FIRE SEVERITY INDEX DISTRIBUTION IN ONTARIO 1963 TO 1968

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ABSTRACT

A study of the distribution of severity index values across Ontario over a period of six fire seasons shows generally high fire severity occurring in the north in late May and early June, while Central and Southern Ontario experience highest severity in late June and throughout July. This distribution is relatively similar if either the 1956 Fire Danger Rating System or the 1970 Fire Weather Index System is used.

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INTRODUCTION

Fire season severity indexes have been in use in parts of the United States since the early 1950's. Lindenmuth and Keetch (1950) developed a risk or severity factor by calculating the average number of fires starting per fire danger index unit. In California, Countryman and Intorf (1953) used both fire occurrence and area burned to develop a severity index showing how much any particular fire season differed from an average fire season. In Canada, Williams (1959) developed the first fire season severity rating system for use in conjunction with the Forestry Branch system of fire danger rating in use at that time. Using data from many small test fires to calculate rate of spread in relation to fire danger class, and using the drought index (for deeper, heavier forest fuels) as a measure of resistance to control, he developed severity factors to represent the relative severity of danger classes in any area where this danger system was in use. The severity factors 0.0, 0.2, 1.0, 4.0, and 12.0 represented the danger classes nil, low, moderate, high, and extreme, respectively. The severity of a fire season was computed by multiplying the number of days falling into each fire danger class by the appropriate severity factor, totalling the results, and dividing by the number of days in the fire season. The severity index (SI) thus had a scale of 0.0 to 12.0 but, unlike the fire danger index, had no class breakdown.

The new Canadian Fire Weather Index (FWI) (Anon, 1970) is replacing the old danger rating system across Canada at this time and recently Van Wagner (1970) has devised a method of converting Williams' severity rating system for use with the FWI. After first converting the class midpoints of the old fire danger index to their corresponding FWI values, he then plotted (on double-log paper) Williams' severity factors for the class midpoints against the FWI equivalents, resulting in a straight line with the equation: $DSR = 0.0272\ (FWI)^{1.77}$. This equation calculates the Daily Severity Rating (DSR) for each FWI value, rather than weighing factors for individual danger classes only.

This study investigates the distribution of fire severity index values (calculated by using Van Wagner's conversion of Williams' Severity Rating System) across Ontario during fire seasons from 1963 through 1968. The three Lands and Forests districts in southwestern Ontario (Lake Huron, Lake Simcoe, and Lake Erie) were excluded from this study because of their relatively unforested nature and the lack of fires occurring within them.

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METHOD

Weather data from 85 Department of Lands and Forests stations (Fig. 1) were used to calculate the FWI for each station for every day of the fire season from May 11 to September 20 for each of the six years studied, a total of 67,830 observations. Although the fire season usually extends from approximately the first of April until the end of October throughout Ontario, this shorter period was used because it was only during this period that all 85 stations were in continuous daily operation.

Each month was broken into three periods of 10 or 11 days, resulting in 13 such periods in each year studied. An average fire severity index (SI) value was then calculated for each day by using the equation mentioned previously--the number of days falling into each danger class being multiplied by the severity factor for that class and the total being divided by either 10 or 11.

The average SI was used in this study rather than the average FWI because it considers and weighs accordingly the distribution of FWI values within the given 10- or 11-day period, as well as the actual values themselves, while an average FWI would only consider the latter. For example, if in two 10-day periods all FWI values in one were "Moderate" and the other had half "Nil" and half "Extreme" days, the total and average FWI would be approximately the same in each case, but the second would be considered the more severe period. The average SI takes this into account while an average FWI does not.

The average SI for each station was calculated for each 10- or 11-day period and these values were then averaged over the six years and plotted at that station location on a map of Ontario. The SI scale was broken down into four arbitrary divisions or classes: 0.00 to 0.99, 1.00 to 1.99, 2.00 to 2.99, and 3.00 plus. Isolines were drawn around stations with SI values within the same SI class and the resulting maps are shown, in chronological order for 10- or 11-day periods, in Figures A1 to A4.

