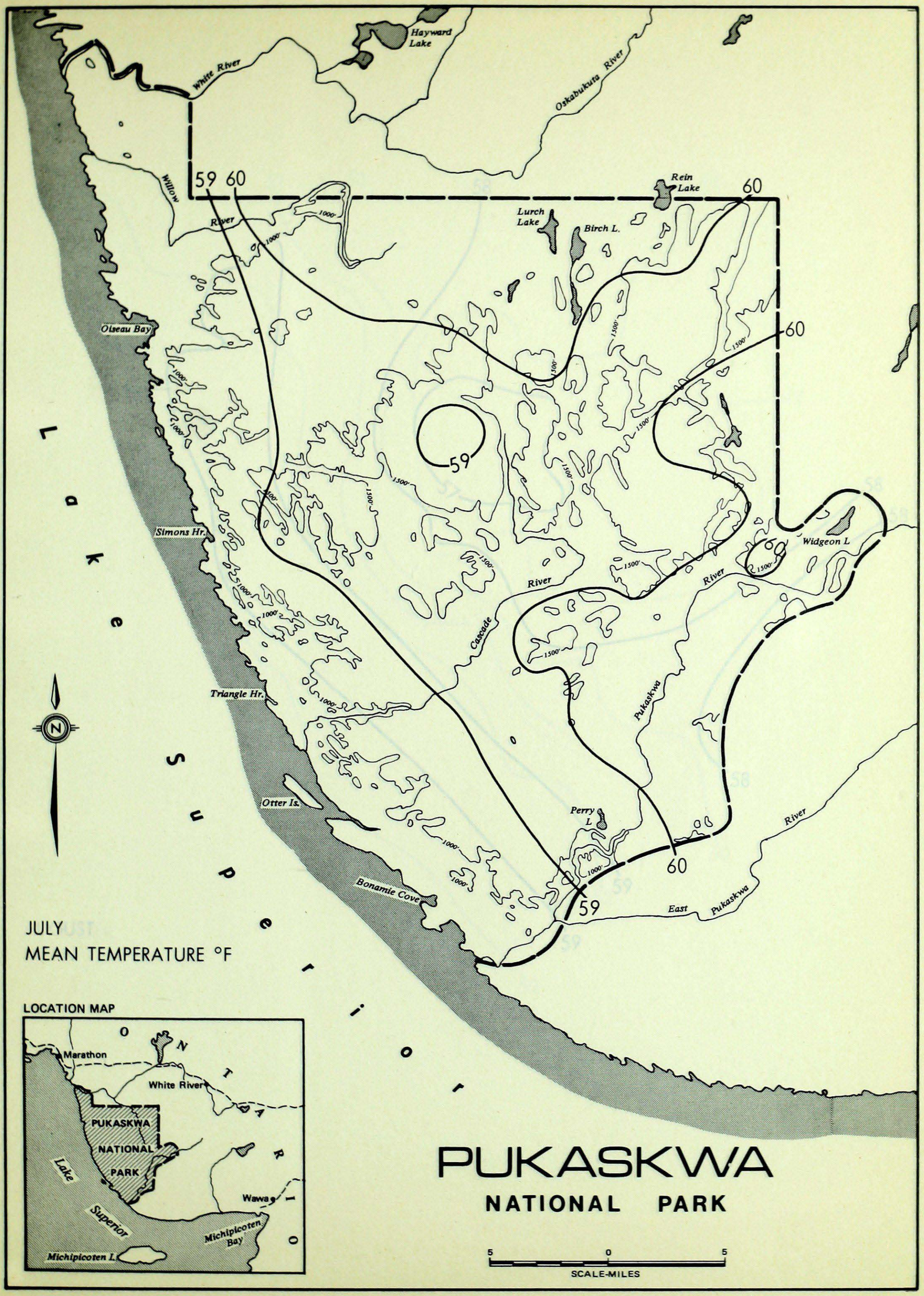
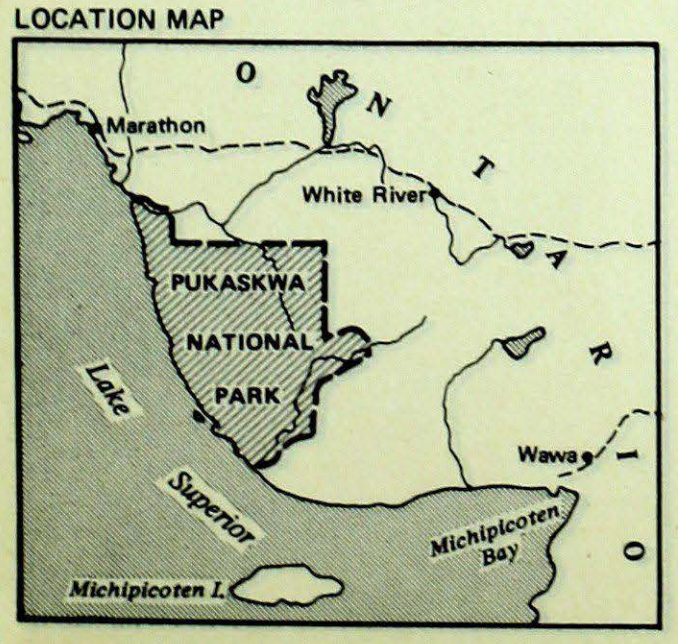

Hayward Lake
White River
Oskabukuta River
Willow River
59 60
Rein Lake
60
Lurch Lake
Birch L.
1000'
1500'
Oiseau Bay
60
59
Simons Hr.
Widgeon L
River
Cascade
Pukaskwa
Triangle Hr.
Otter Is.
Perry L
Bonamie Cove
East Pukaskwa
Lake Superior
JULY
MEAN TEMPERATURE °F
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten L.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 10.

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Perry L.
Widgeon L.
Cascade River
Pukaskwa River
East Pukaskwa River
1000'
1500'
58
57
59
Lake Superior
AUGUST
MEAN TEMPERATURE °F

LOCATION MAP



PUKASKWA
NATIONAL PARK

5 0 5
SCALE-MILES

Figure 11.

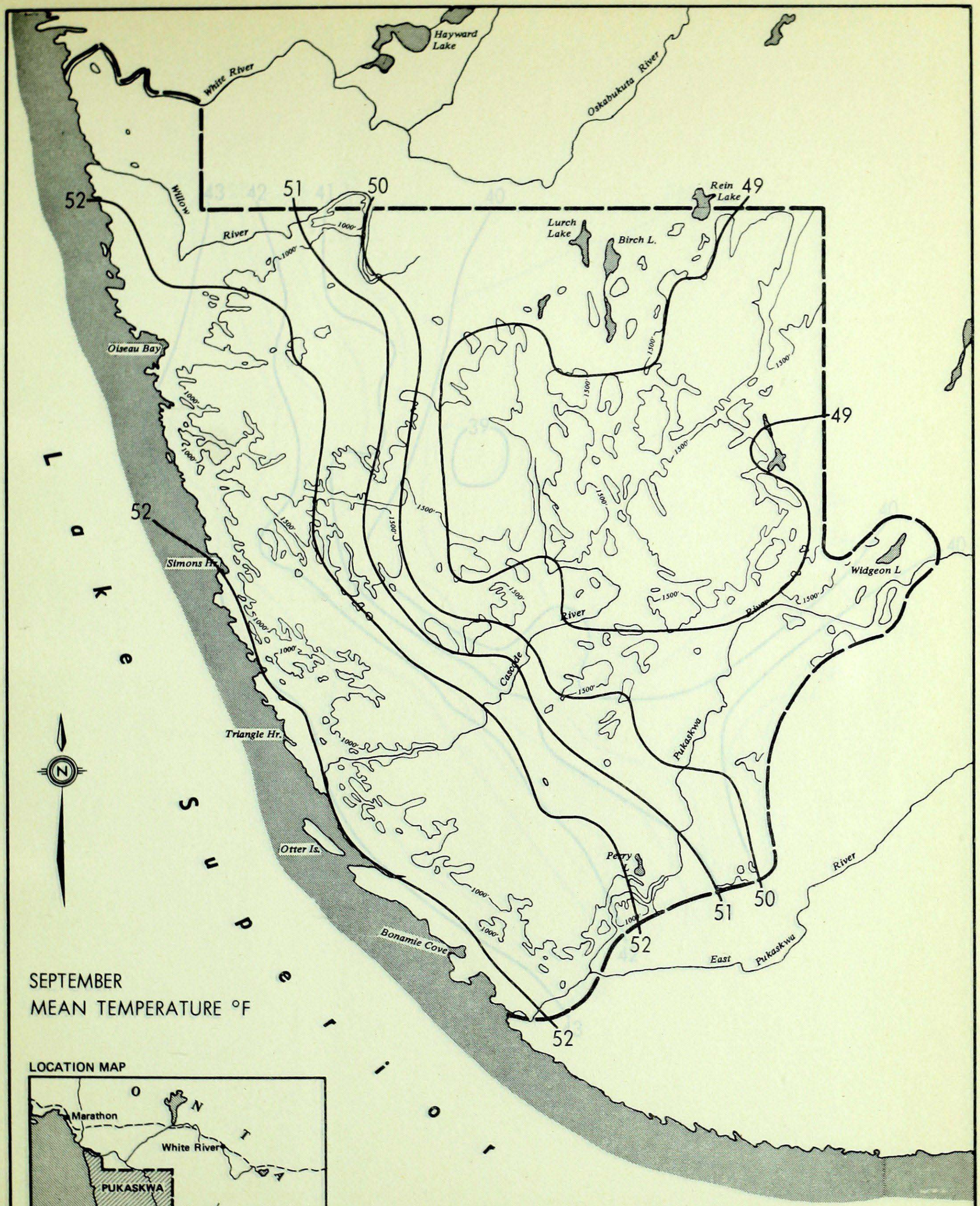

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
Widgeon L
Petry L
East Pukaskwa River
Lake Superior
52
51
50
49
1000'
1500'
SEPTEMBER
MEAN TEMPERATURE °F
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 12.

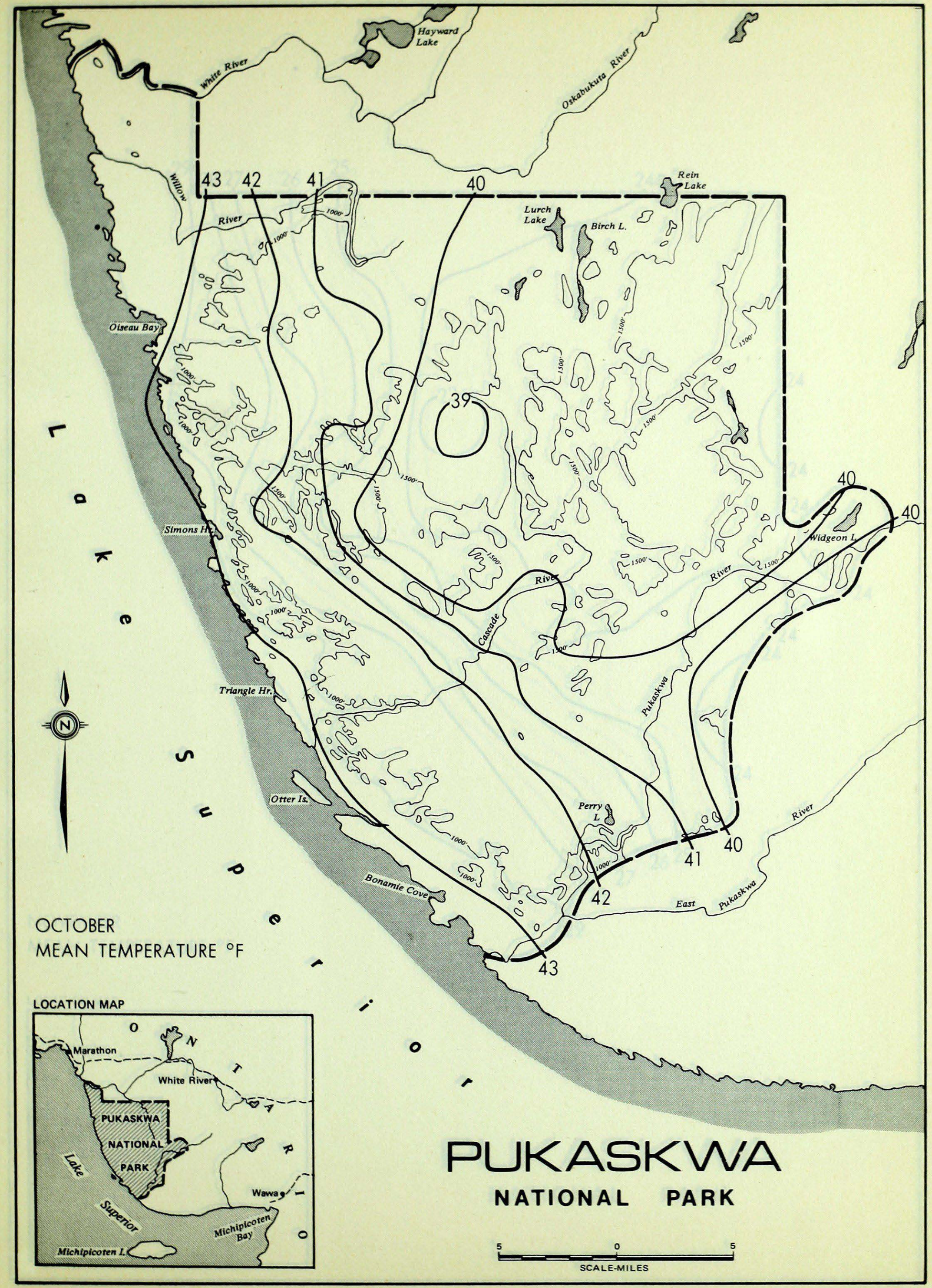

Hayward Lake
White River
Oskabukuta River
Willow River
43
42
41
40
Rein Lake
Lurch Lake
Birch L.
1000'
1500'
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Lake Superior
39
Widgeon L.
Cascade River
Pukaskwa River
Perry L.
East Pukaskwa River
N
OCTOBER
MEAN TEMPERATURE °F
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 13.

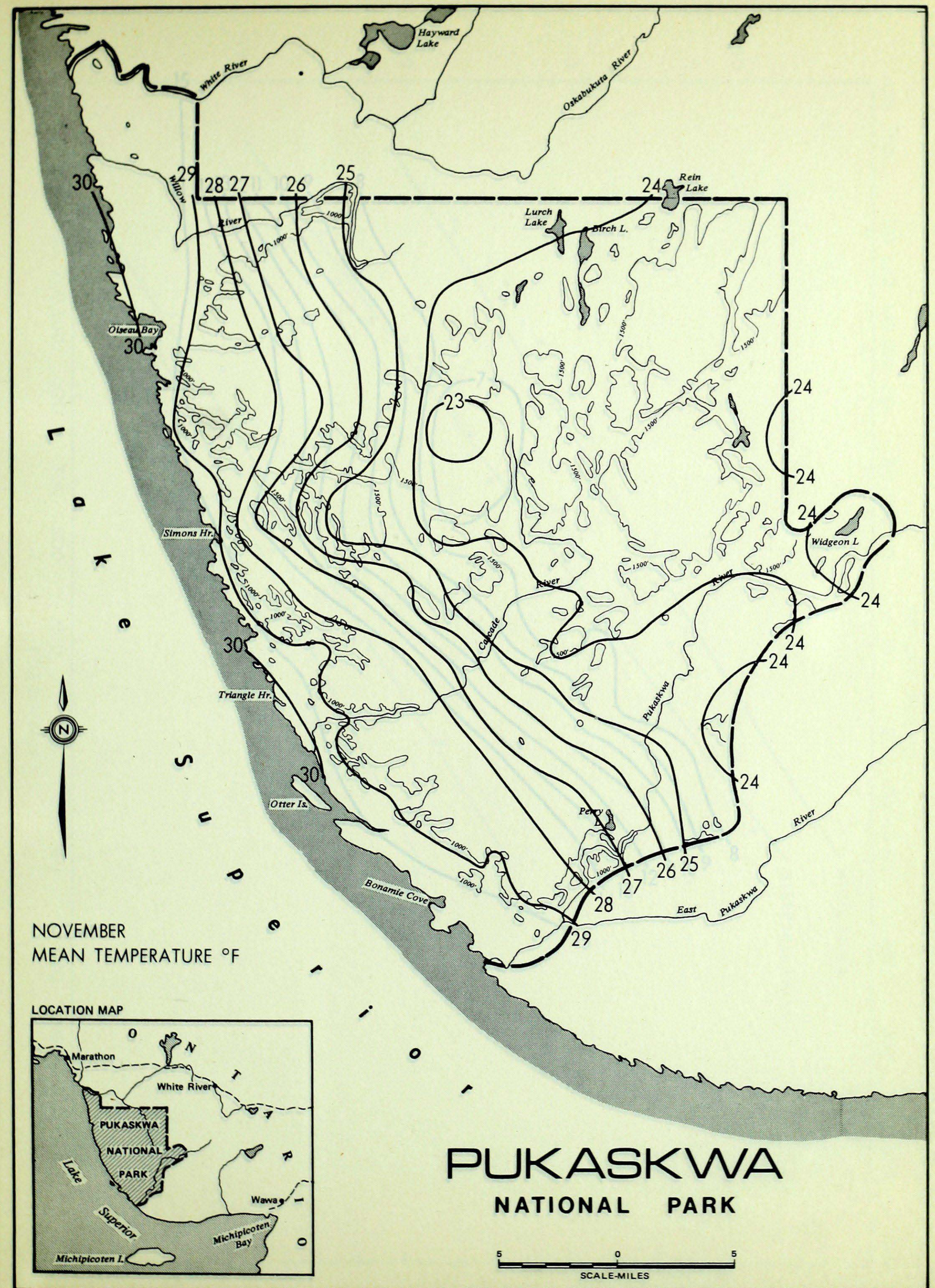

Hayward Lake
White River
Oskabukuta River
Willow River
Lurch Lake
Birch L.
Rein Lake
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
East Pukaskwa River
Widgeon L
Lake Superior
NOVEMBER
MEAN TEMPERATURE °F
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 14.

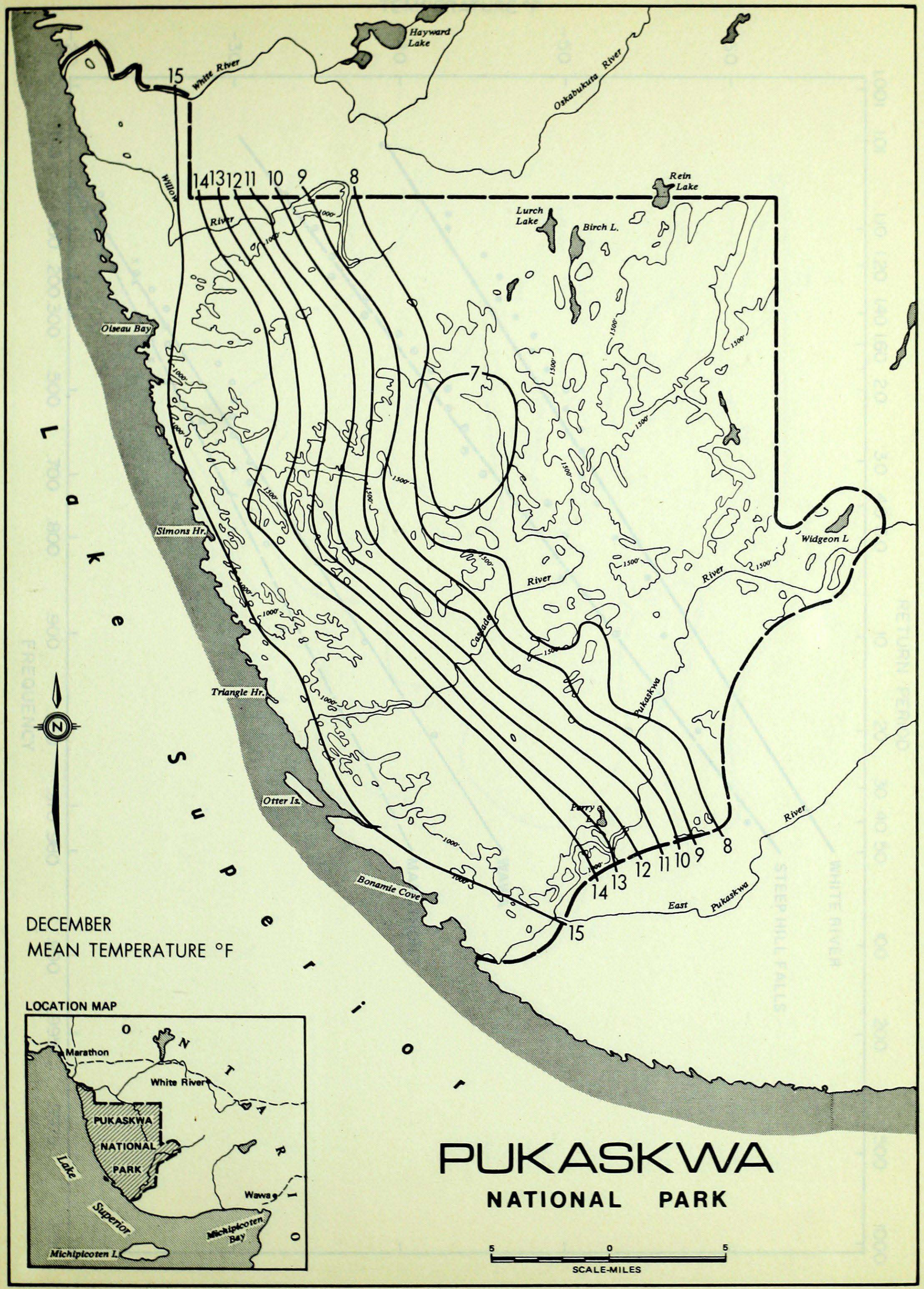

Hayward Lake
White River
Oskabukuta River
15
14 13 12 11 10 9 8
Willow River
Rein Lake
Lurch Lake
Birch L.
Otter Is.
7
Simons Hr.
Widgeon L
River
Cascade
Pukaskwa
Triangle Hr.
Bonamie Cove
East Pukaskwa
14 13 12 11 10 9 8
15
Lake Superior
1000'
1500'
N
DECEMBER
MEAN TEMPERATURE °F
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA
NATIONAL
PARK
Lake
Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 15.

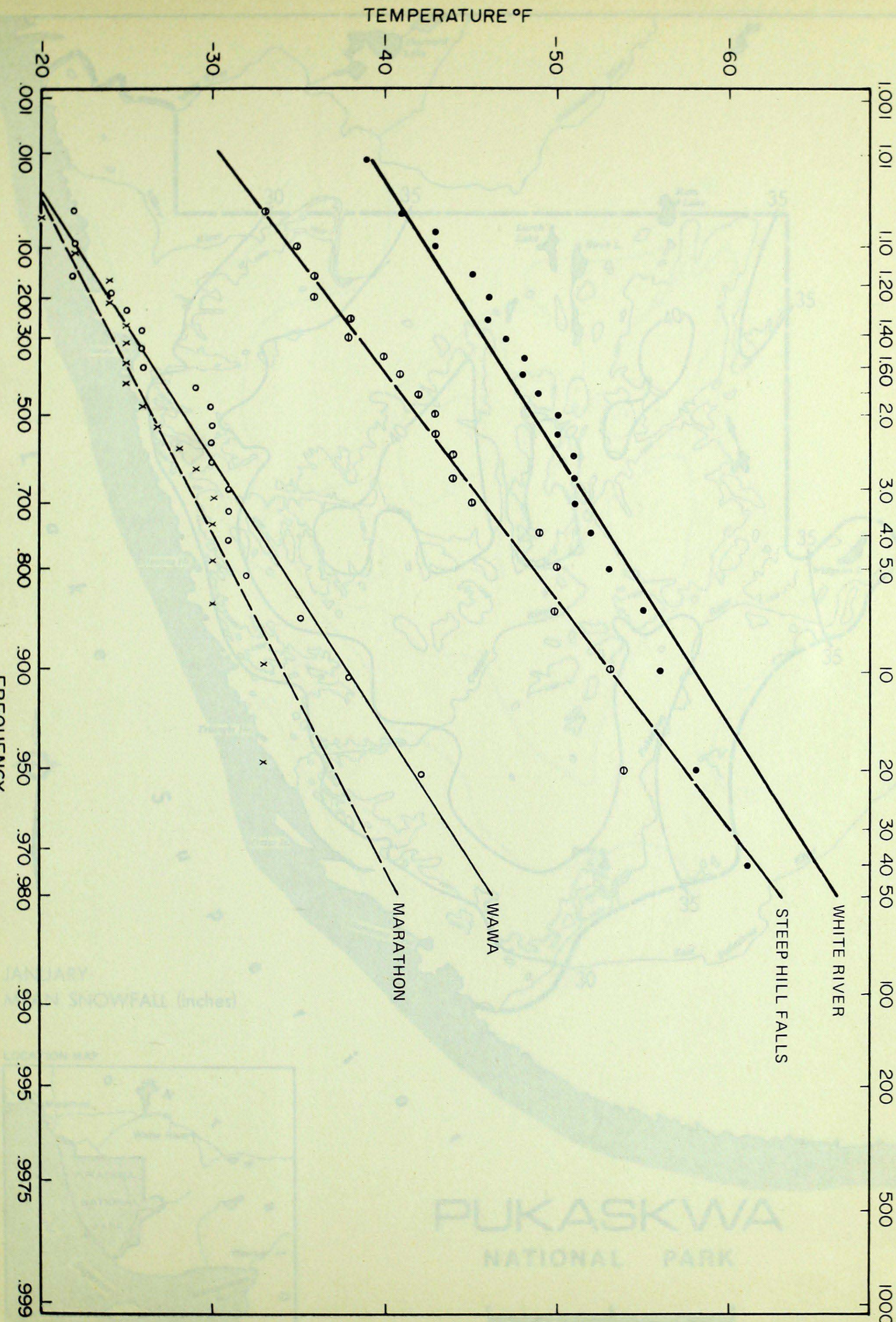


Figure 16. Return Period of Extreme Minimum Temperatures.

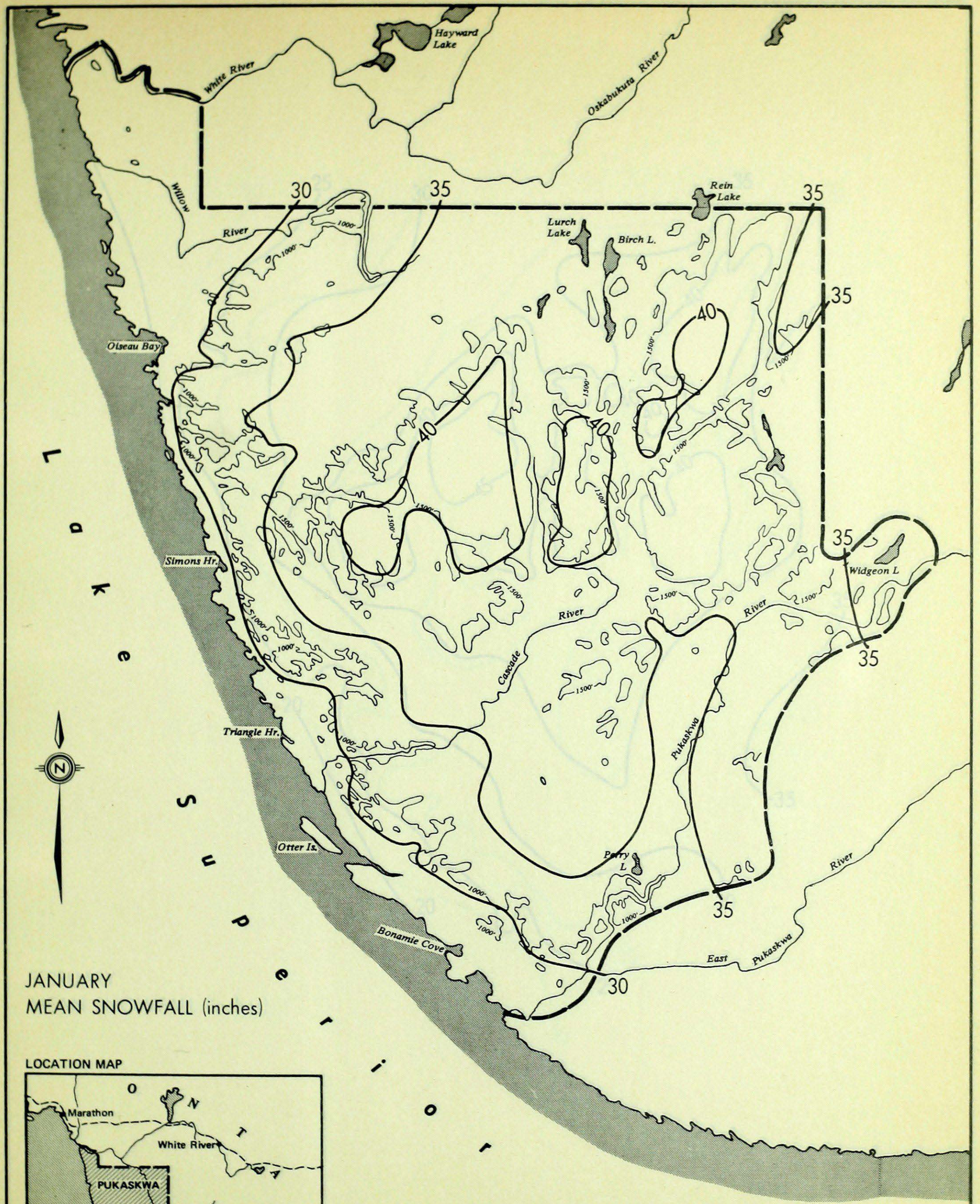

Hayward Lake
White River
Oskabukuta River
Rein Lake
Lurch Lake
Birch L.
Willow River
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
Perry L
Widgeon L
East Pukaskwa River
30
35
40
1000'
1500'
Lake Superior
JANUARY
MEAN SNOWFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 17.

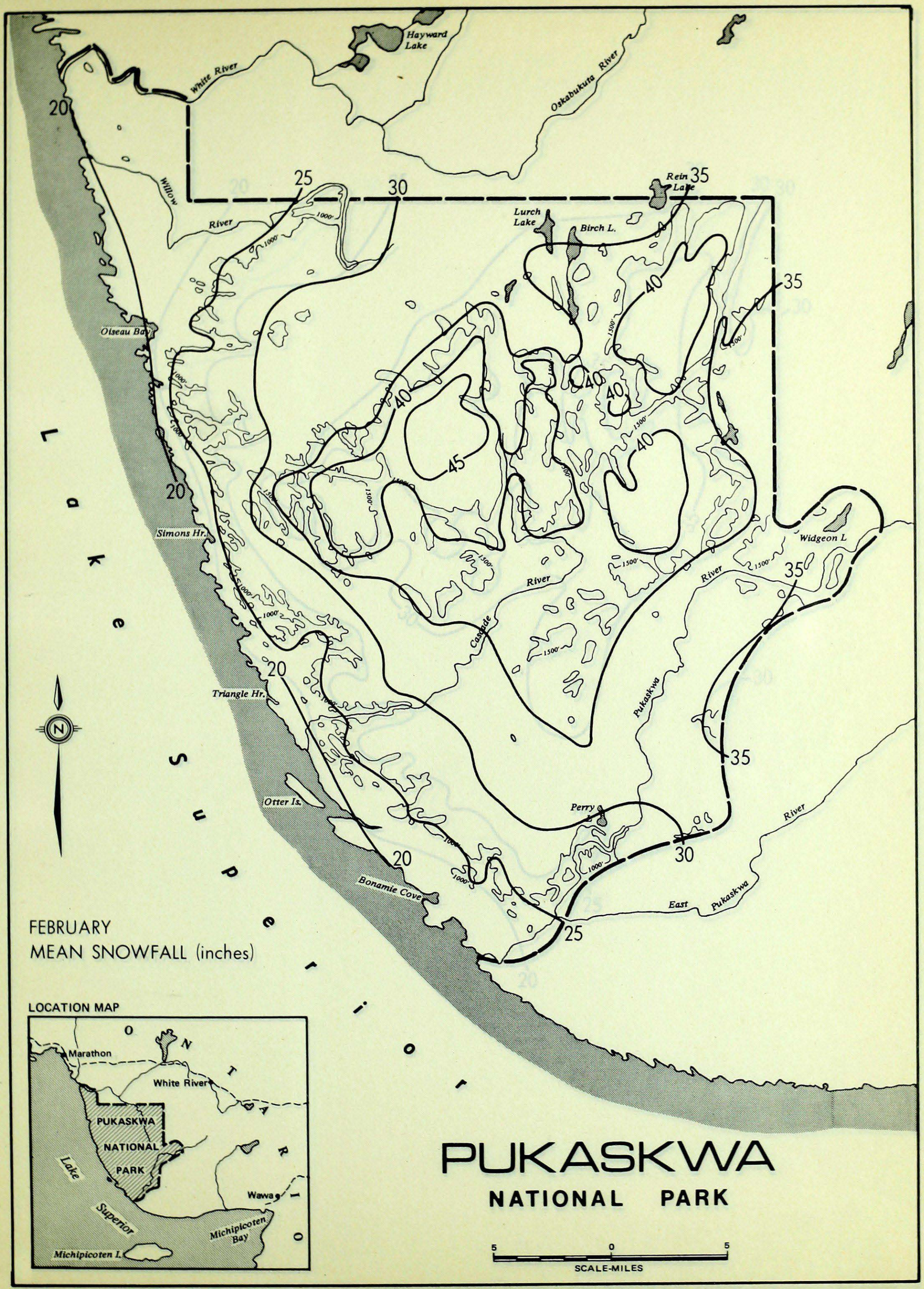

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
East Pukaskwa River
Perry
Widgeon L
Lake Superior
20
25
30
35
40
45
1000'
1500'
FEBRUARY
MEAN SNOWFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 18.

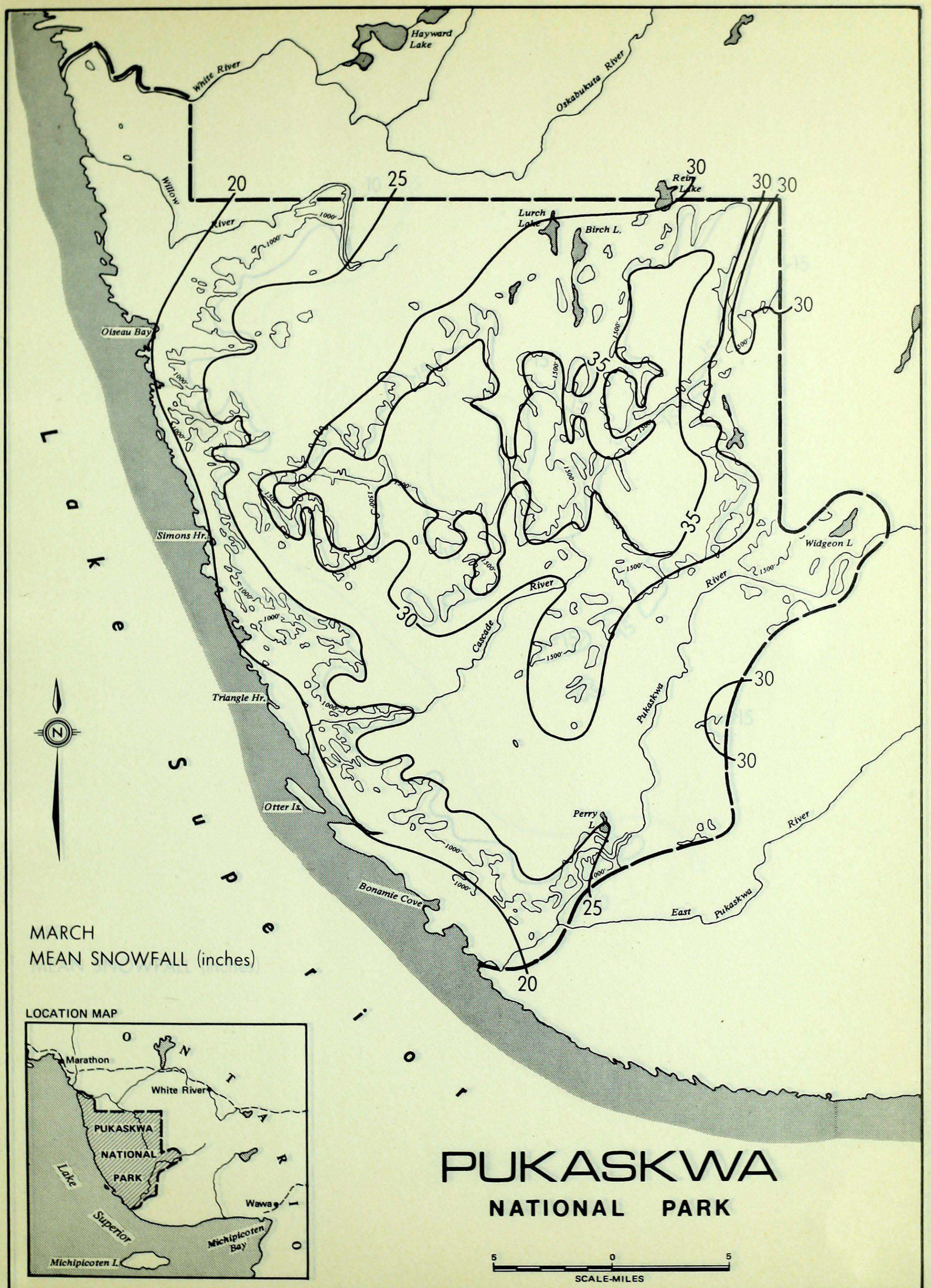

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
East Pukaskwa River
Widgeon L
Perry L
Lake Superior
20
25
30
35
1000'
1500'
N
MARCH
MEAN SNOWFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 19.

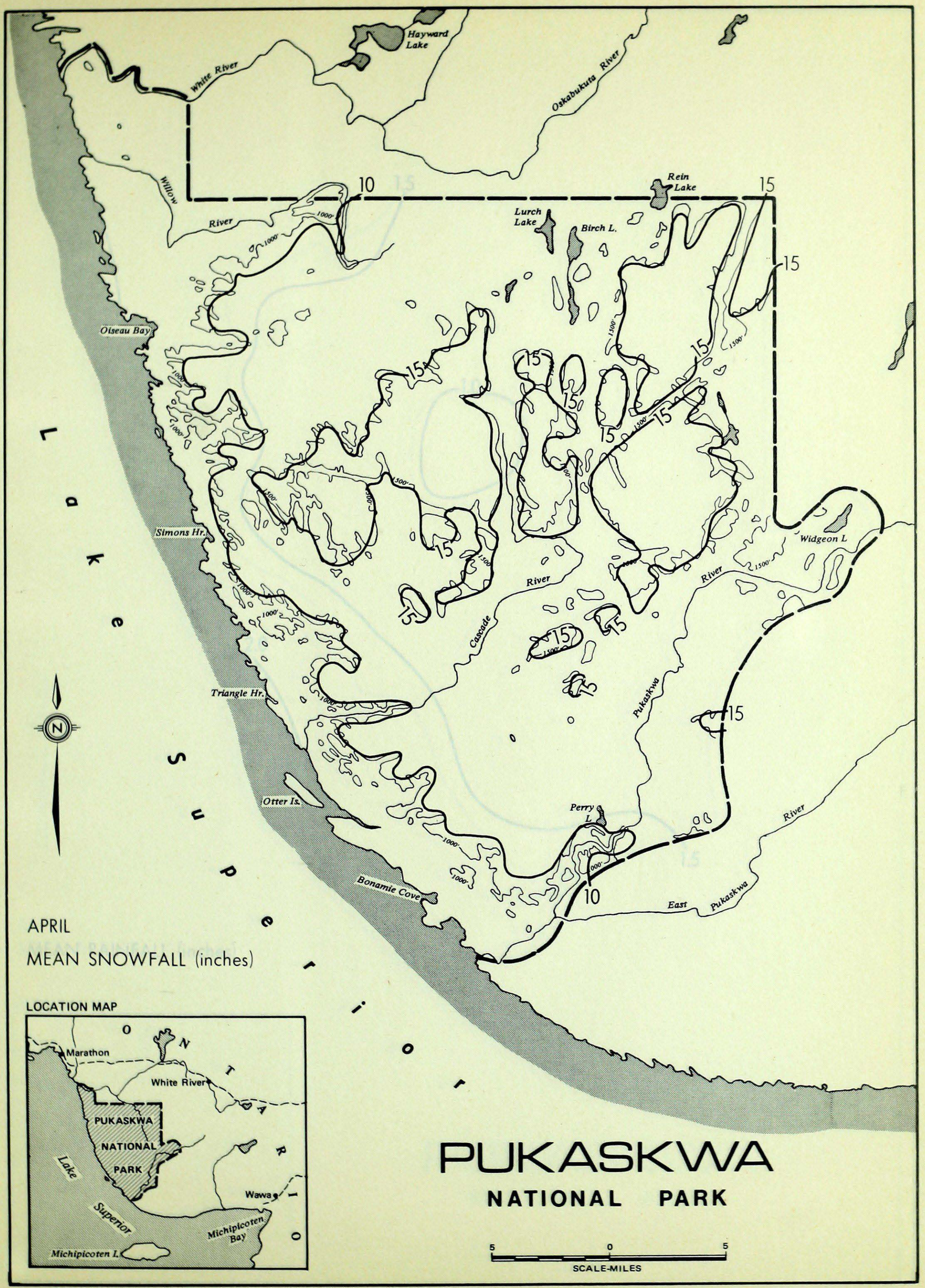
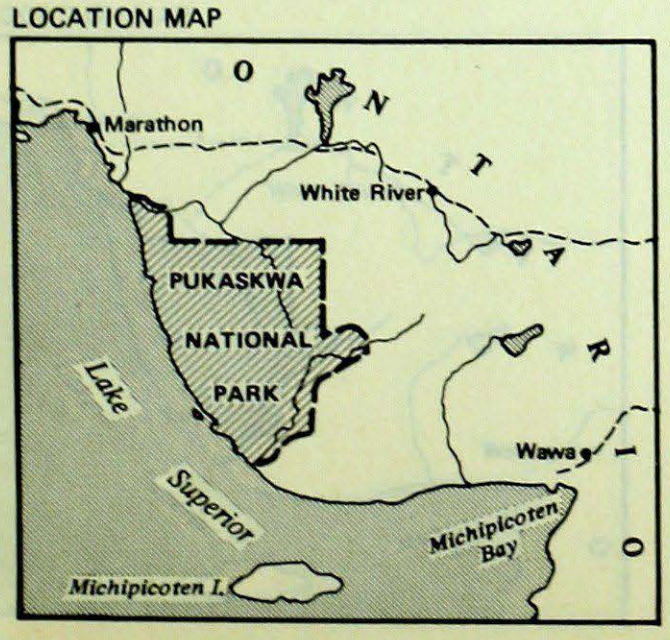

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
East Pukaskwa River
Perry L
Widgeon L
Lake Superior
10
15
1000'
1500'
APRIL
MEAN SNOWFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten L.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 20.

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Perry
Bonamie Cove
Widgeon L
Cascade River
Pukaskwa River
East Pukaskwa River
Lake Superior
1.5
2.0
1.0
1000'
1500'

APRIL
MEAN RAINFALL (inches)

LOCATION MAP



PUKASKWA
NATIONAL PARK

5 0 5
SCALE-MILES

Figure 21.

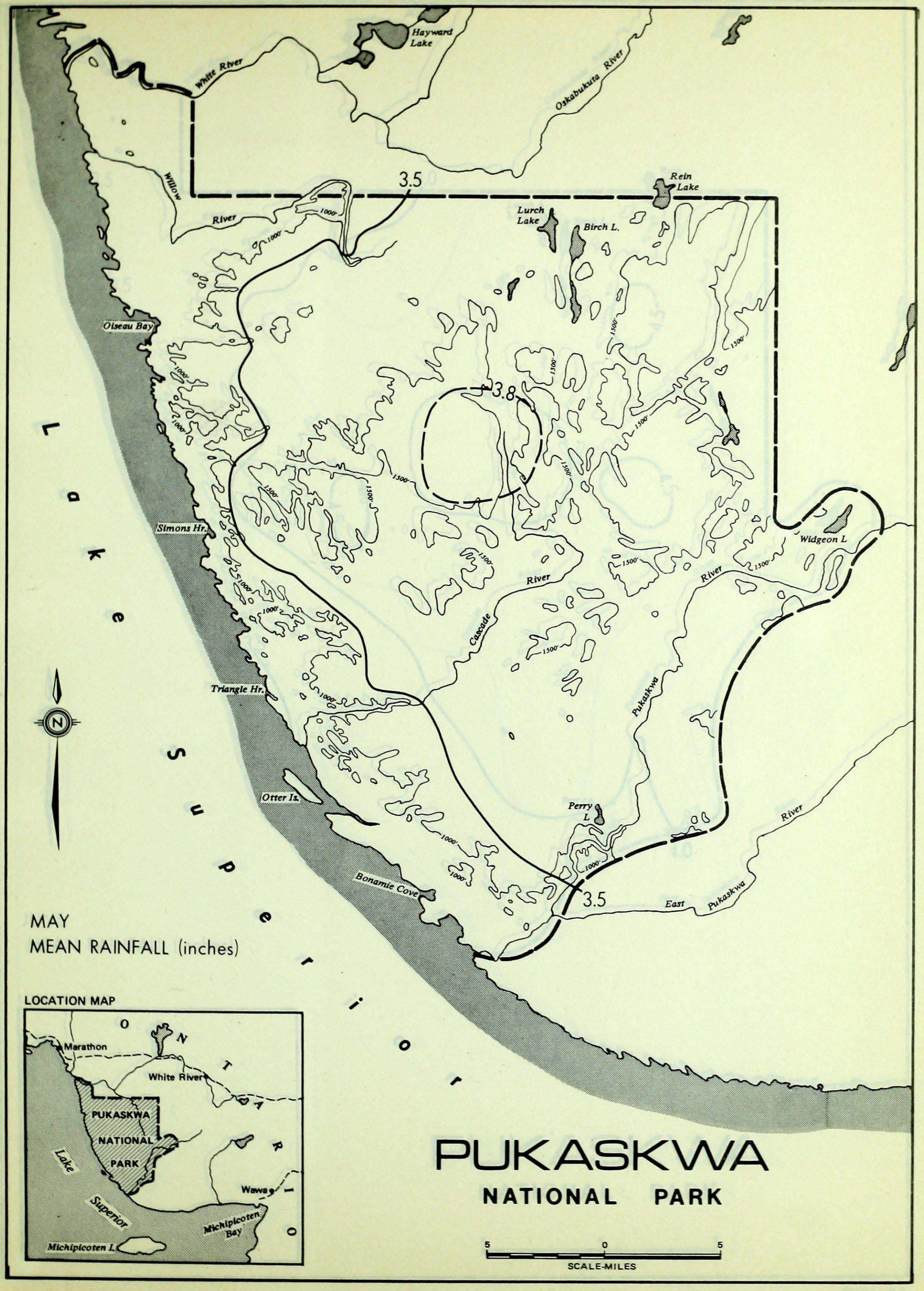

Hayward Lake
White River
Oskabukuta River
Willow River
3.5
Rein Lake
Lurch Lake
Birch L.
1000'
1500'
Oiseau Bay
3.8
Simons Hr.
Widgeon L
River
Cascade
Pukaskwa
Triangle Hr.
Otter Is.
Perry L
Bonamie Cove
East Pukaskwa
Lake Superior
MAY
MEAN RAINFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA
NATIONAL
PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 22.