In addition, maps showing the distribution of seasonal SI values at each station across the Province are shown for the years 1963 to 1968 in Figures A5 and A6.

The SI class breakdown decided upon for this study is arbitrary and is not in any way meant to represent a specific degree of severity (low, moderate, high, or extreme). Although fire severity does increase from Class I up to Class IV, this scale increase is not necessarily proportional (although Williams' original severity scale was intended to be proportional to fire suppression effort), and Class II cannot therefore be definitely considered twice as severe as Class I. The SI distribution with the four classes outlined (based on 10- or 11-day periods for all 85 stations) is shown in Table 1.

Figure 1. Location of 85 Department of Lands and Forests weather stations across Ontario.

Table 1 Distribution of days in each severity index class (using Fire Weather Index system)

Severity index Class	Range	% of days in this class
I	0.00-0.99	69.8
II	1.00-1.99	15.5
III	2.00-2.99	7.3
IV	3.00+	7.4
Total		100.0

A study was made of the number of forest fires (excluding grass fires) occurring from May 11 until September 20 (for 1963 to 1968, inclusive) within each of the SI classes, and the results are shown in Table 2.

Table 2 Forest fires by severity index (SI) class, 1963 to 1968 (using Fire Weather Index system)

SI class	SI class limits	No. of occurrences of SI value in this class*	No. of fires	No. of fires per day in each SI class
I	0.00-0.99	4627	1260	0.27
II	1.00-1.99	1028	505	0.49
III	2.00-2.99	484	309	0.64
IV	3.00+	491	882	1.80
Total		6630	2956	

*Average SI for all 85 stations for all years studied was 1.00.

As an additional part of this study, the preceding steps were duplicated by using Williams' Severity Rating System as applied to the older fire danger rating system (Anon, 1956). The maps drawn are not presented here, but the major differences in SI patterns discovered in using this older system versus the converted one are discussed in the next section.

Tables 3 and 4 deal with the same subject matter as the two previous tables, but the results were arrived at by using Williams' Severity Rating System.

Table 3 Distribution of days in each severity index class (using 1956 fire danger rating system)

Severity index		
Class	Range	% of days in this class
I	0.00-0.99	48.5
II	1.00-1.99	25.2
III	2.00-2.99	10.4
IV	3.00+	15.9
Total		100.0

In Table 4 the 10- or 11-day average SI was applied to any fires occurring in that time span, whereas in Table 2 the daily severity index on the day the fire occurred was used.

In both cases all SI values were calculated from data for the weather station for the forest division in which the fire occurred.

Table 4 Forest fires by severity index (SI) class, 1963 to 1968 (using 1956 fire danger rating system)

SI class	SI class limits	No. of occurrences of SI value in this class*	No. of fires	No. of fires per day in each SI class
I	0.00-0.99	3218	573	0.18
II	1.00-1.99	1669	830	0.50
III	2.00-2.99	687	398	0.58
IV	3.00+	1056	1155	1.09
Total		6630	2956	

*Average SI for all 85 stations for all years studied was 1.61.

RESULTS AND DISCUSSION

The maps in Figures A1 to A4, tracing SI distribution throughout Ontario during the "average" fire season, showed a definite pattern from mid-May through late September.

During the middle of May, SI values were uniformly low over almost all of Ontario, with Class I severity being widespread. During the next 11-day period, however, a noticeable increase in severity occurred especially in the eastern part of the Province.

This increase continued into early June with Class II severity now widespread and more severe areas developing in the far north. In mid-June SI values dropped off throughout most of Ontario with Class I severity common and Class II severity occurring mainly in the north. By late June, however, severity had increased drastically, with Class II values common, especially in the eastern half of the Province.

Throughout July the pattern of severity remained relatively fixed across Ontario. Class II severity was common in the northwest, while lower values (Class I) were almost exclusive in the north central and northeastern areas of the Province. However, at this same time, both south central and southern Ontario had a large percentage of Class III and Class IV severity.

During August and September, the SI dropped off sharply across the Province, with Class I severity very widespread, except in north-

western Ontario where the SI values were somewhat higher during both months.