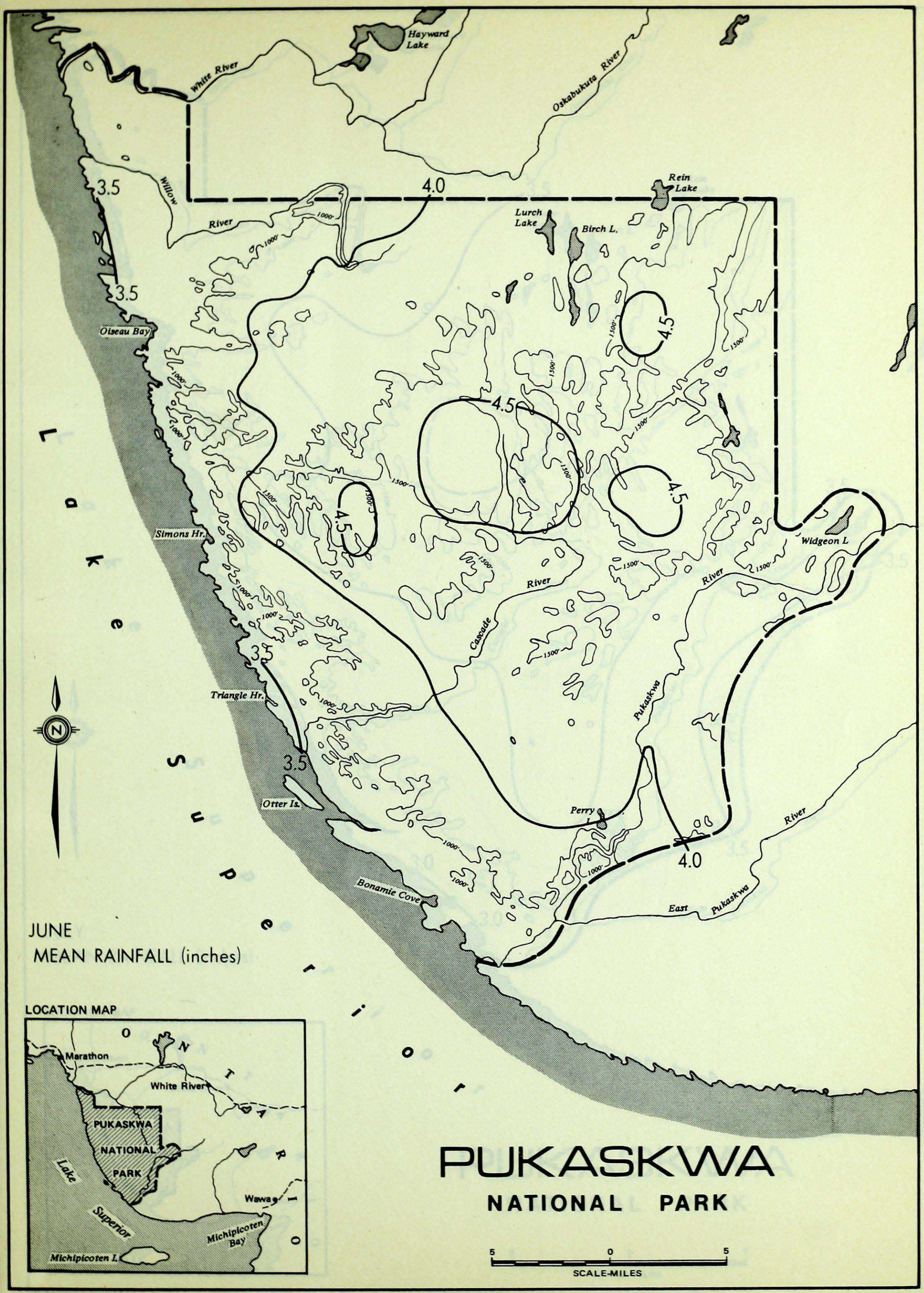

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Perry I.
Widgeon L
Cascade River
Pukaskwa River
East Pukaskwa River
Lake Superior
3.5
4.0
4.5
1000'
1500'
N
JUNE
MEAN RAINFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 23.

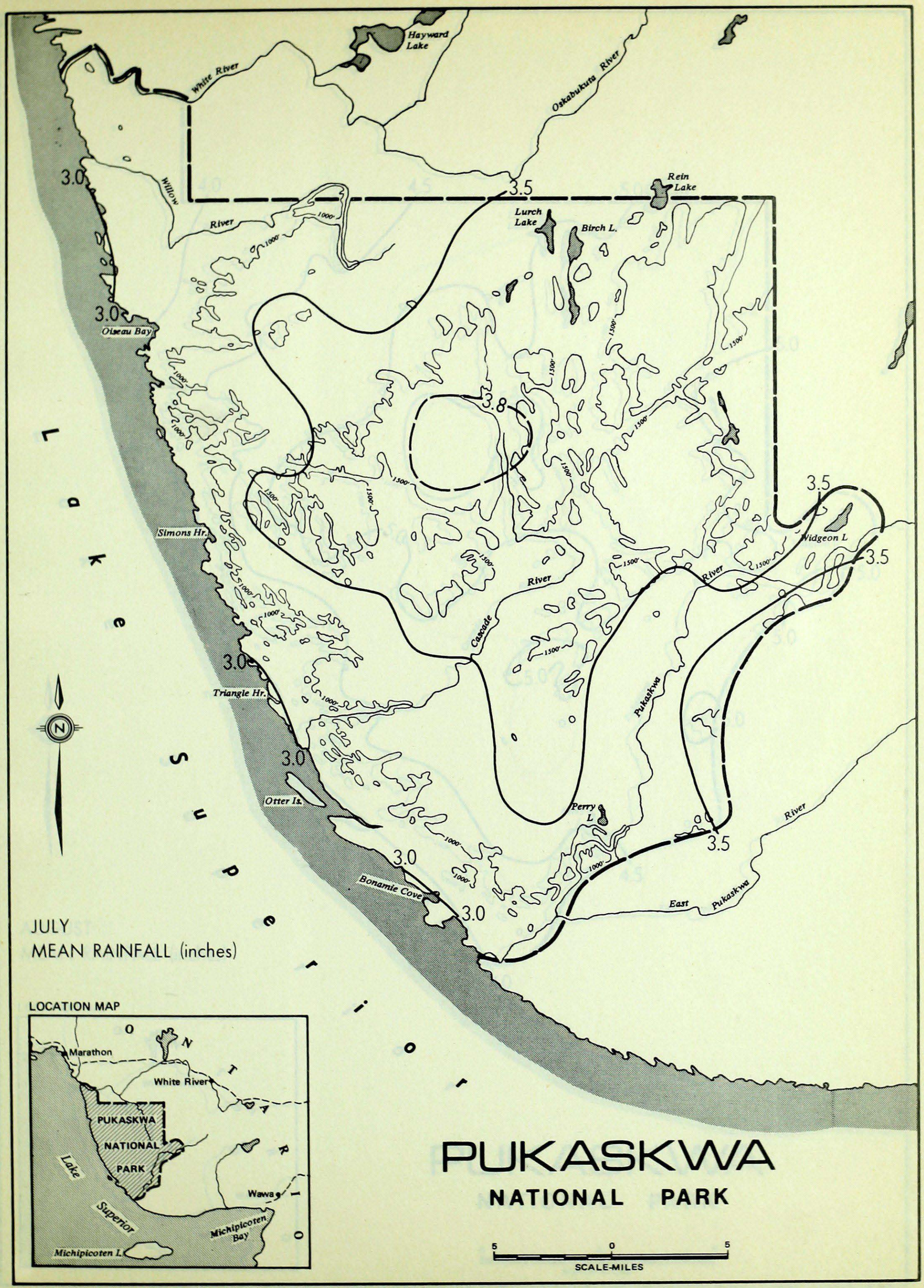

Hayward Lake
White River
Oskabukuta River
Rein Lake
Lurch Lake
Birch L.
Willow River
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
Perry L
East Pukaskwa River
Widgeon L
Lake Superior
3.0
3.5
3.8
1000'
1500'
JULY
MEAN RAINFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 24.

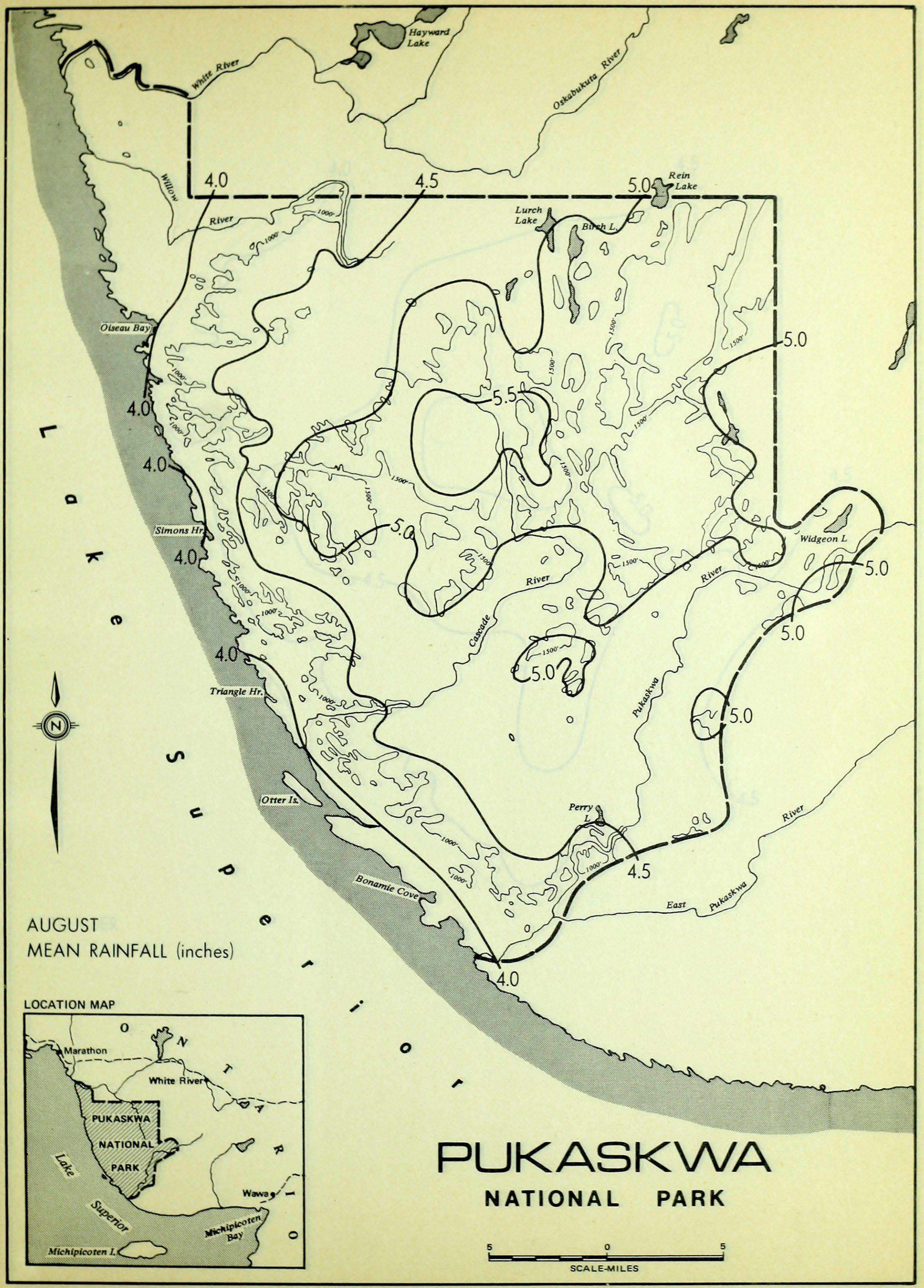

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
Widgeon L
Perry L
East Pukaskwa River
Lake Superior
4.0
4.5
5.0
5.5
1000'
1500'
N
AUGUST
MEAN RAINFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 25.

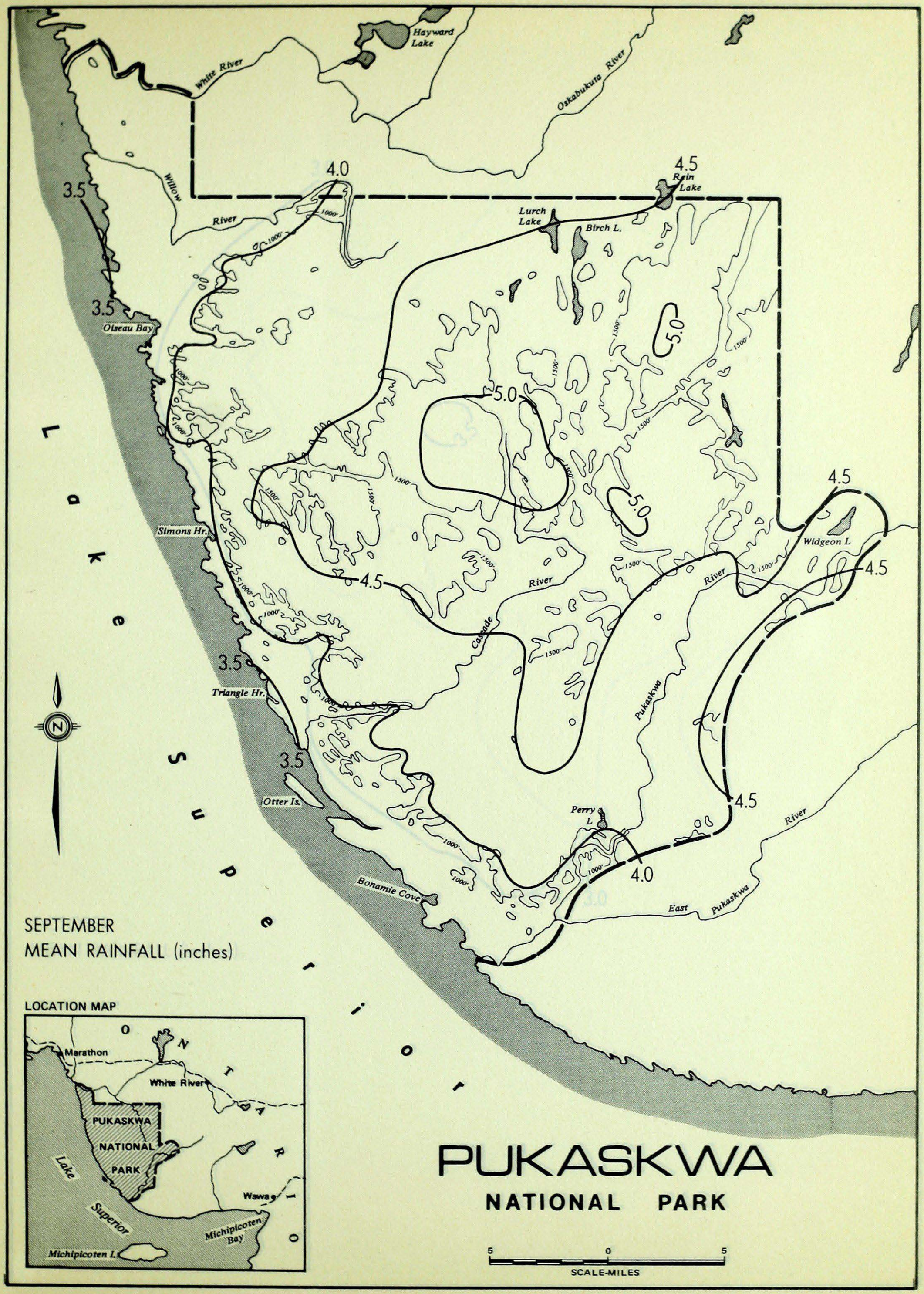

Hayward Lake
White River
Oskabukuta River
Willow River
Rain Lake
Lurch Lake
Birch L.
Olseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
Widgeon L
Perry L
East Pukaskwa River
Lake Superior
4.0
4.5
5.0
3.5
1000'
1500'
N
SEPTEMBER
MEAN RAINFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 26.

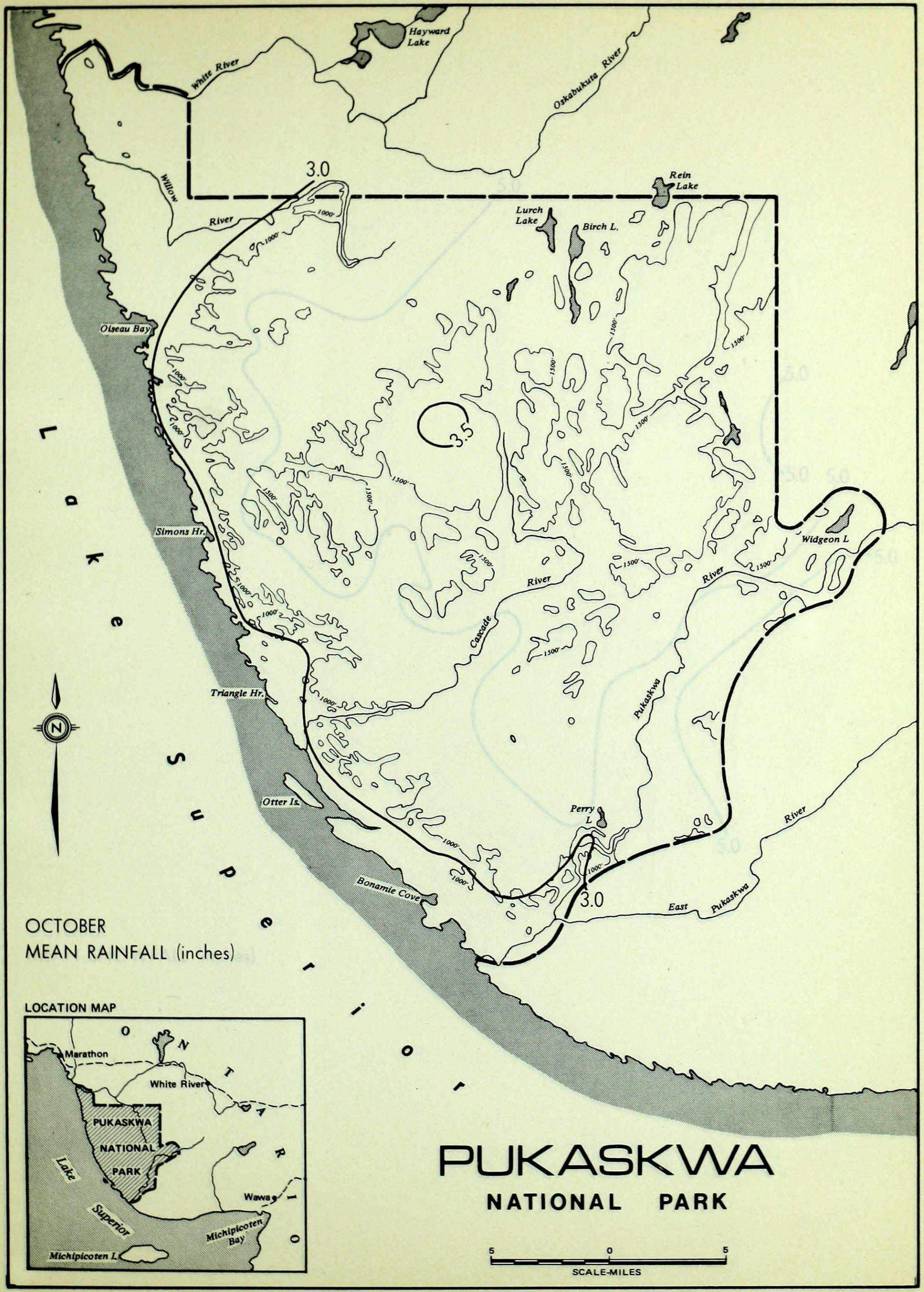

Hayward Lake
White River
Oskabukuta River
Willow River
3.0
Rein Lake
Lurch Lake
Birch L.
1000'
1500'
Olseau Bay
3.5
Simons Hr.
Widgeon L
Cascade River
Pukaskwa River
Triangle Hr.
Otter Is.
Perry L
Bonamie Cove
East Pukaskwa River
Lake Superior
OCTOBER
MEAN RAINFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 27.

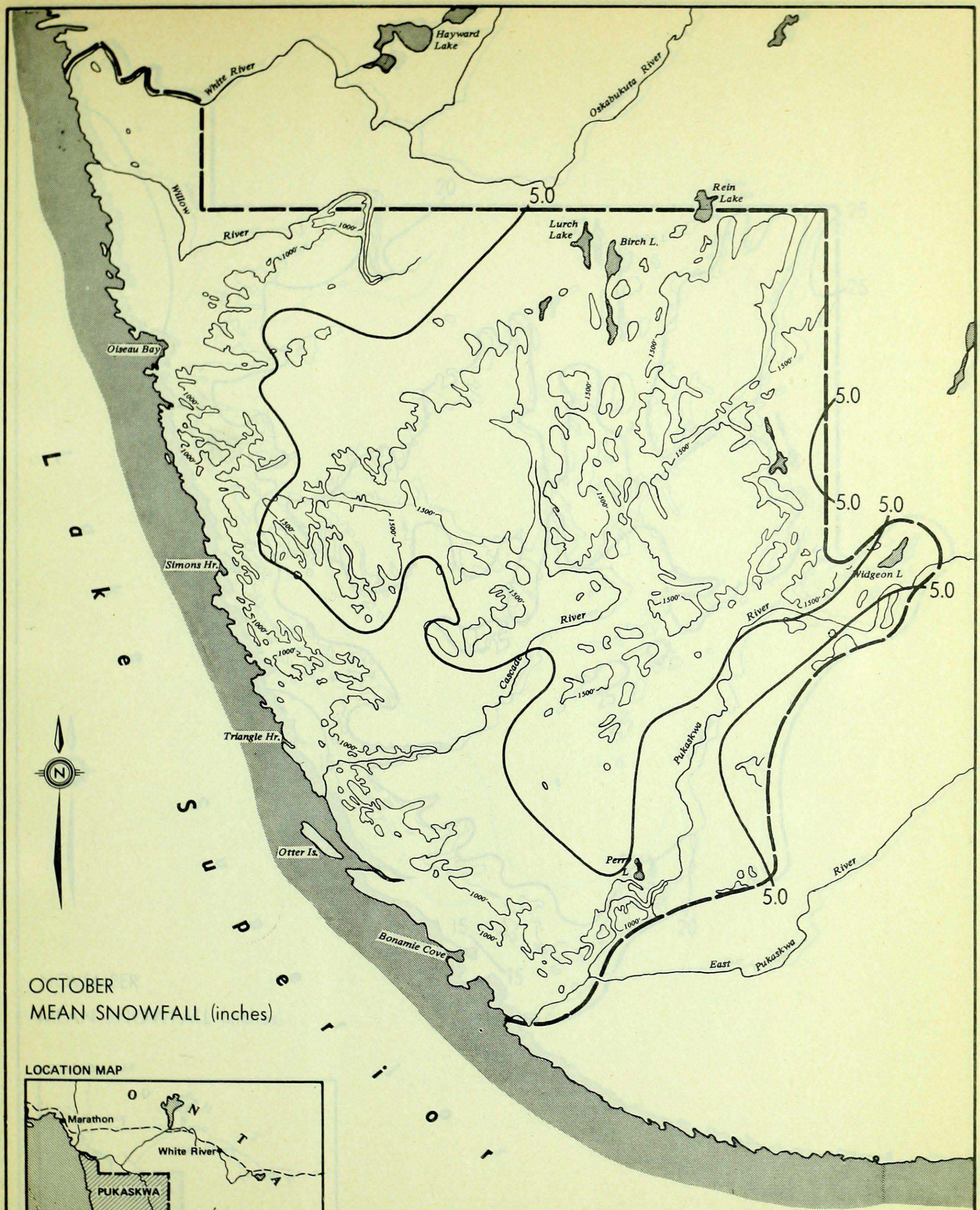

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
East Pukaskwa River
Widgeon L
Perry L
Lake Superior
1000'
1500'
5.0
OCTOBER
MEAN SNOWFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA
NATIONAL
PARK
Lake
Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 28.

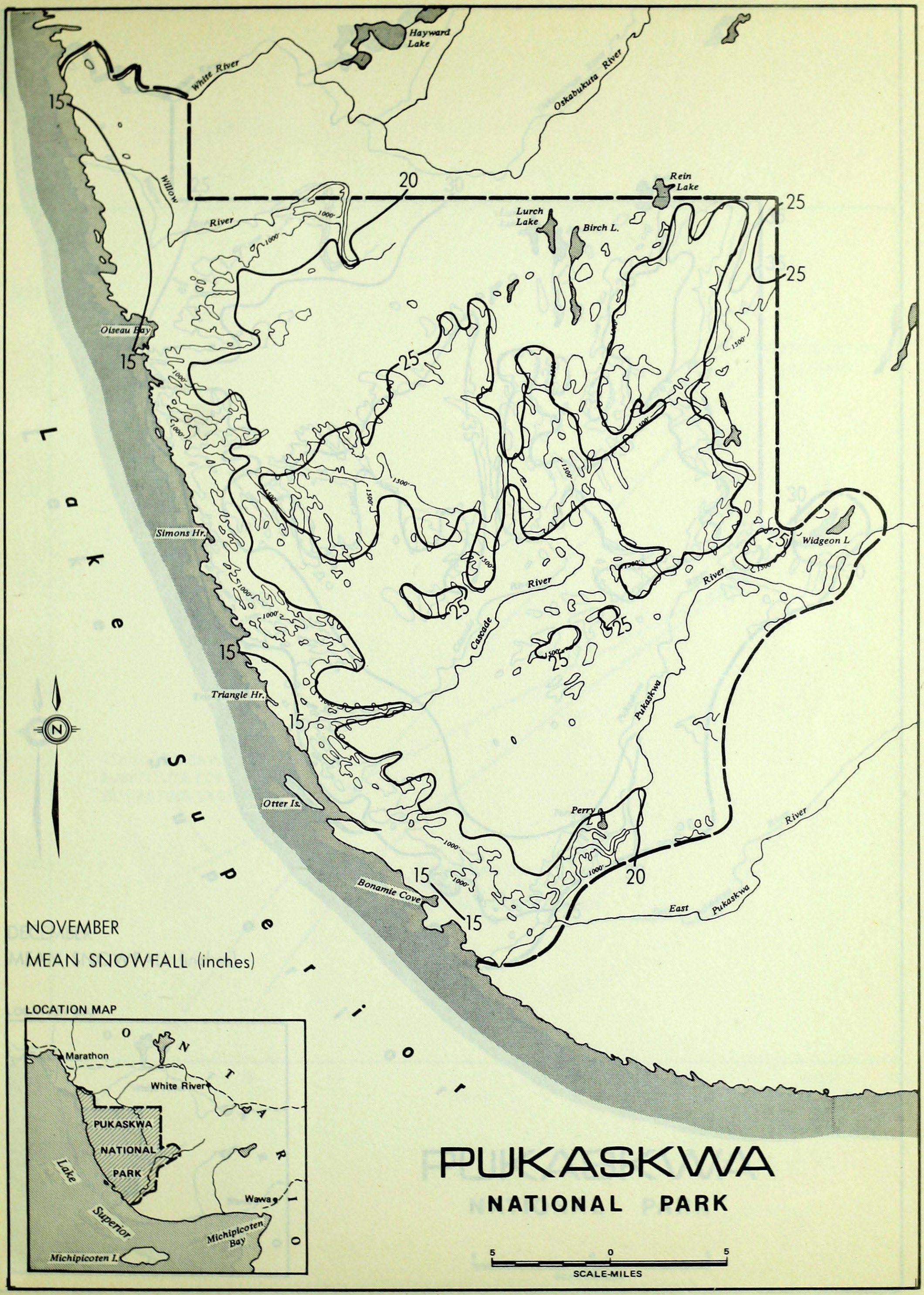

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
East Pukaskwa River
Widgeon L
Perry L
Lake Superior
15
20
25
1000'
1500'
NOVEMBER
MEAN SNOWFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 29.

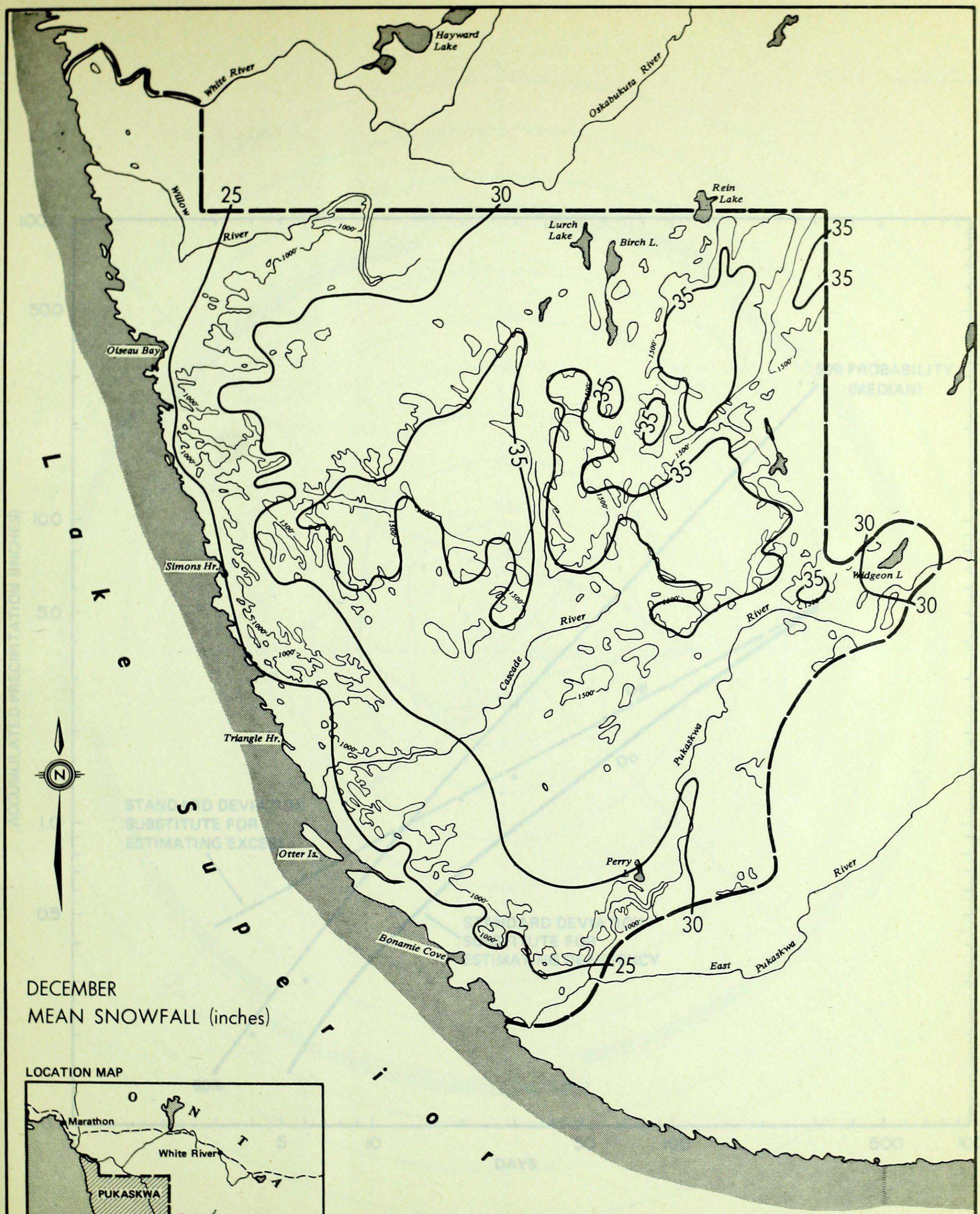

Hayward Lake
White River
Oskabukuta River
Rein Lake
Lurch Lake
Birch L.
Willow River
25
30
35
1000'
1500'
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Perry
Cascade River
Pukaskwa River
East Pukaskwa River
Widgeon L
Lake Superior
N
DECEMBER
MEAN SNOWFALL (inches)
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 30.

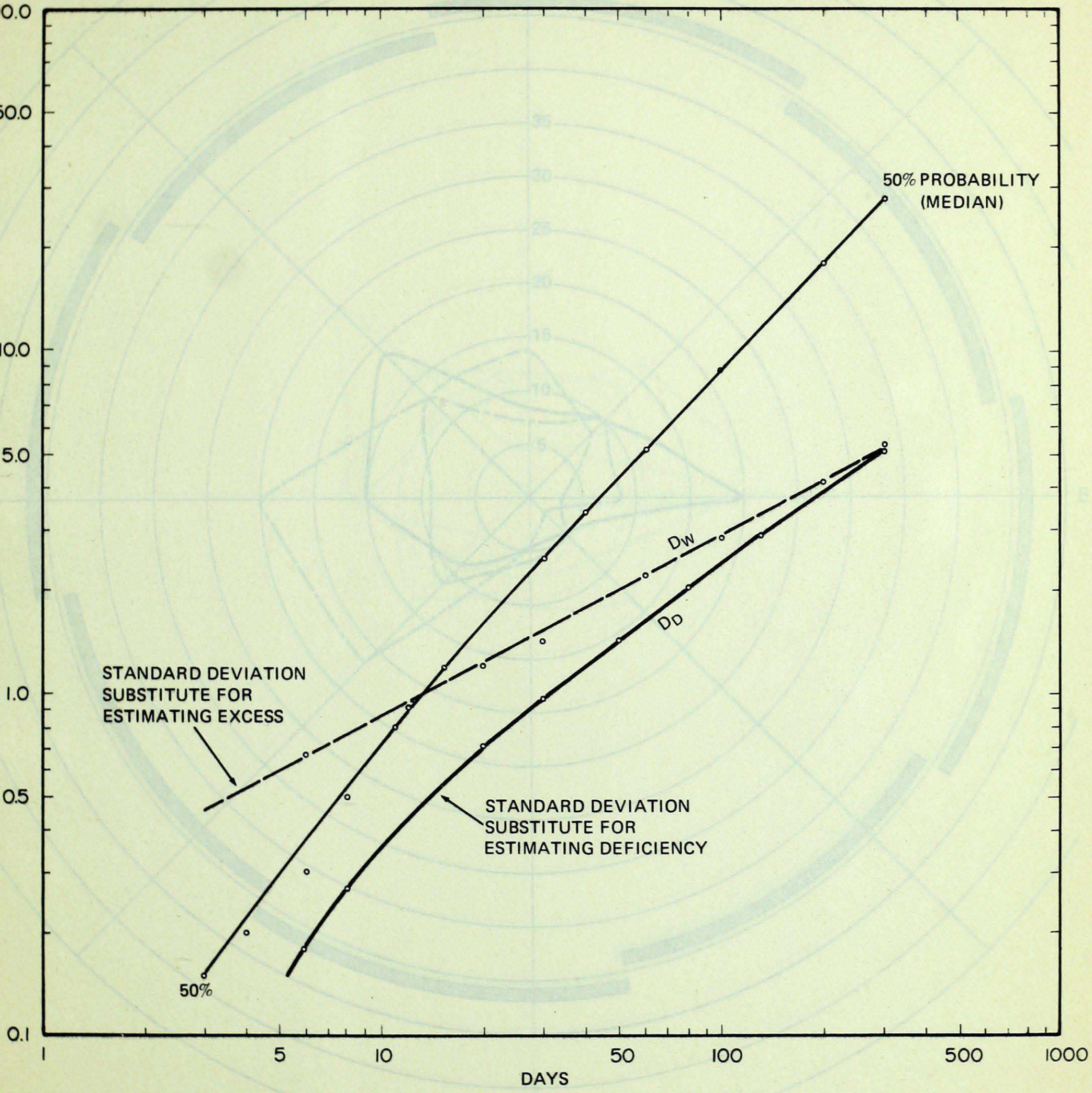
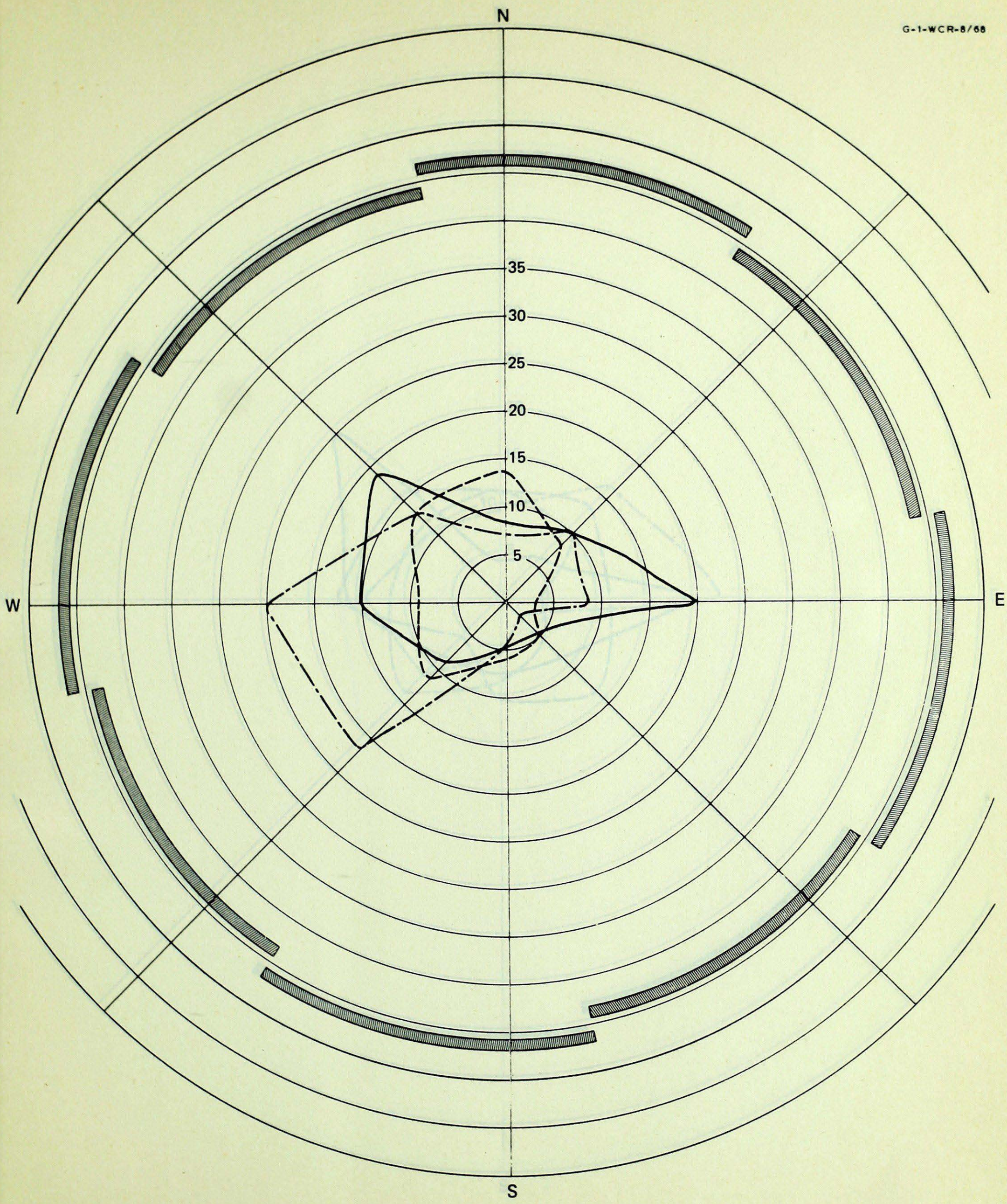


Figure 31. Estimation of Climatological Drought or Precipitation Excess.

G-1-WCR-8/68

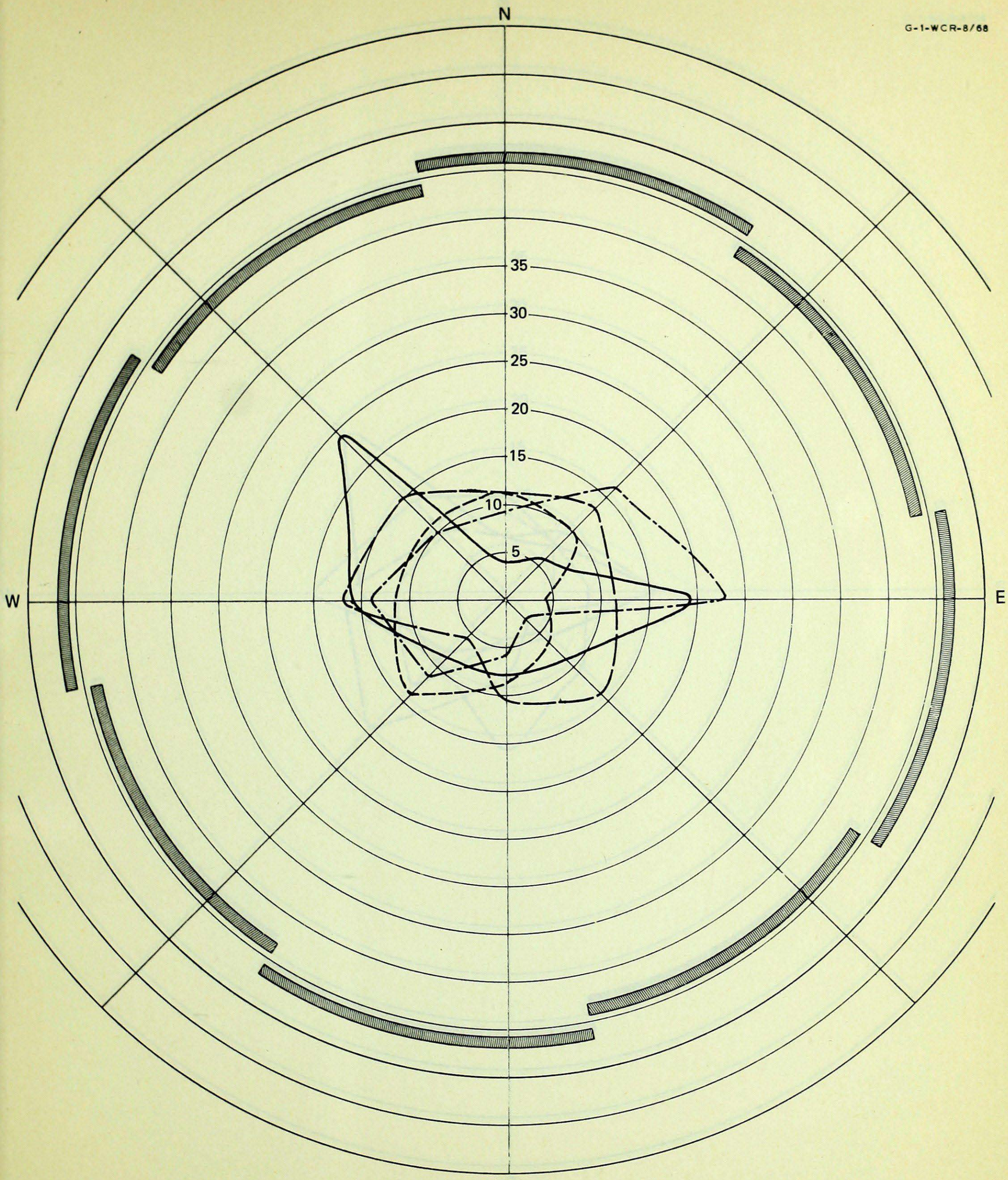


SAULT STE. MARIE A —— CALM 9%
WHITE RIVER – – – – 31%
THUNDER BAY —·— 8%

FEBRUARY DIRECTION

Figure 32. 10-Metre Wind Field.

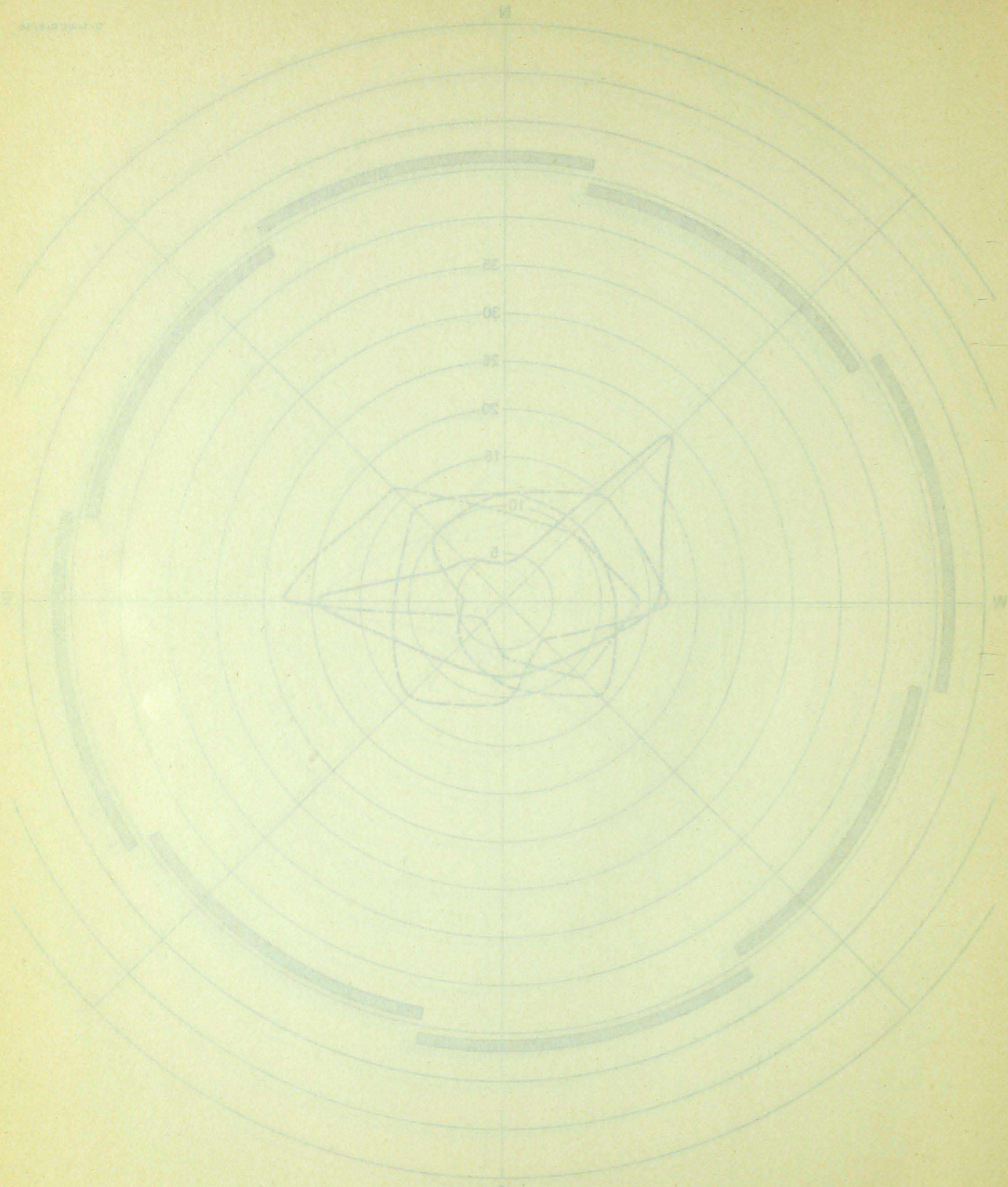
G-1-WCR-8/68



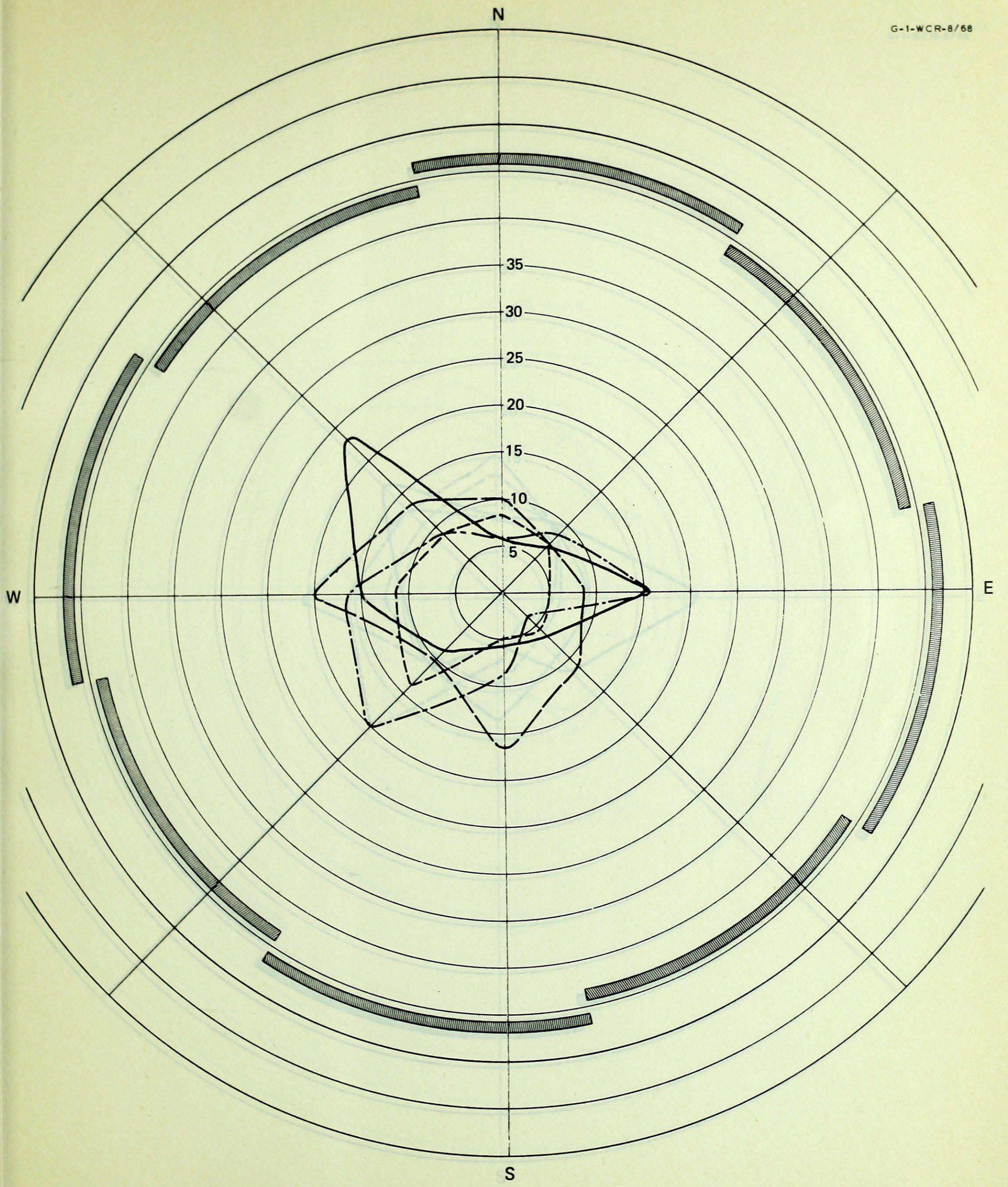
SAULT STE. MARIE A	—— CALM	8%
WHITE RIVER	– – – –	21%
THUNDER BAY	—·—	8%
CARIBOU ISLAND	——	1%

MAY DIRECTION

Figure 33. 10-Metre Wind Field.