The maps obtained by using Williams' Severity Rating System differed greatly from those shown for the month of May, with most of the Province under Class III and Class IV severity. Throughout the remainder of the fire season, however, the maps for both systems are strikingly similar, both showing the drop in severity in mid-June, as well as the slight severity increase in northwestern Ontario during August and September. The two SI systems for May differ because the old fire danger system (which was used in Williams' Severity Rating) had no correction for temperature and day length, whereas the FWI does. Dry but cool weather in May would produce higher SI values in the old system, but relatively lower values in the FWI.

The seasonal SI distributions for each year (Fig. A5 and A6) show that SI values in southern Ontario were in Class I or Class II during all years between 1963 and 1968. In the central and northern parts of the Province, however, seasonal SI values showed more annual fluctuation. In this respect 1967 looms as the most severe year with 1963 and 1966 as slightly less severe years (1963 showing higher severity in central Ontario and 1966, in the northwestern part of the Province). The years 1964, 1965, and 1968 were relatively insignificant from the standpoint of seasonal fire severity.

The severity rating system based on the FWI results in a substantially different distribution of SI values within the four classes outlined, with a significantly higher percentage of lower SI values occurring (Tables 1 and 3). Therefore, the overall average SI drops from 1.61 when using the old danger system to 1.00 with the FWI and, in the latter system, significantly more fires occur for each day the SI is in Class IV (Tables 2 and 4). An increase in fires per SI day with increasing SI class is also strongly evident.

The number of forest fires (grass fires excluded) between May 11 and September 20 for 1963 to 1968 was calculated from Provincial government fire statistics. Tables 5 and 6 deal with the number of fires occurring in various months and years in four geographic areas of Ontario: Northwestern Ontario (Kenora, Fort Frances, Thunder Bay, and Sioux Lookout districts), Northeastern Ontario (Geraldton, Kapuskasing, and Cochrane districts), Central Ontario (Sault Ste. Marie, White River, Chapleau, Swastika, Sudbury, and North Bay districts) and Southern Ontario (Pembroke, Parry Sound, Lindsay, Tweed, and Kemptville districts).

From Table 5, which shows the percentage of fires occurring in each area of Ontario each month (expressed as a percentage of the total number of fires occurring in that area over the six years studied), it is evident that fire occurrence and degree of severity are strongly related. During June severity is highest in the northeastern part of the Province

and 47% of this area's fires occur during this month. In Central and Southern Ontario, by far the greatest number of fires occur in July (51% and 48%) and severity is highest in these areas during this month. Northwestern Ontario also has high fire occurrence (33%) and severity at this time. In August and September, severity and fire occurrence are generally low throughout Ontario, although they are slightly above average, in the northwest (Table 5).

Table 5 Number and percentage of forest fires (grass fires excluded) occurring by month in four areas of Ontario (1963-1968)

	May 11-31		June 1-30		July 1-31		Aug. 1-31		Sept. 1-20		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
NW Ontario	123	12.0	232	22.7	333	32.6	251	24.5	84	8.2	1023	100.0
NE Ontario	20	9.0	103	46.6	66	29.9	21	9.5	11	5.0	221	100.0
Central Ontario	123	14.2	190	21.9	445	51.4	73	8.4	35	4.1	866	100.0
Southern Ontario	129	15.2	159	18.8	405	47.8	129	15.3	24	2.9	846	100.0

Table 6 shows the percentage of fires occurring annually in four areas of Ontario, based on the number of fires in that area from 1963 to 1968. On this basis 1963 shows up as a bad fire year in Northeastern Ontario and as a relatively bad year in Central Ontario. Northwestern, Central and Southern Ontario showed relatively high fire occurrence in 1964, while 1966 was a bad fire year in all four areas. Only Northwestern Ontario had a high fire occurrence in 1967, while the number of fires throughout Ontario dropped considerably in 1965 and 1968. The severity index distribution maps show that SI values are closely related to the fire occurrence distribution just outlined.

Northeastern Ontario has very few fires in comparison to the other areas, probably due in part to there being only three districts in this area and also to the preponderance of black spruce peatland in this part of the Province (Tables 5 and 6).