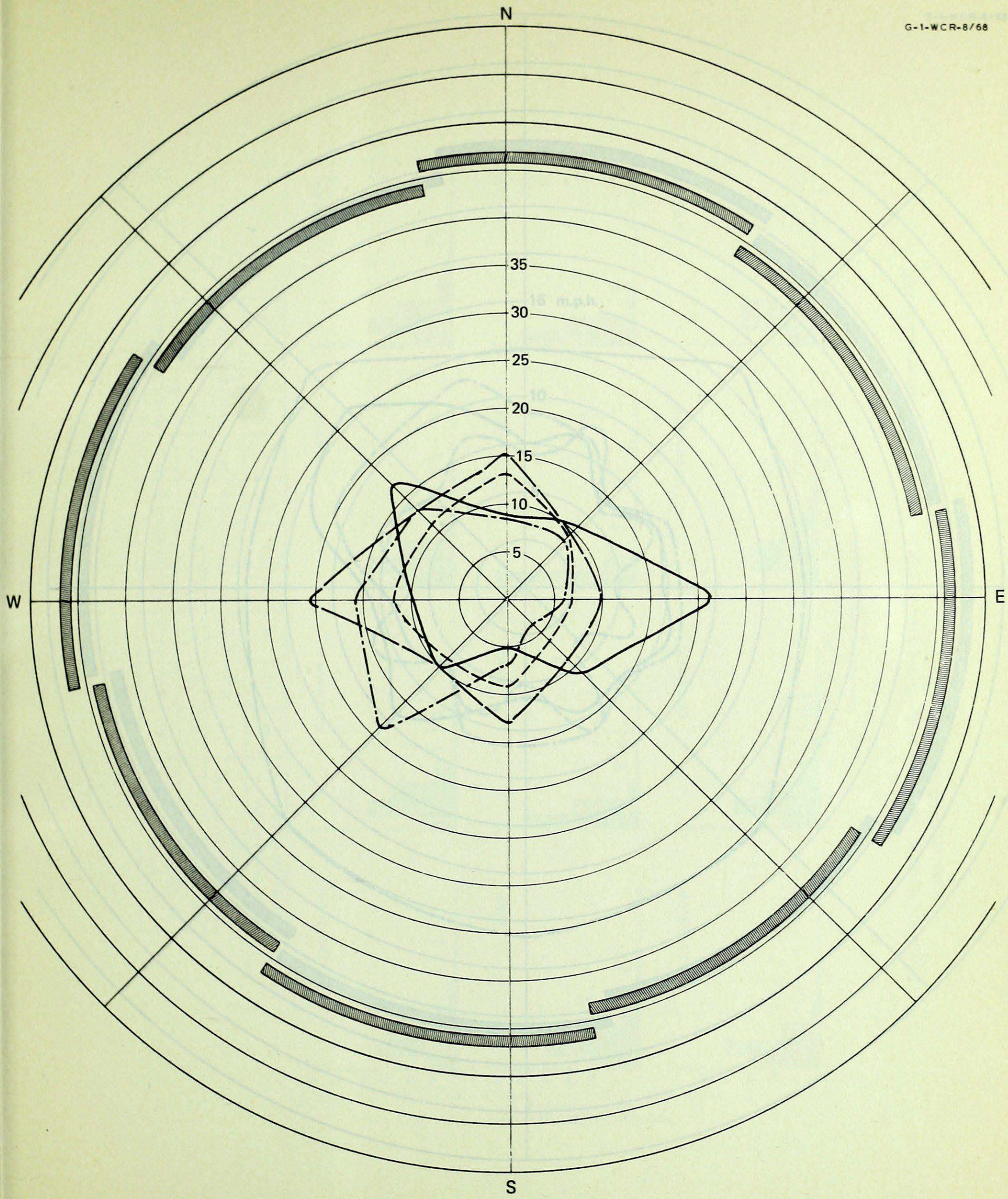
G-1-WCR-8/68



SAULT STE. MARIE A	CALM	12%
WHITE RIVER		34%
THUNDER BAY		11%
CARIBOU ISLAND		2%

AUGUST DIRECTION

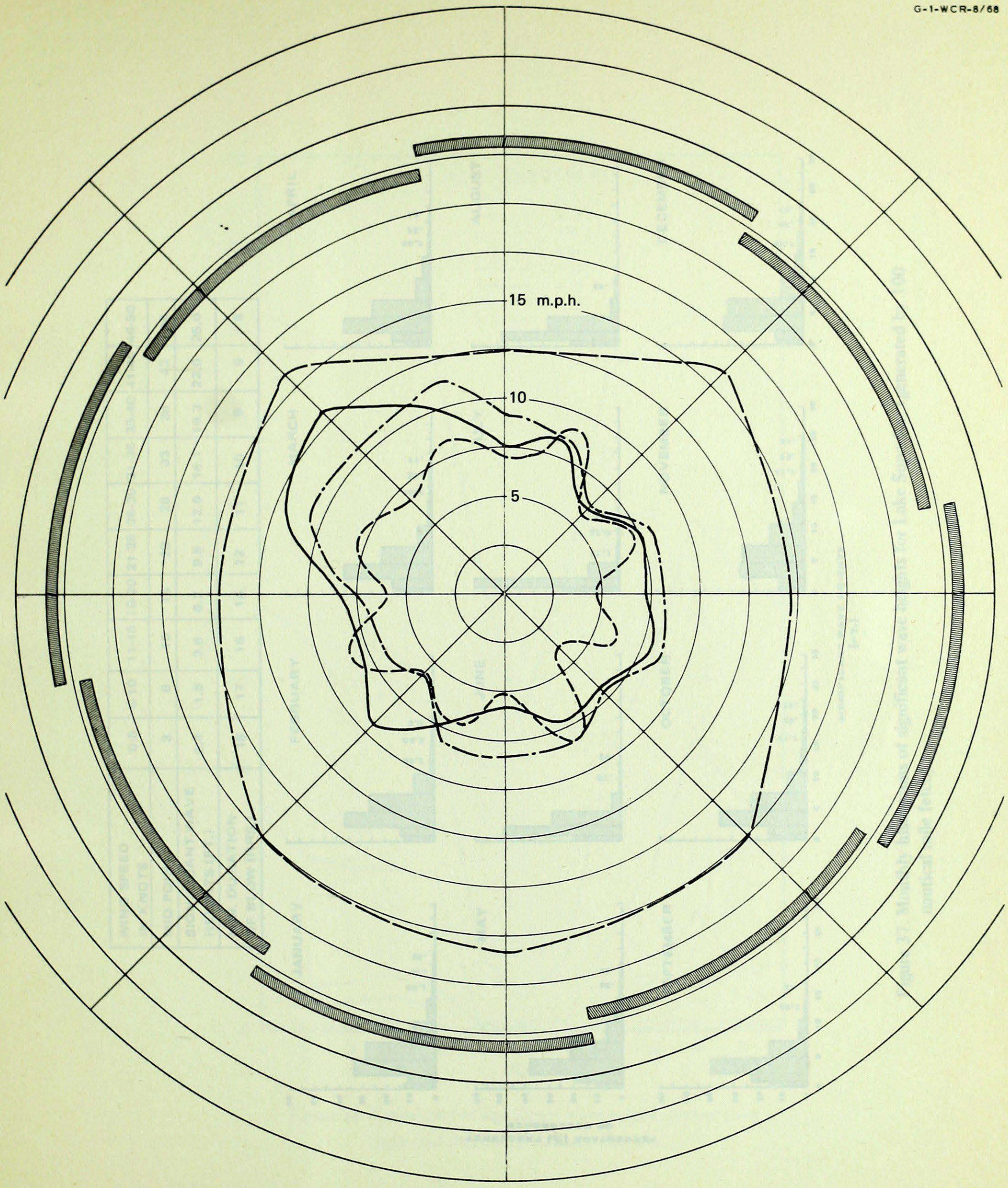
Figure 34. 10-Metre Wind Field.



SAULT STE. MARIE A ——— CALM 6%
WHITE RIVER – – – – 24%
THUNDER BAY —·— 9%
CARIBOU ISLAND —— <1%

NOVEMBER DIRECTION

Figure 35. 10-Metre Wind Field.



SAULT STE. MARIE A ———
WHITE RIVER – – – –
THUNDER BAY —·—
CARIBOU ISLAND ——

AUGUST MEAN SPEEDS

Figure 36. 10-Metre Wind Field.

WIND SPEED IN KNOTS	0-5	6-10	11-15	16-20	21-25	26-30	31-35	35-40	41-45	46-50
MID POINT	3	8	13	18	23	28	33	38	43	48
SIGNIFICANT WAVE HEIGHTS (FT.)	0.4	1.5	3.6	6.2	9.5	12.9	16.1	19.3	22.0	25.0
MIN. DURATION OF BLOW (HRS.)	18	17	16	14	12	11	10	9	9	8

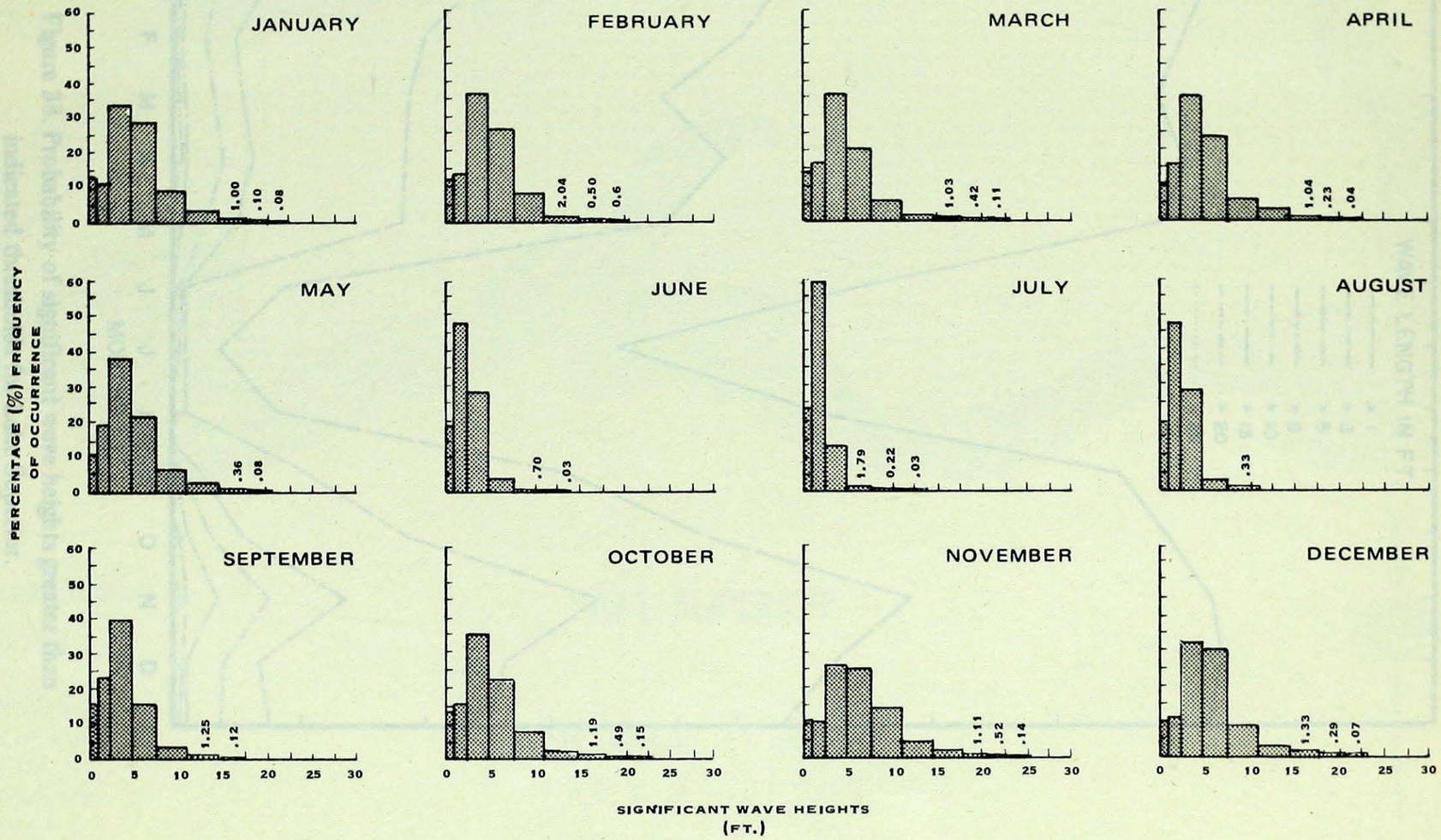


Figure 37. Monthly histograms of significant wave heights for Lake Superior: (generated by 100 nautical mile fetch).

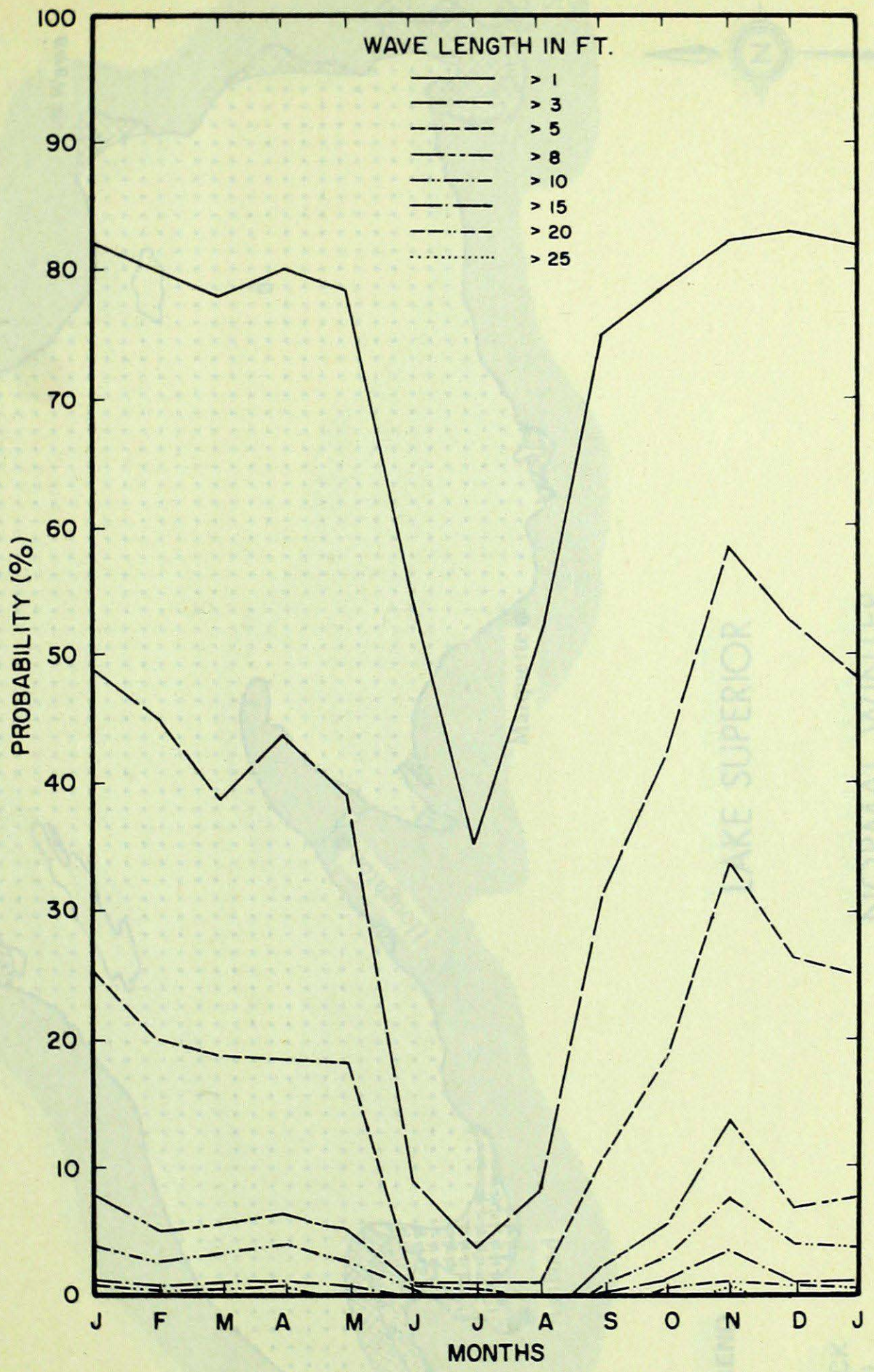


Figure 38. Probability of significant wave heights greater than indicated thresholds for Lake Superior.

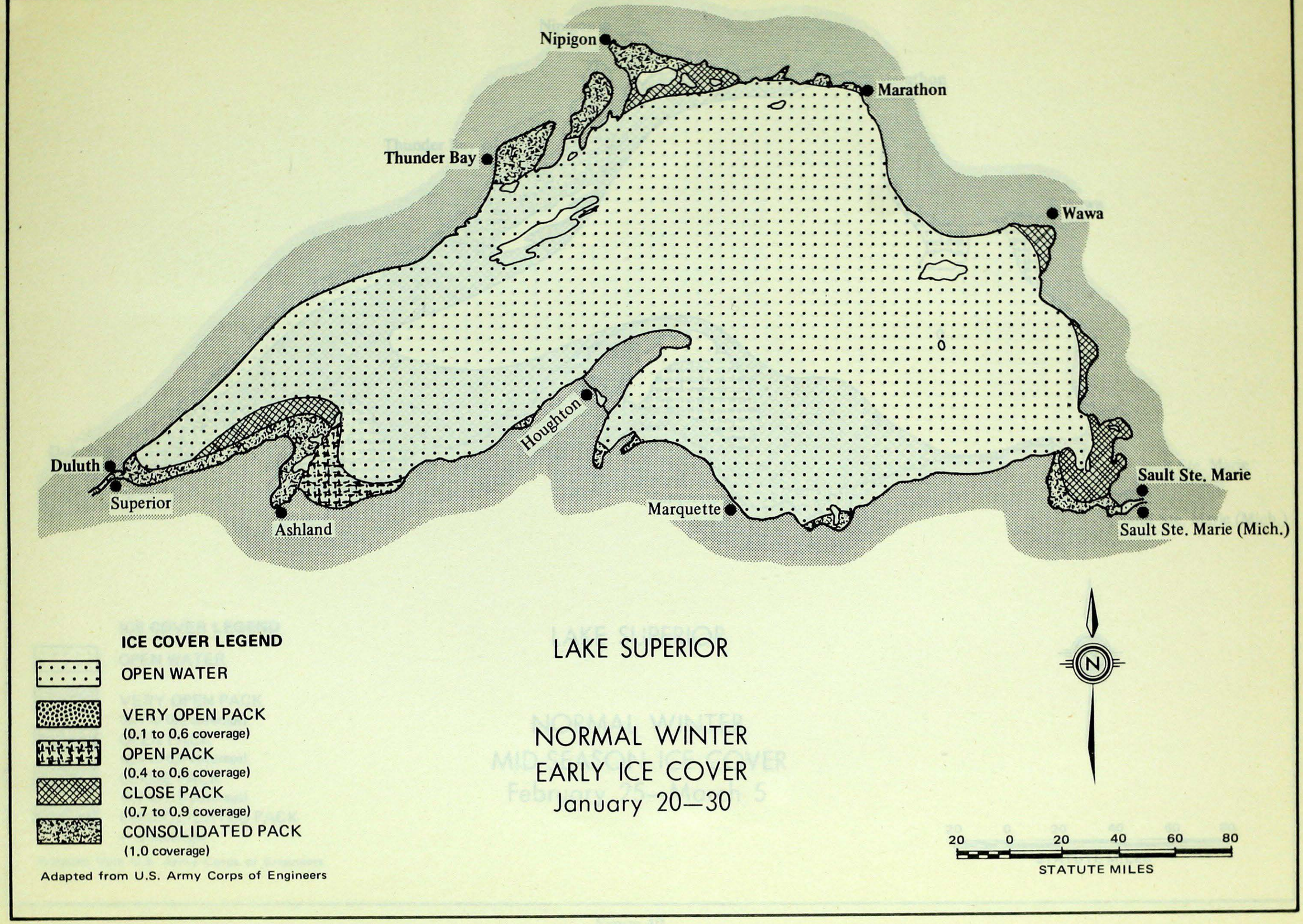

Nipigon
Marathon
Thunder Bay
Wawa
Houghton
Duluth
Superior
Ashland
Marquette
Sault Ste. Marie
Sault Ste. Marie (Mich.)
ICE COVER LEGEND
OPEN WATER
VERY OPEN PACK
(0.1 to 0.6 coverage)
OPEN PACK
(0.4 to 0.6 coverage)
CLOSE PACK
(0.7 to 0.9 coverage)
CONSOLIDATED PACK
(1.0 coverage)
Adapted from U.S. Army Corps of Engineers
LAKE SUPERIOR
NORMAL WINTER
EARLY ICE COVER
January 20—30
N
20 0 20 40 60 80
STATUTE MILES

Figure 39.

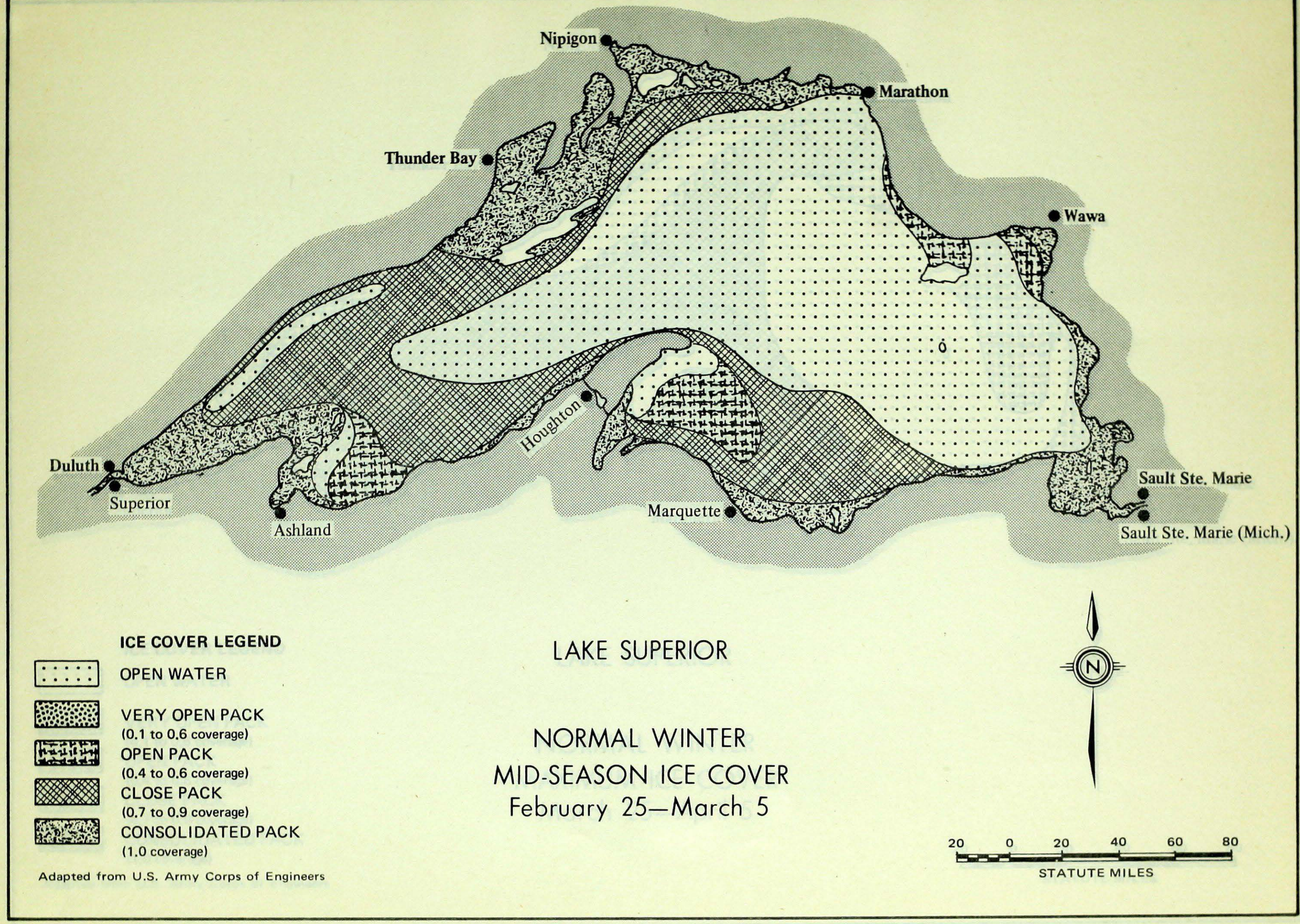

Nipigon
Marathon
Thunder Bay
Wawa
Houghton
Duluth
Superior
Ashland
Marquette
Sault Ste. Marie
Sault Ste. Marie (Mich.)
ICE COVER LEGEND
OPEN WATER
VERY OPEN PACK
(0.1 to 0.6 coverage)
OPEN PACK
(0.4 to 0.6 coverage)
CLOSE PACK
(0.7 to 0.9 coverage)
CONSOLIDATED PACK
(1.0 coverage)
Adapted from U.S. Army Corps of Engineers
LAKE SUPERIOR
NORMAL WINTER
MID-SEASON ICE COVER
February 25—March 5
N
20 0 20 40 60 80
STATUTE MILES

Figure 40.

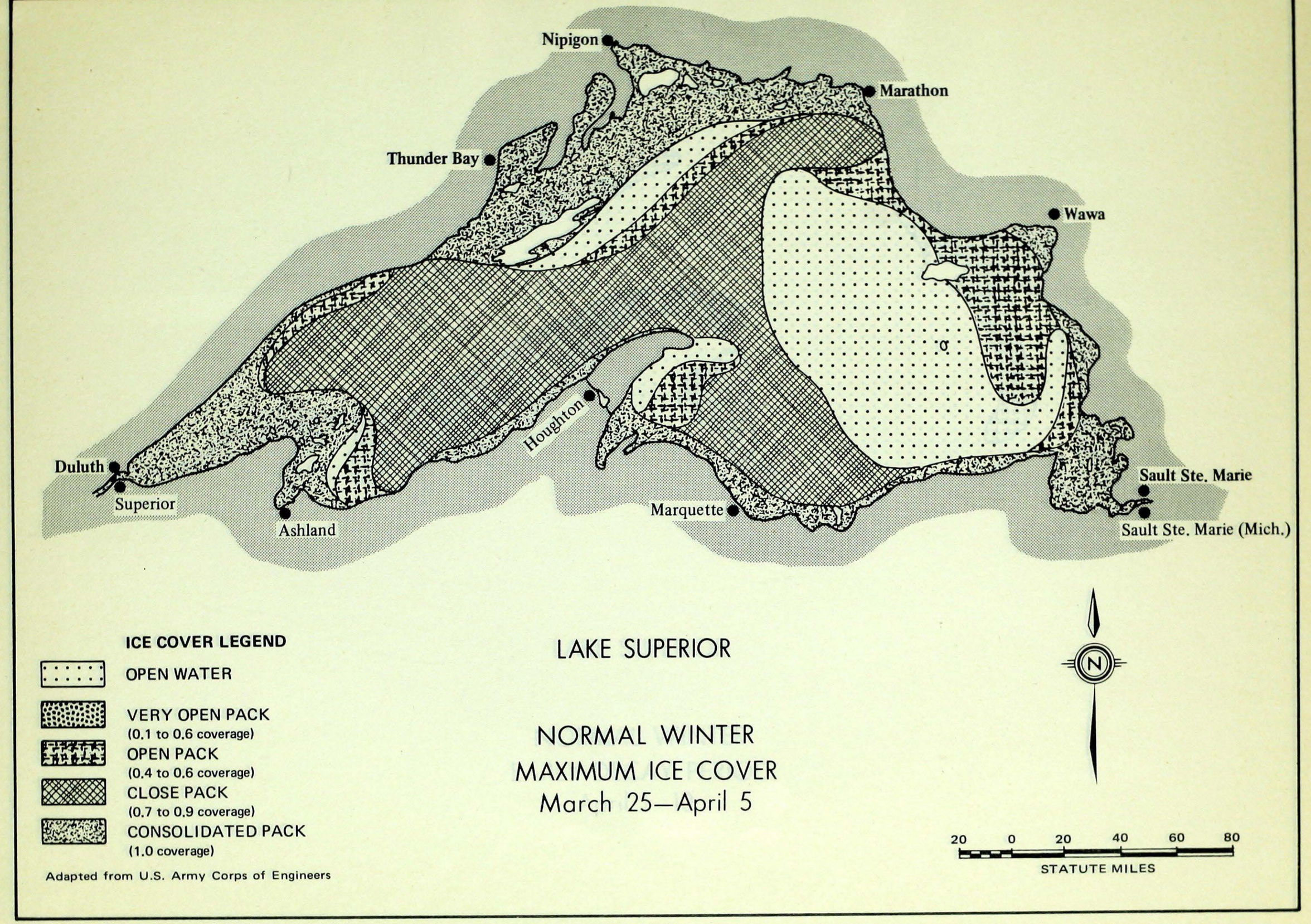

Nipigon
Marathon
Thunder Bay
Wawa
Houghton
Duluth
Superior
Ashland
Marquette
Sault Ste. Marie
Sault Ste. Marie (Mich.)
ICE COVER LEGEND
OPEN WATER
VERY OPEN PACK
(0.1 to 0.6 coverage)
OPEN PACK
(0.4 to 0.6 coverage)
CLOSE PACK
(0.7 to 0.9 coverage)
CONSOLIDATED PACK
(1.0 coverage)
Adapted from U.S. Army Corps of Engineers
LAKE SUPERIOR
NORMAL WINTER
MAXIMUM ICE COVER
March 25—April 5
N
20 0 20 40 60 80
STATUTE MILES

Figure 41.

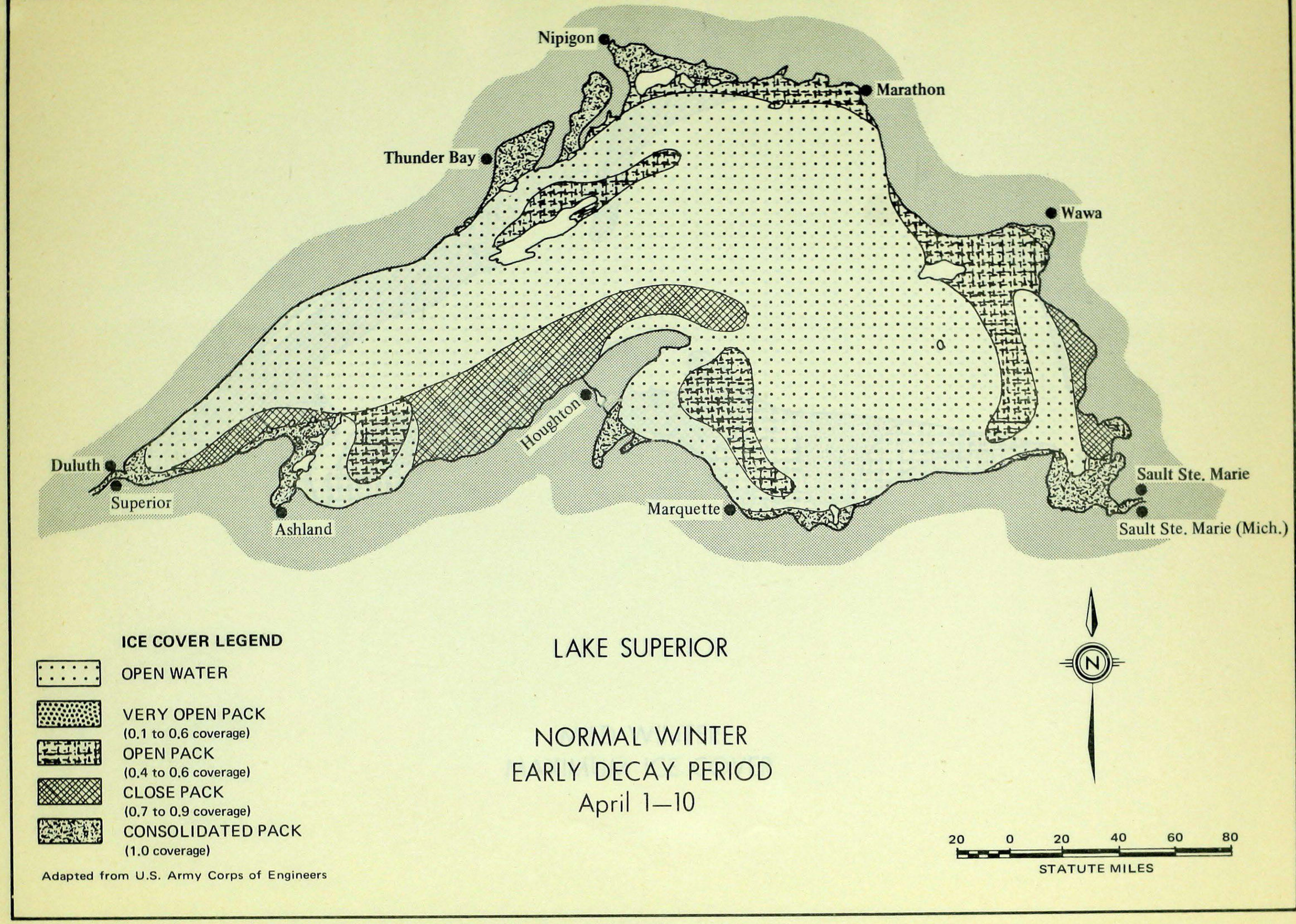

Nipigon
Marathon
Thunder Bay
Wawa
Houghton
Duluth
Superior
Ashland
Marquette
Sault Ste. Marie
Sault Ste. Marie (Mich.)
ICE COVER LEGEND
OPEN WATER
VERY OPEN PACK
(0.1 to 0.6 coverage)
OPEN PACK
(0.4 to 0.6 coverage)
CLOSE PACK
(0.7 to 0.9 coverage)
CONSOLIDATED PACK
(1.0 coverage)
Adapted from U.S. Army Corps of Engineers
LAKE SUPERIOR
NORMAL WINTER
EARLY DECAY PERIOD
April 1—10
N
20 0 20 40 60 80
STATUTE MILES

Figure 42.

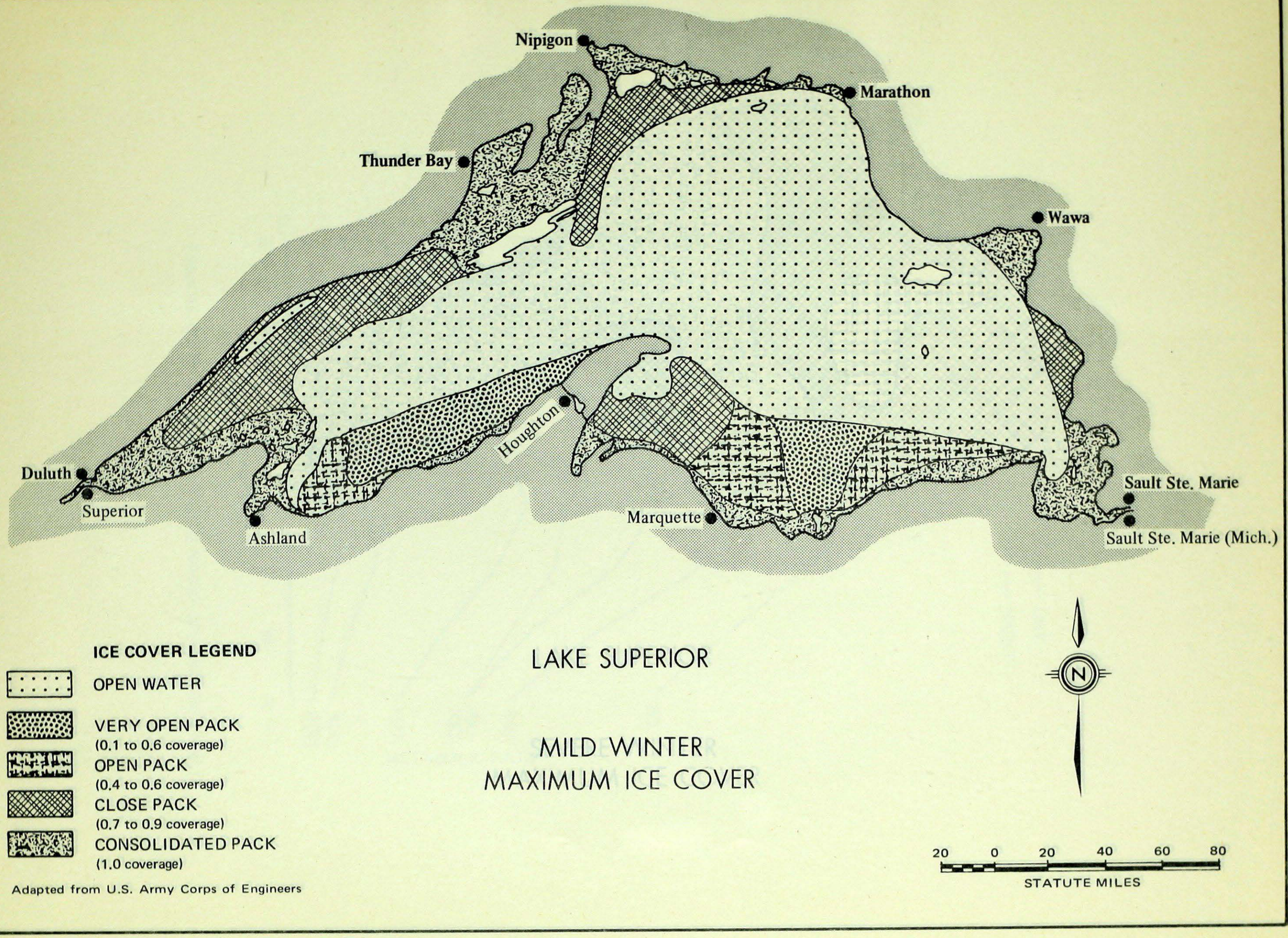

Nipigon
Marathon
Thunder Bay
Wawa
Houghton
Duluth
Superior
Ashland
Marquette
Sault Ste. Marie
Sault Ste. Marie (Mich.)
ICE COVER LEGEND
OPEN WATER
VERY OPEN PACK
(0.1 to 0.6 coverage)
OPEN PACK
(0.4 to 0.6 coverage)
CLOSE PACK
(0.7 to 0.9 coverage)
CONSOLIDATED PACK
(1.0 coverage)
Adapted from U.S. Army Corps of Engineers
LAKE SUPERIOR
MILD WINTER
MAXIMUM ICE COVER
N
20 0 20 40 60 80
STATUTE MILES

Figure 43.

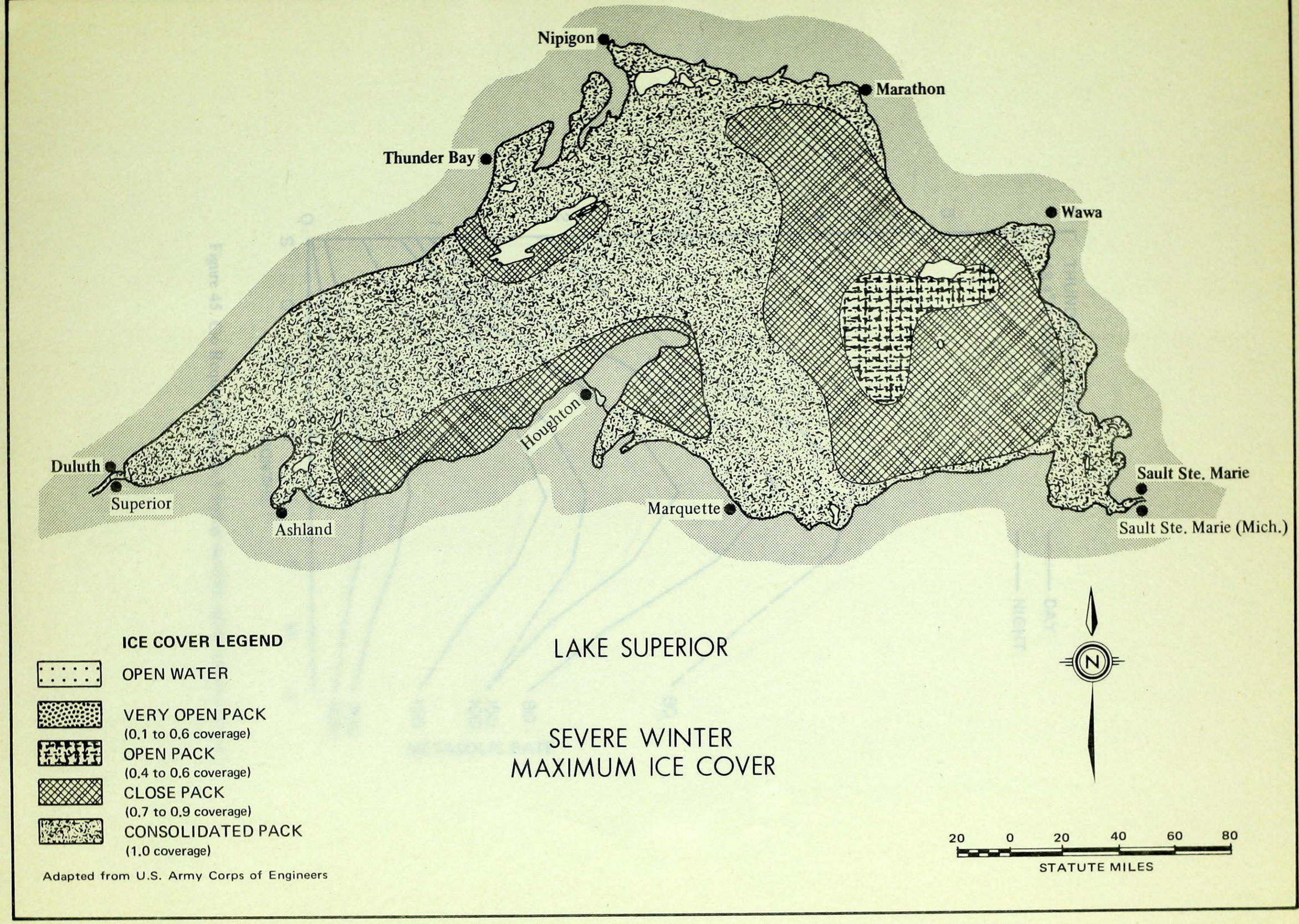

Nipigon
Marathon
Thunder Bay
Wawa
Houghton
Duluth
Superior
Ashland
Marquette
Sault Ste. Marie
Sault Ste. Marie (Mich.)
ICE COVER LEGEND
OPEN WATER
VERY OPEN PACK
(0.1 to 0.6 coverage)
OPEN PACK
(0.4 to 0.6 coverage)
CLOSE PACK
(0.7 to 0.9 coverage)
CONSOLIDATED PACK
(1.0 coverage)
Adapted from U.S. Army Corps of Engineers
LAKE SUPERIOR
SEVERE WINTER
MAXIMUM ICE COVER
N
20 0 20 40 60 80
STATUTE MILES

Figure 44.

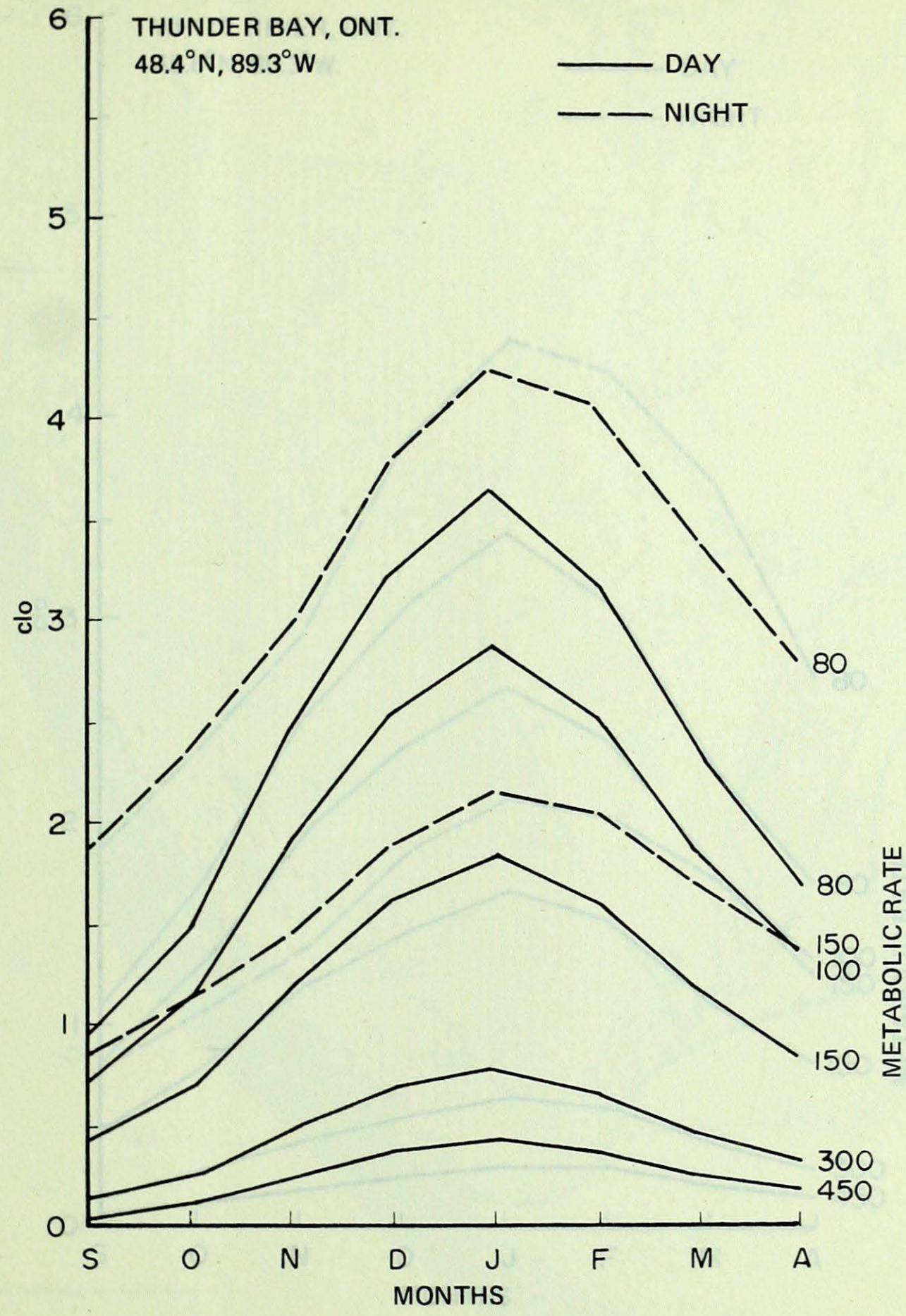


Figure 45. Clo Requirements for Varying Activity (after Auliciems et al.)