Table 6 Number and percentage of fires (grass fires excluded) occurring yearly in four areas of Ontario (May 11-Sept. 20 each year)

	1963		1964		1965		1966		1967		1968		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
NW Ontario	148	14.5	245	23.9	119	11.6	236	23.1	234	22.9	41	4.0	1023	100.0
NE Ontario	73	33.0	26	11.8	27	12.2	58	26.2	26	11.8	11	5.0	221	100.0
Central Ontario	169	19.5	185	21.4	64	7.4	268	30.9	130	15.0	50	5.8	866	100.0
Southern Ontario	64	7.6	236	28.1	122	14.2	219	25.9	101	11.9	104	12.3	846	100.0

CONCLUSIONS

From the six years studied, it appears that highest SI values occur in Central and Southern Ontario during late June and the month of July. Fire severity is generally less pronounced in the north with relatively high values occurring in late May and early June. The northwest part of the Province is the only area showing even moderately high severity during August and September.

SI distribution is relatively similar, when using both danger rating systems, over most of the fire season--the only significant difference occurring in May when SI values are considerably lower when using the newer, converted SI system based on the FWI.

An analysis of fire statistics for Ontario for this period shows fire occurrence in various areas of the Province increasing with increasing SI, both on a monthly and a yearly basis. Results also show more fires occurring for each day that the SI is in higher severity classes.

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Van Wagner, C.E. 1970. Conversion of Williams' Severity Rating for use with the Fire Weather Index. Dep. Fish. Forest., Can. Forest. Serv., Petawawa, Ontario. Inform. Rep. PS-X-21.

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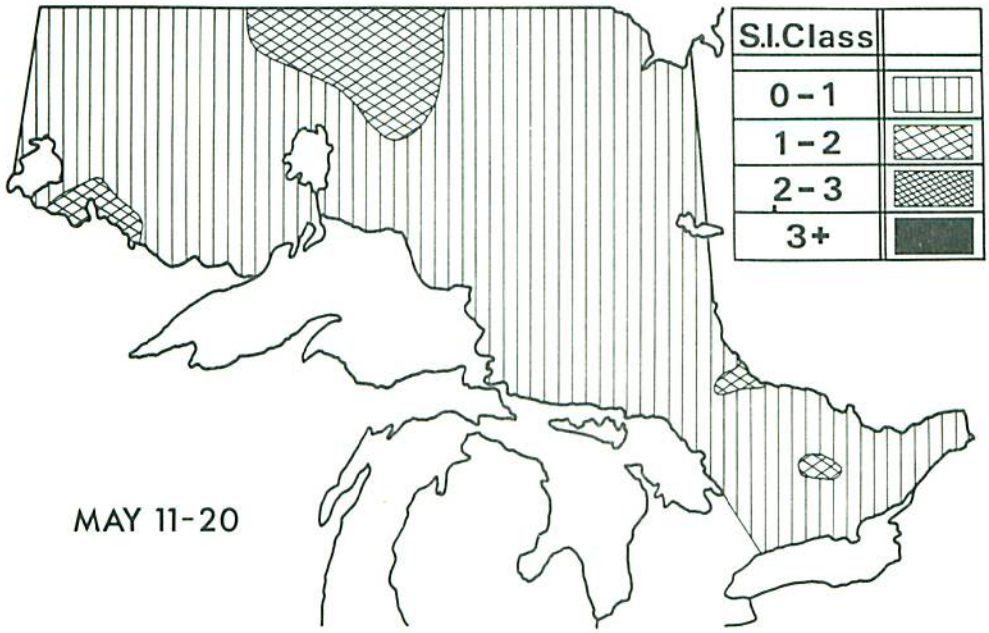
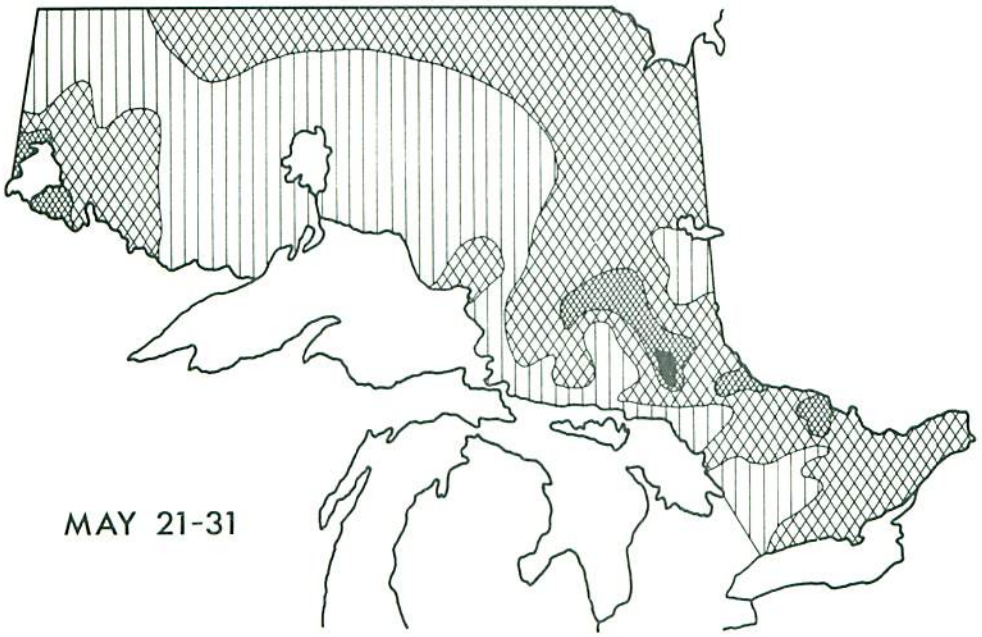
APPENDIX