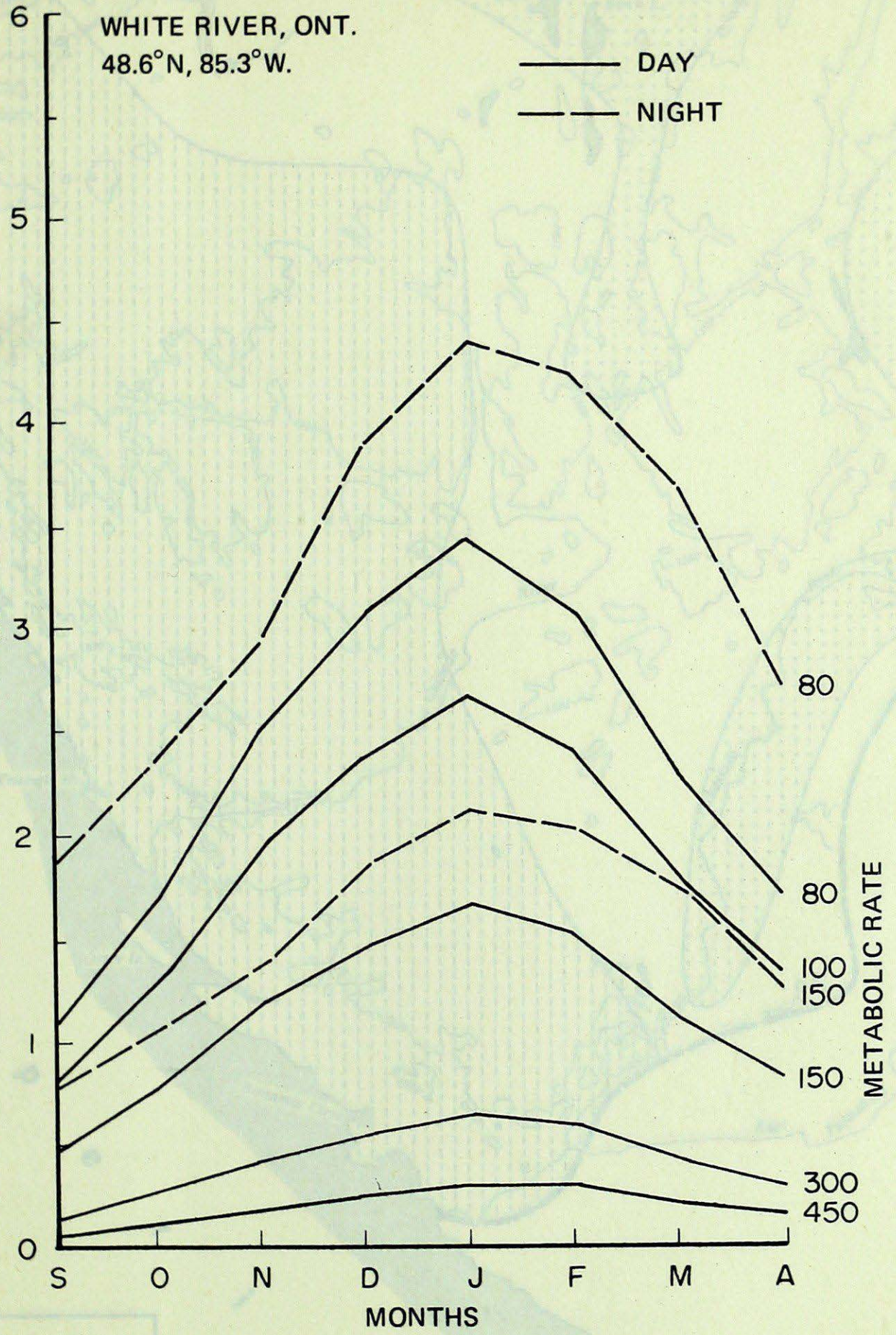

WHITE RIVER, ONT.
48.6°N, 85.3°W.
DAY
NIGHT
clo
6
5
4
3
2
1
0
80
80
100
150
150
300
450
METABOLIC RATE
S
O
N
D
J
F
M
A
MONTHS

Figure 46.

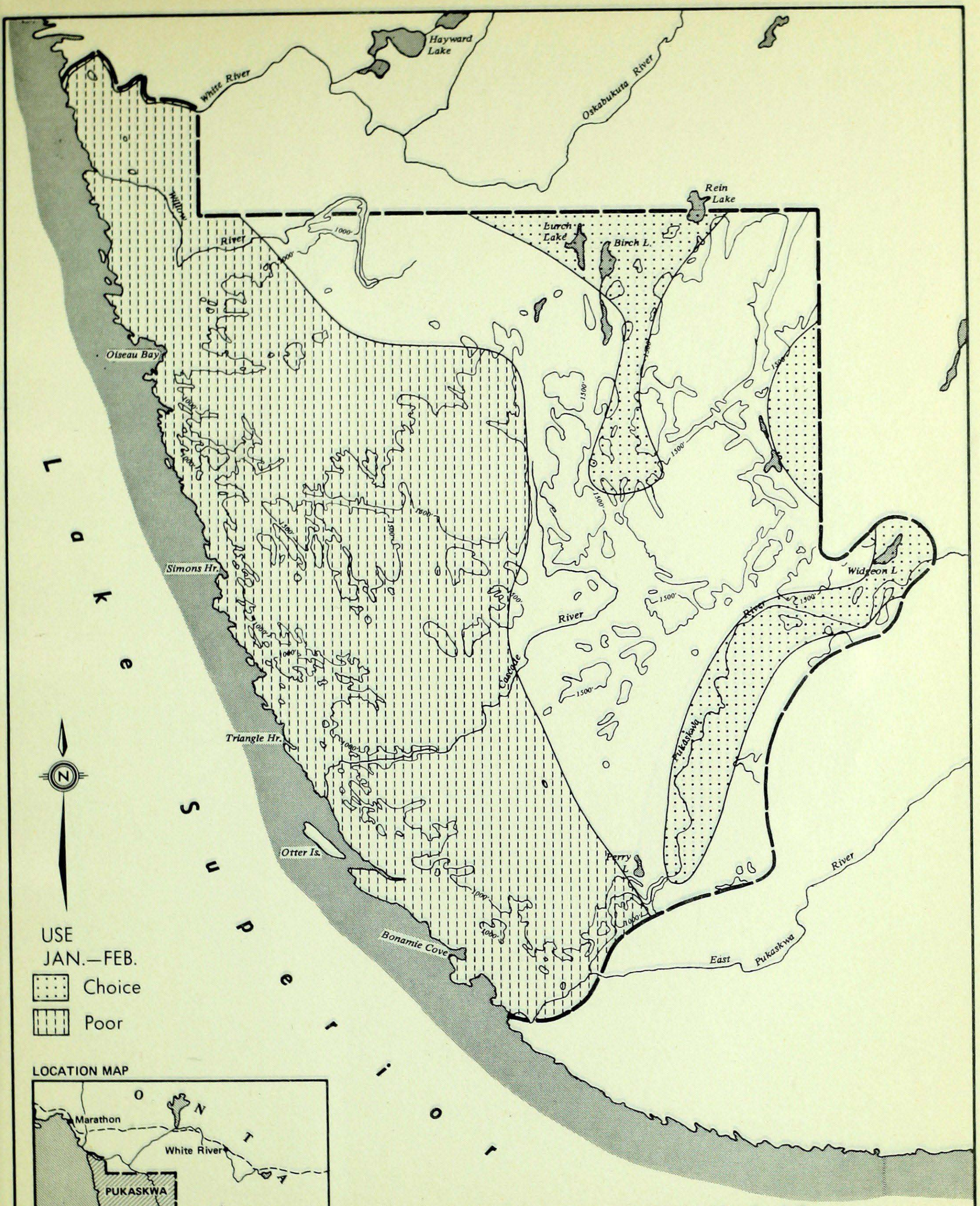

Hayward Lake
White River
Oskabukuta River
Rein Lake
Lurch Lake
Birch L.
Willow River
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Perry
Widgeon L
Gargle River
Pukaskwa River
East Pukaskwa River
Lake Superior
1000'
1500'
N
USE
JAN.—FEB.
Choice
Poor
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 47.

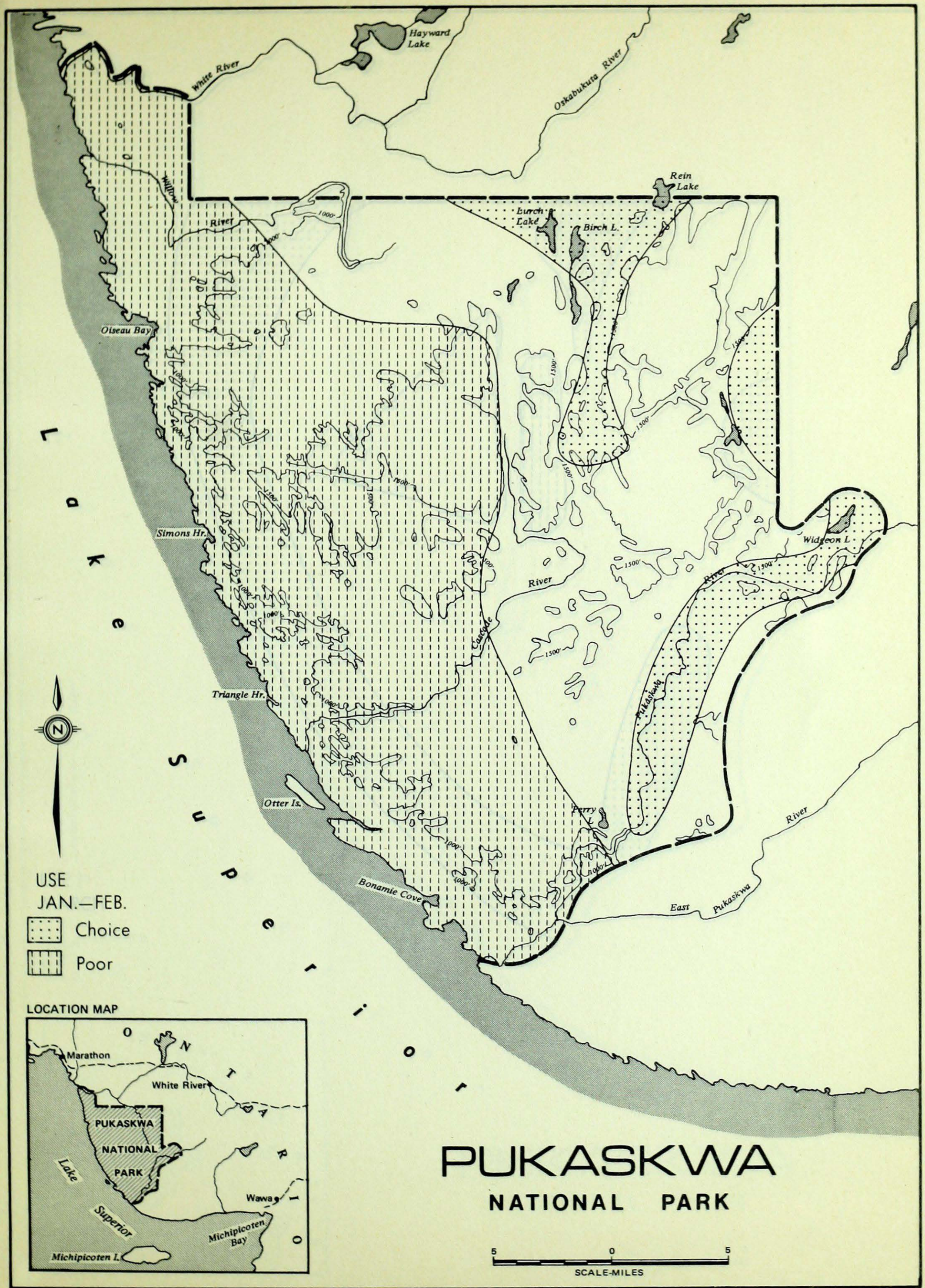

Lake Superior
White River
Hayward Lake
Oskabukuta River
Rein Lake
Birch Lake
Birch L.
Willow River
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Perry L.
Widgeon L
Pukaskwa River
East Pukaskwa River
Castoe River
1000'
1500'
N
USE
JAN.—FEB.
Choice
Poor
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 47.

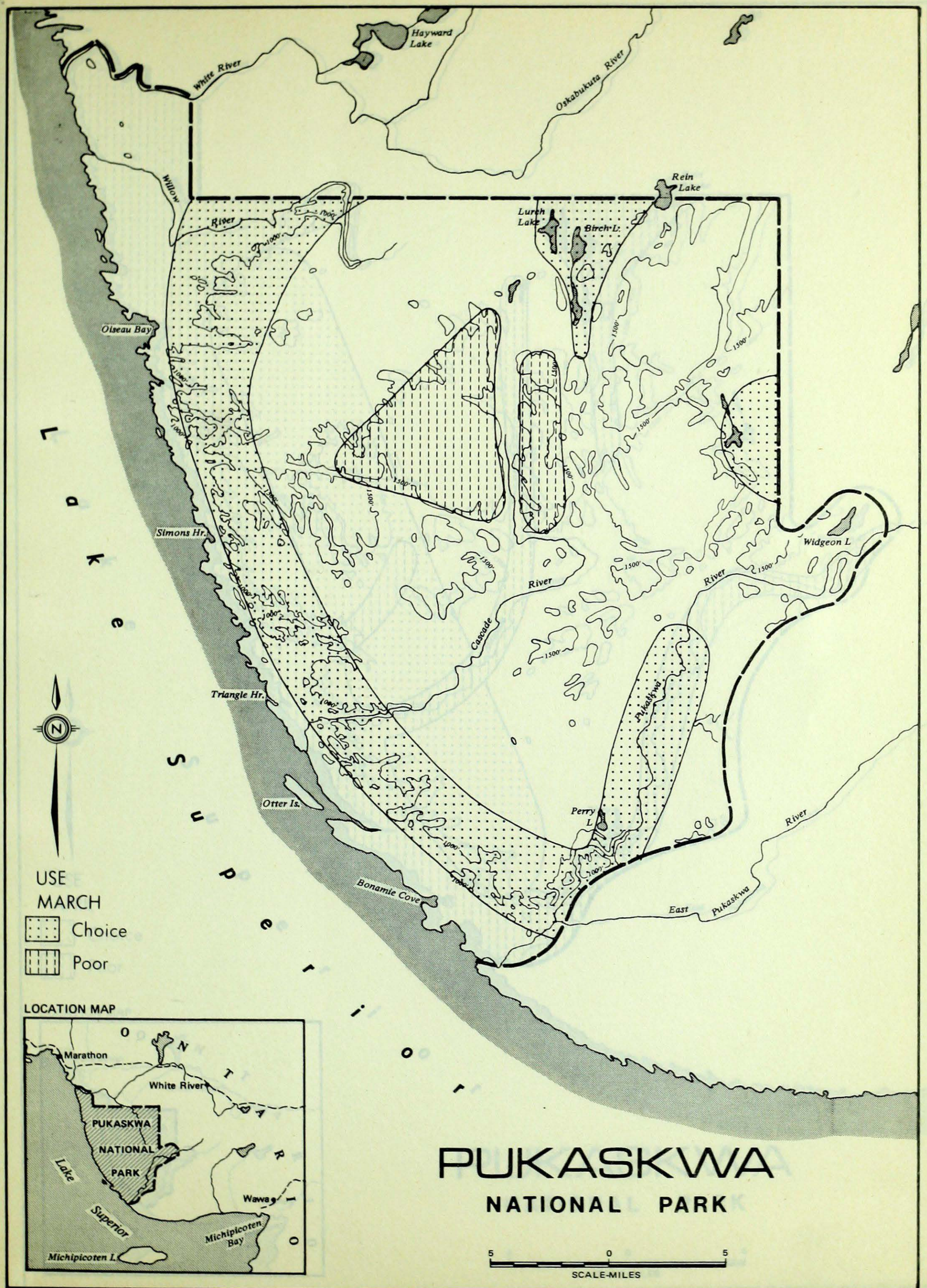
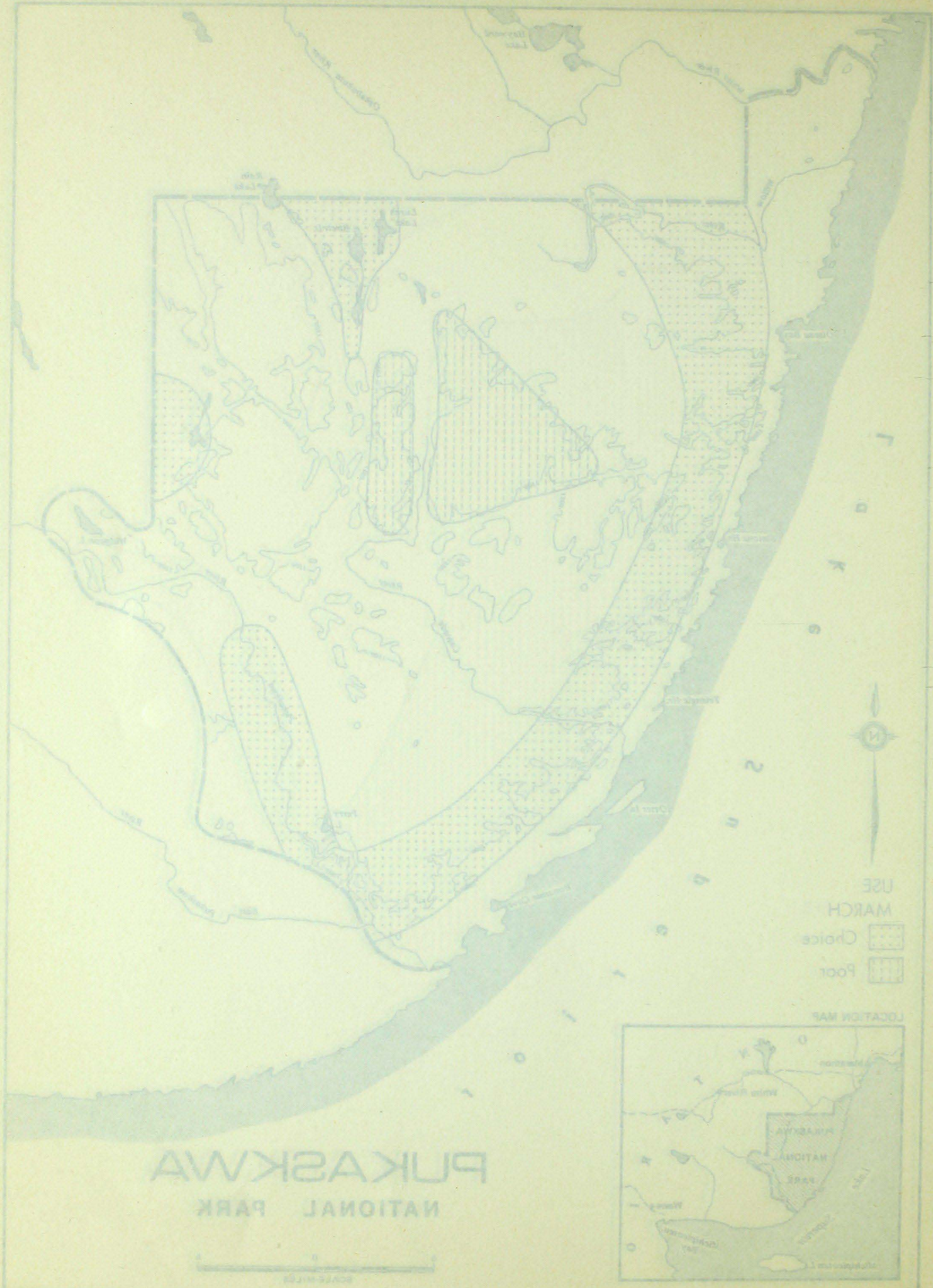

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
Perry L
Widgeon L
East Pukaskwa River
1000'
1500'
Lake Superior
N
USE
MARCH
Choice
Poor
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 48.


PUKASKWA
NATIONAL PARK
USE
MARCH
Choice
Poor
LOCATION MAP

Hayward Lake
White River
Oskabukuta River
Rein Lake
Lurgh Lake
Birch L.
Willow River
Oiseau Bay
1500'
Simons Hr.
Widgeon L.
River
Cascade
Triangle Hr.
Parkaskwa River
Otter Is.
Perry L.
Bonamie Cove
East Pukaskwa River
N
USE
APRIL
Choice
Poor
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 49.

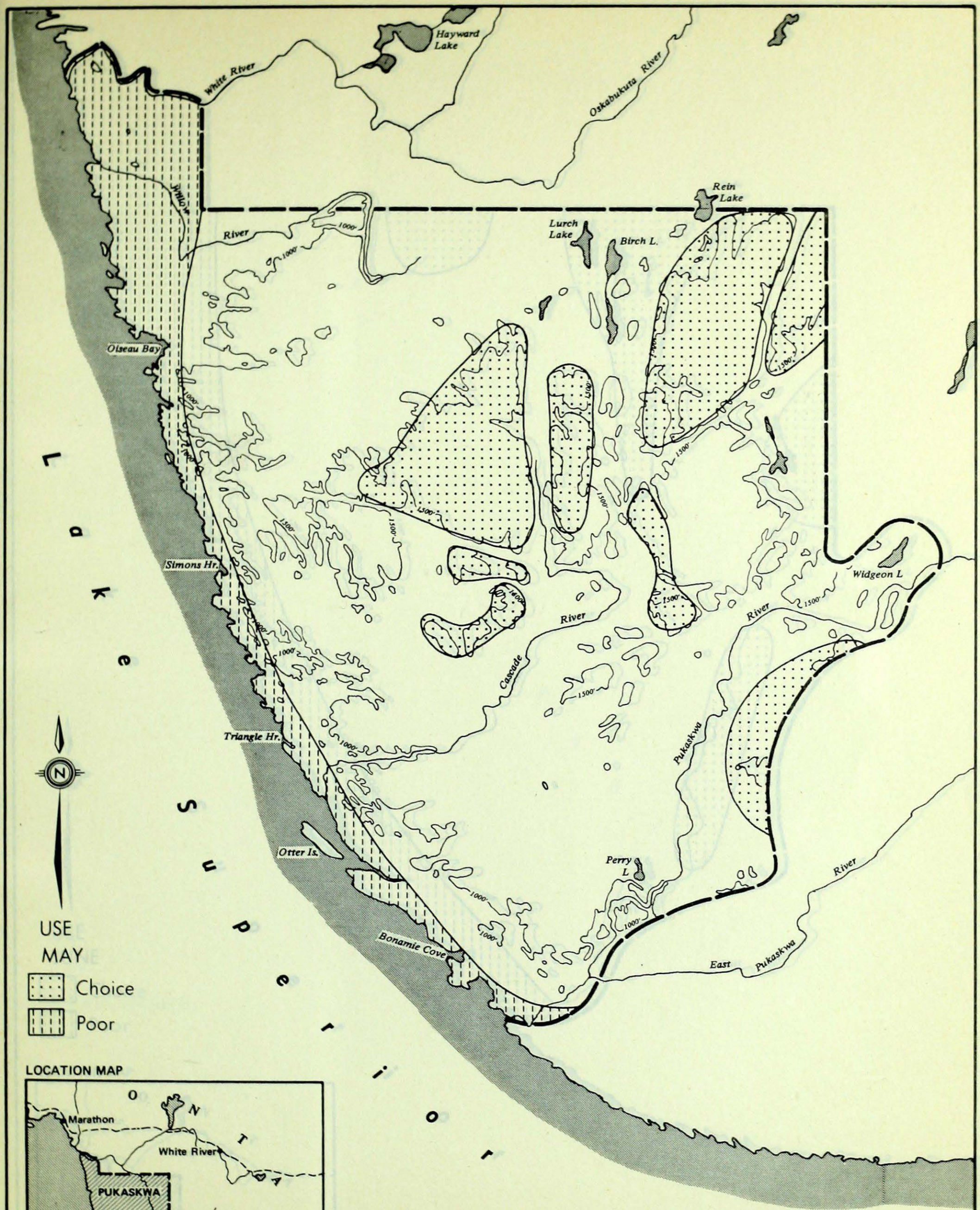

Hayward Lake
White River
Oskabukuta River
Rein Lake
Lurch Lake
Birch L.
Willow River
1000'
Oiseau Bay
1500'
Simons Hr.
Widgeon L
River
Cascade
Pukaskwa
Triangle Hr.
Otter Is.
Perry L
Bonamie Cove
East Pukaskwa
Lake Superior
N
USE
MAY
Choice
Poor
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA
NATIONAL
PARK
Lake
Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 50.

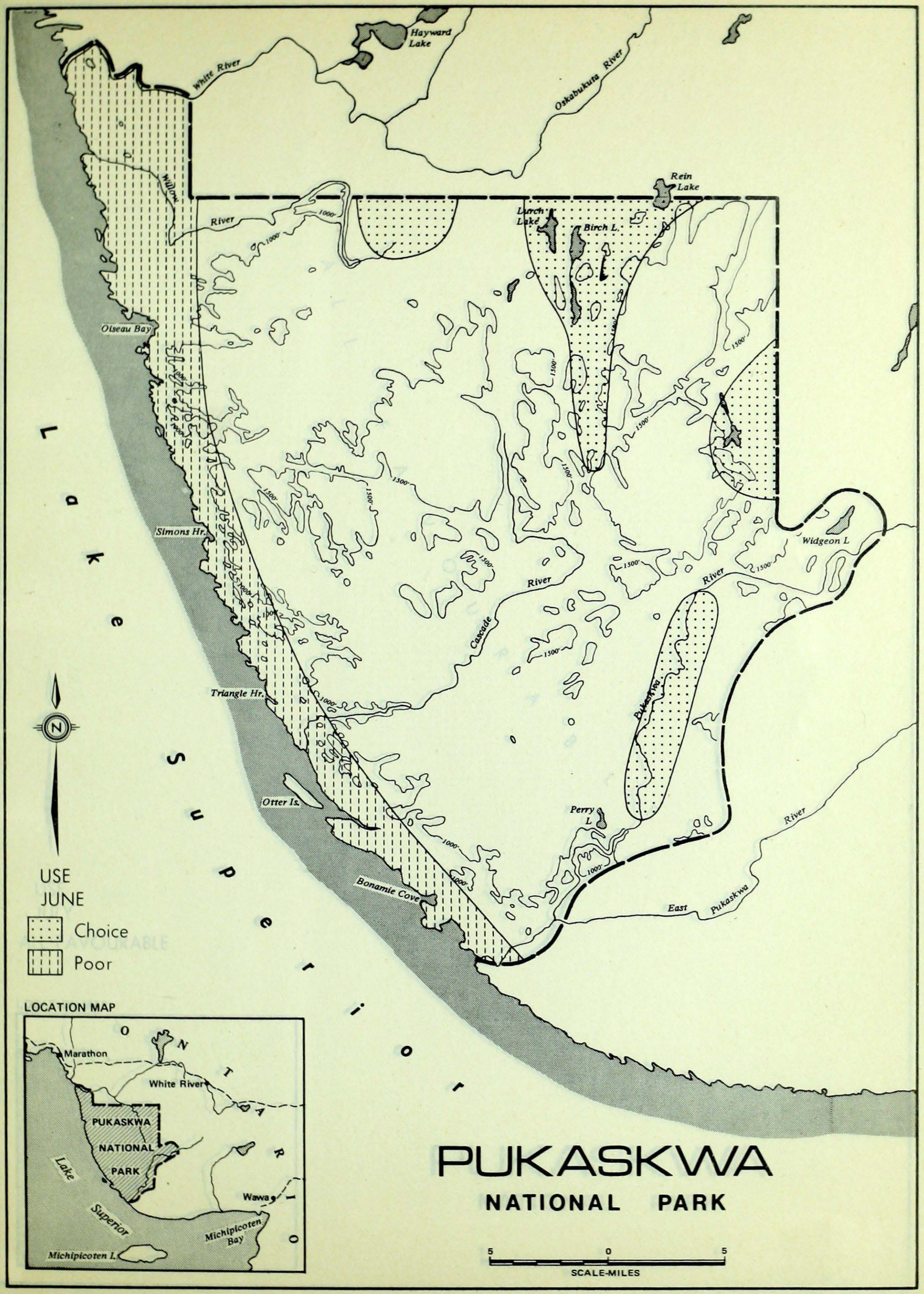

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Larch Lake
Birch L.
1000'
1500'
Olseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Cascade River
Pukaskwa River
Widgeon L
Perry L
East Pukaskwa River
Lake Superior
N
USE
JUNE
Choice
Poor
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA
NATIONAL
PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 51.

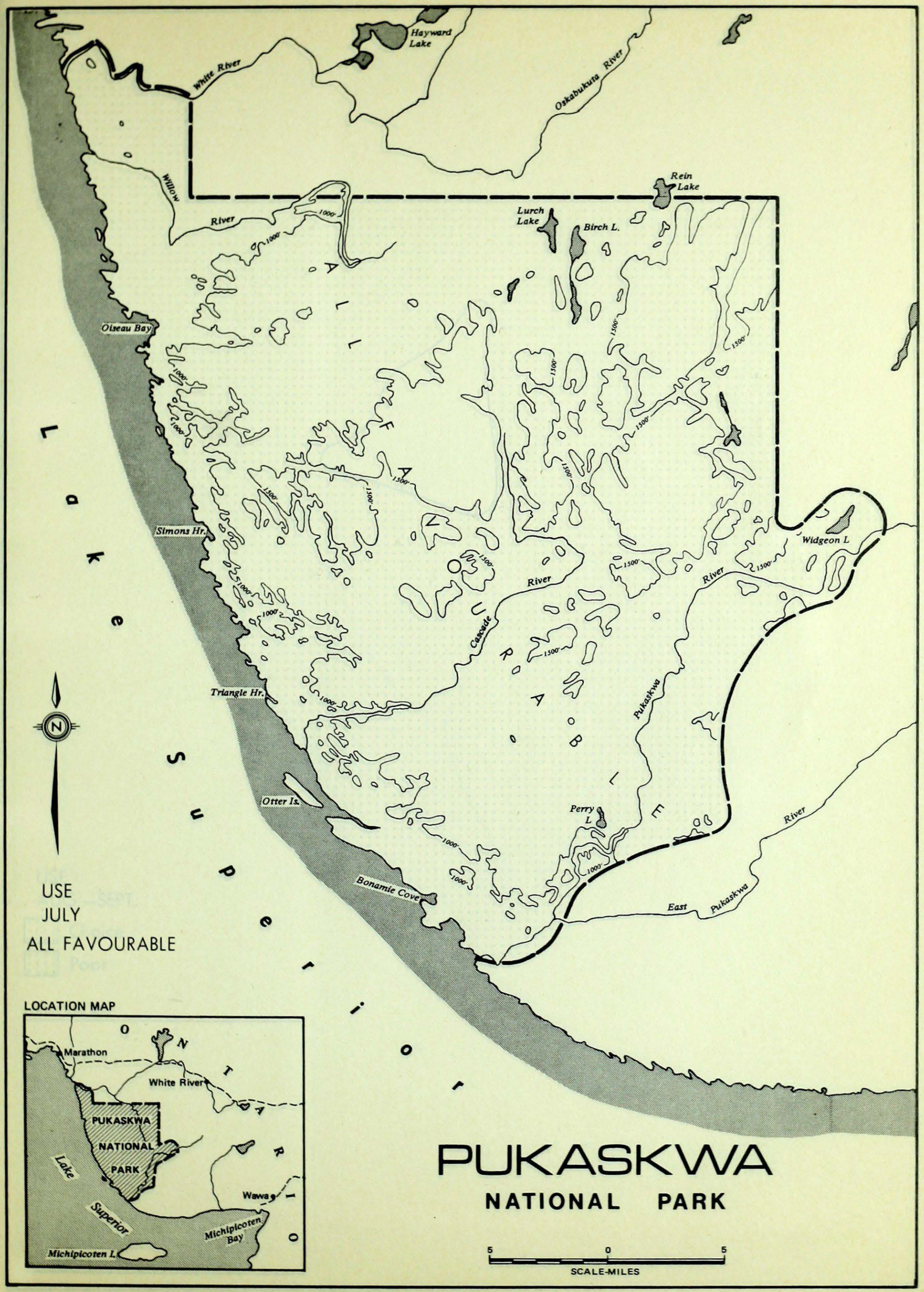

Hayward Lake
White River
Oskabukuta River
Willow River
Rein Lake
Lurch Lake
Birch L.
1000'
1500'
Olseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Lake Superior
FALCONBRIDGE
Cascade River
Pukaskwa River
East Pukaskwa River
Perry L
Widgeon L
N
USE
JULY
ALL FAVOURABLE
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA
NATIONAL
PARK
Lake
Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 52.

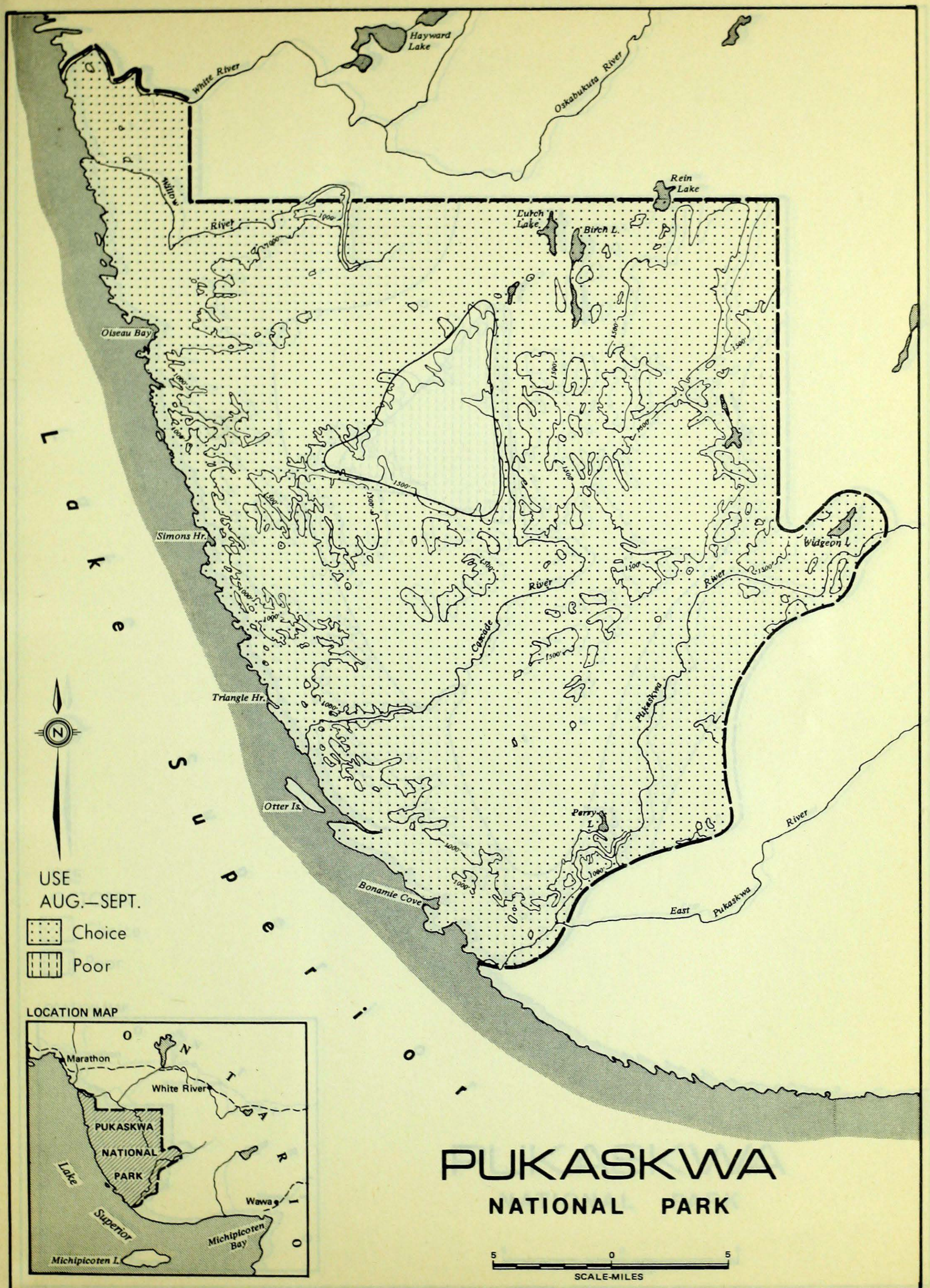

Hayward Lake
White River
Oskabukuta River
Rein Lake
Willow River
Dutch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Widgeon L.
Cascade River
Pukaskwa River
Perry L.
Bonamie Cove
East Pukaskwa River
Lake Superior
1000'
1500'
N
USE
AUG.—SEPT.
Choice
Poor
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 53.

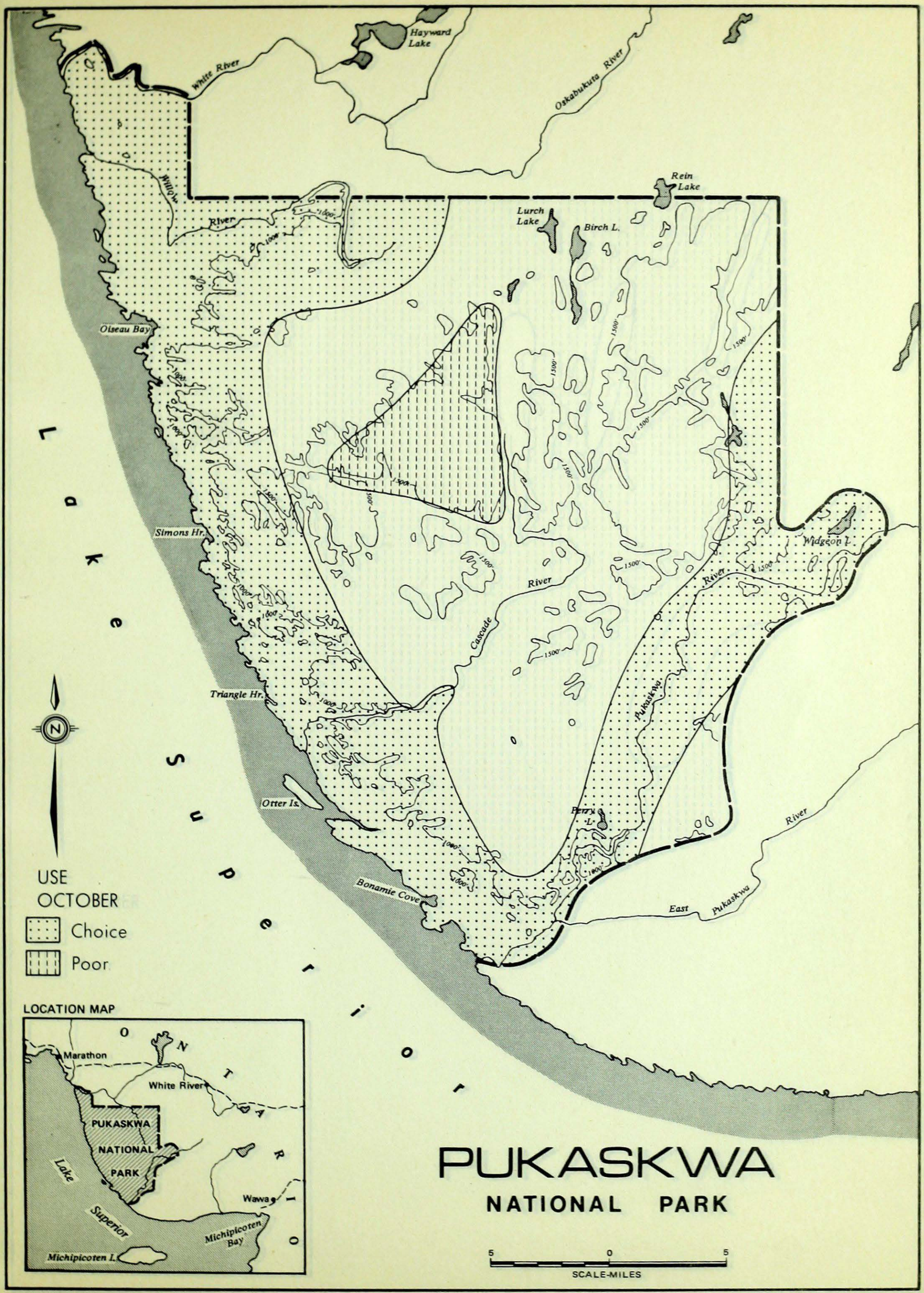

Hayward Lake
White River
Oskabukuta River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
1500'
Simons Hr.
Widgeon L.
River
Cascade
Triangle Hr.
Pukaskwa
Otter Is.
Perry L.
Bonamie Cove
East Pukaskwa River
Lake Superior
N
USE
OCTOBER
Choice
Poor
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA
NATIONAL
PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten L.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 54.

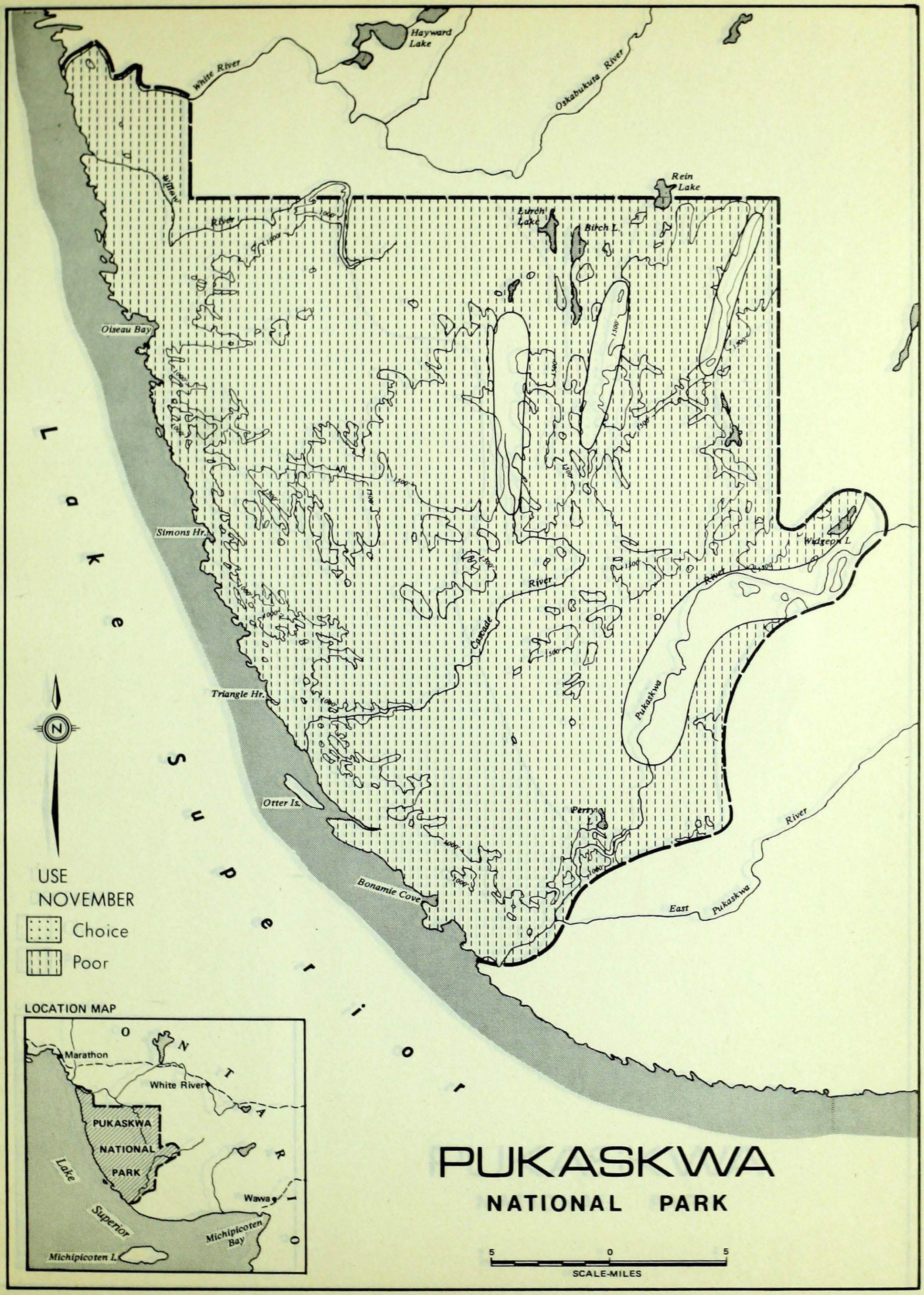

Hayward Lake
White River
Oskabukuta River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Widgeon L
Pukaskwa River
Cascade River
East Pukaskwa River
Lake Superior
N
USE
NOVEMBER
Choice
Poor
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 55.

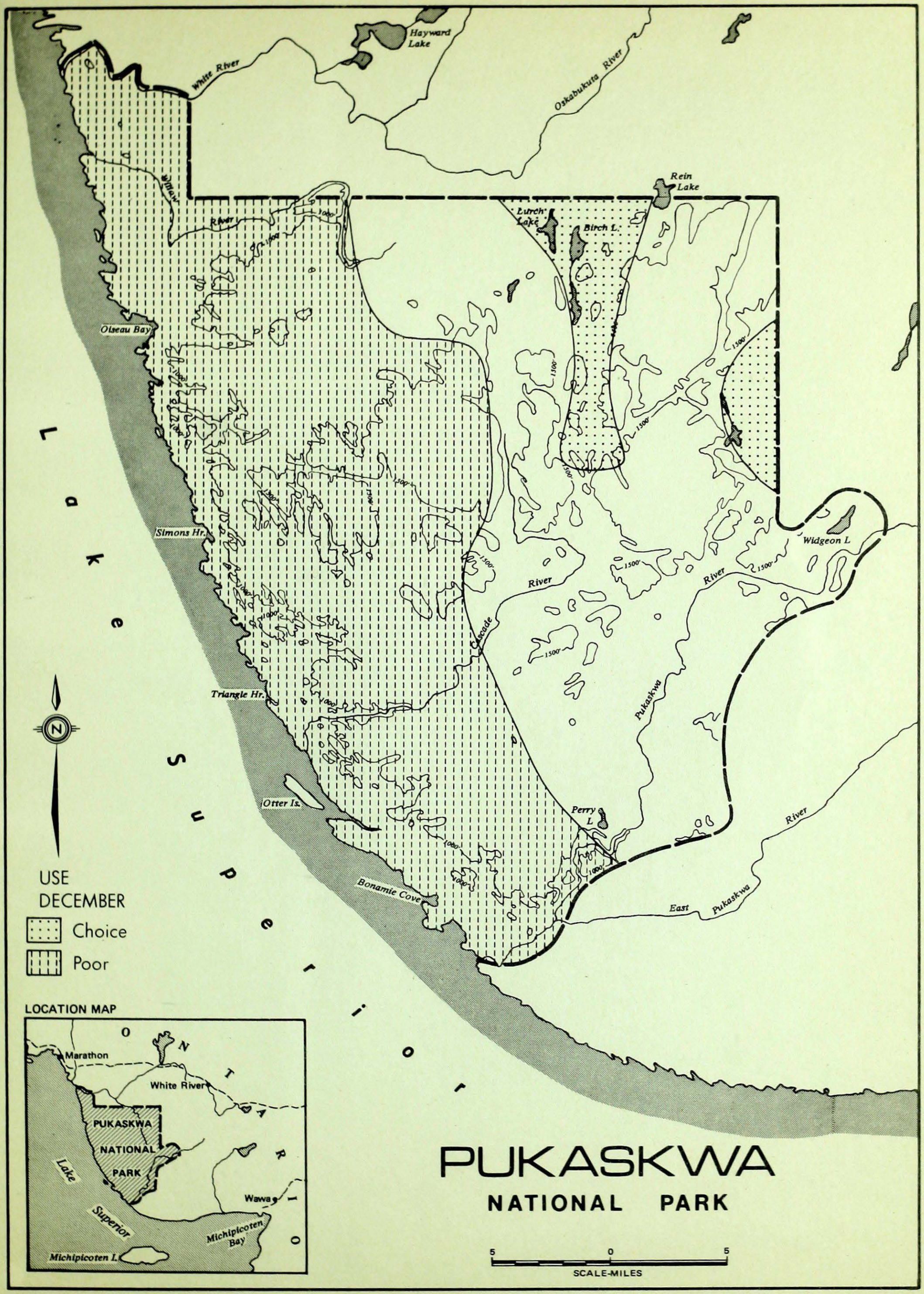

Hayward Lake
White River
Oskabukuta River
Rein Lake
Lurch Lake
Birch L.
Oiseau Bay
Simons Hr.
Triangle Hr.
Otter Is.
Bonamie Cove
Widgeon L
Cascade River
Pukaskwa River
Perry L
East Pukaskwa River
Lake Superior
N
USE DECEMBER
Choice
Poor
LOCATION MAP
ONTARIO
Marathon
White River
PUKASKWA NATIONAL PARK
Lake Superior
Wawa
Michipicoten Bay
Michipicoten I.
PUKASKWA
NATIONAL PARK
5 0 5
SCALE-MILES

Figure 56.