Figure A1. Average severity index distribution in Ontario (1963 to 1968) from May 11 to June 10.


S.I.Class
0-1
1-2
2-3
3+
MAY 11-20


MAY 21-31

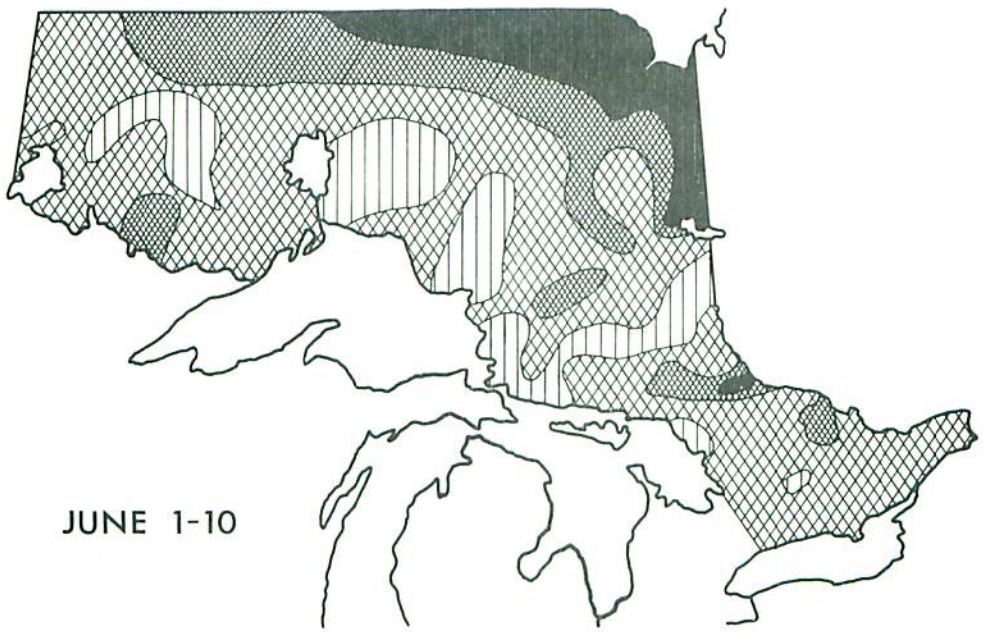

JUNE 1-10

Figure A2. Average severity index distribution in Ontario (1963 to 1968) from June 11 to July 10.

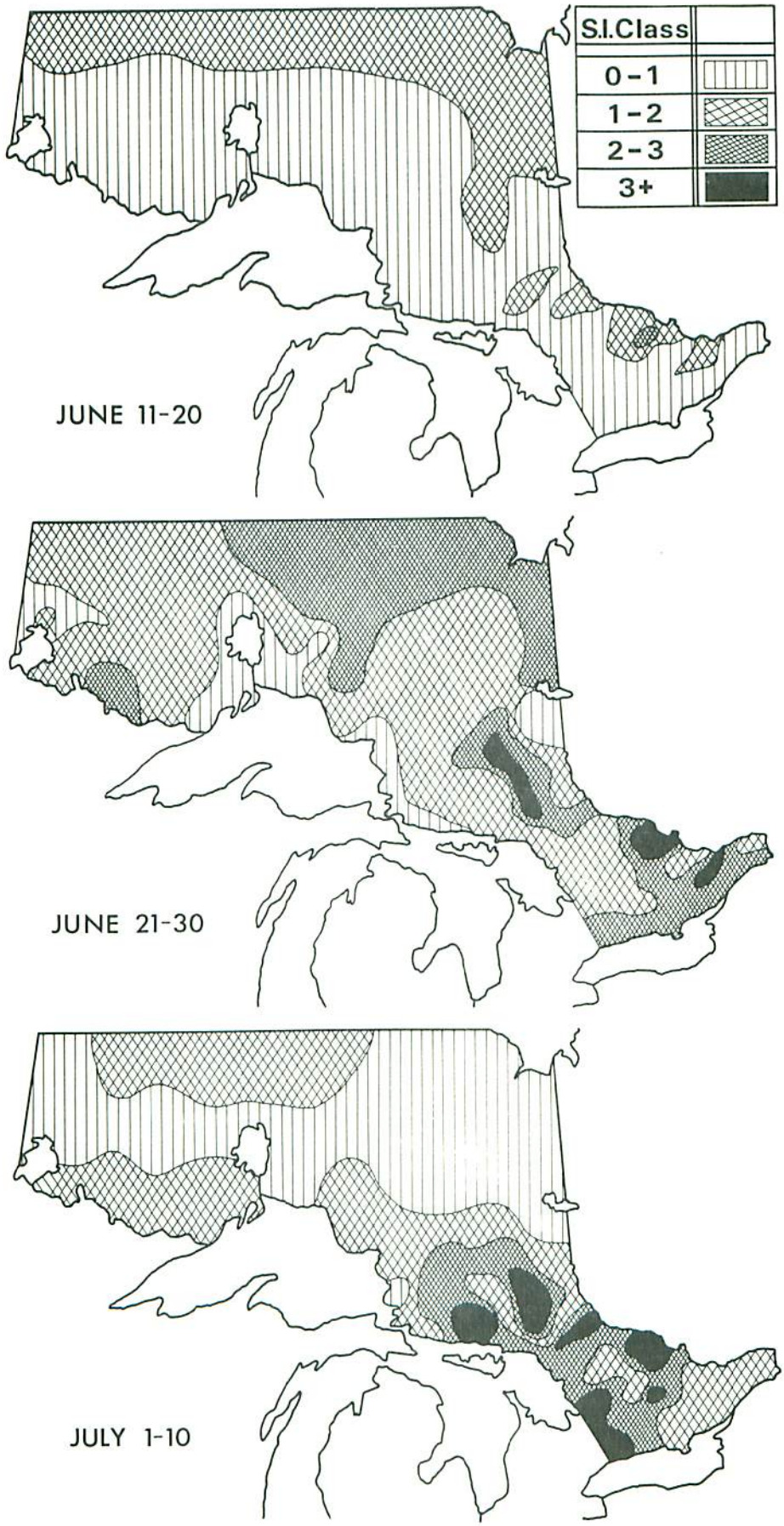

S.I.Class
0-1
1-2
2-3
3+
JUNE 11-20
JUNE 21-30
JULY 1-10

Figure A3. Average severity index distribution in Ontario (1963 to 1968) from July 11 to August 10.

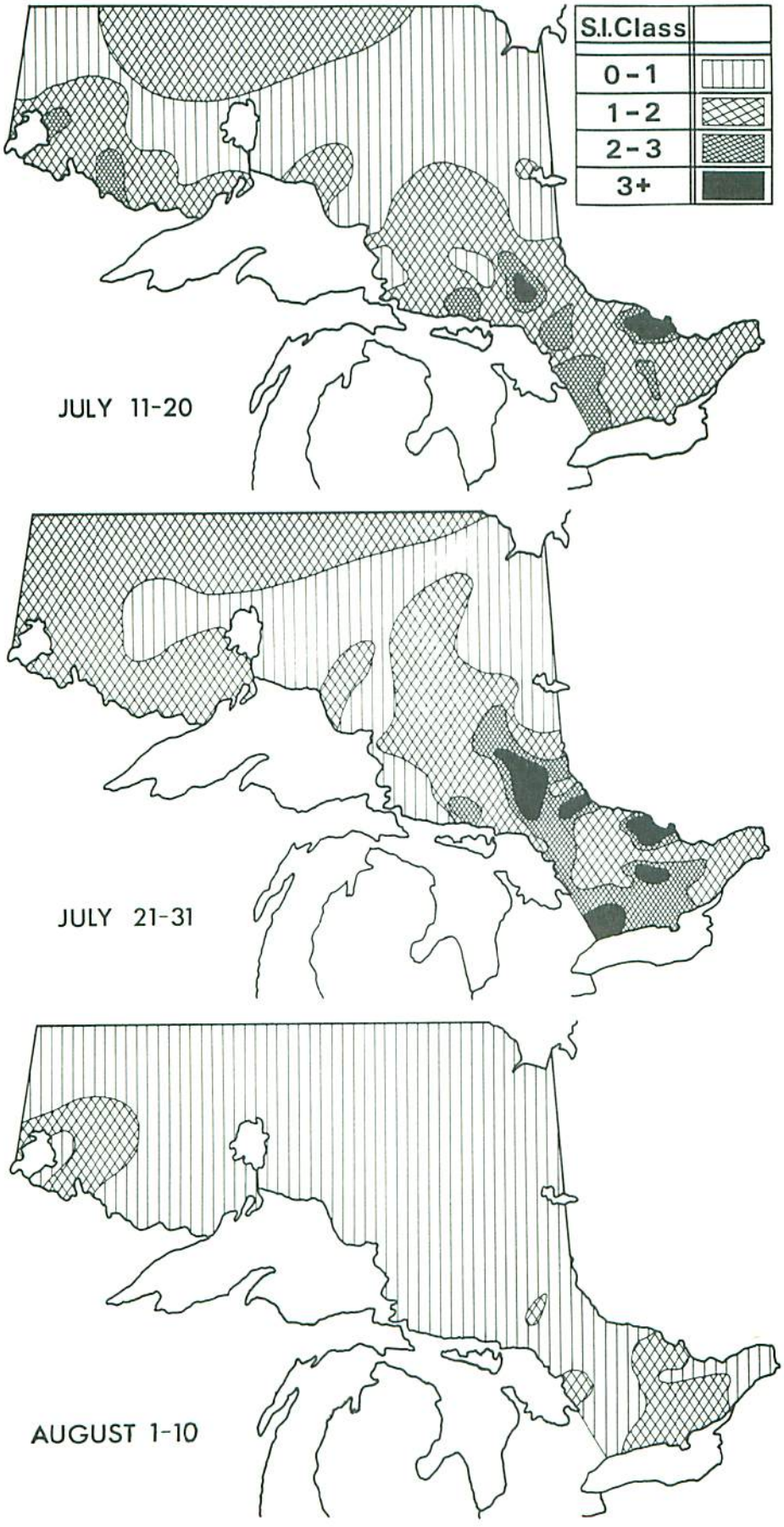

S.I.Class
0-1
1-2
2-3
3+
JULY 11-20
JULY 21-31
AUGUST 1-10

Figure A4. Average severity index distribution in Ontario (1963 to 1968) from August 11 to September 20.

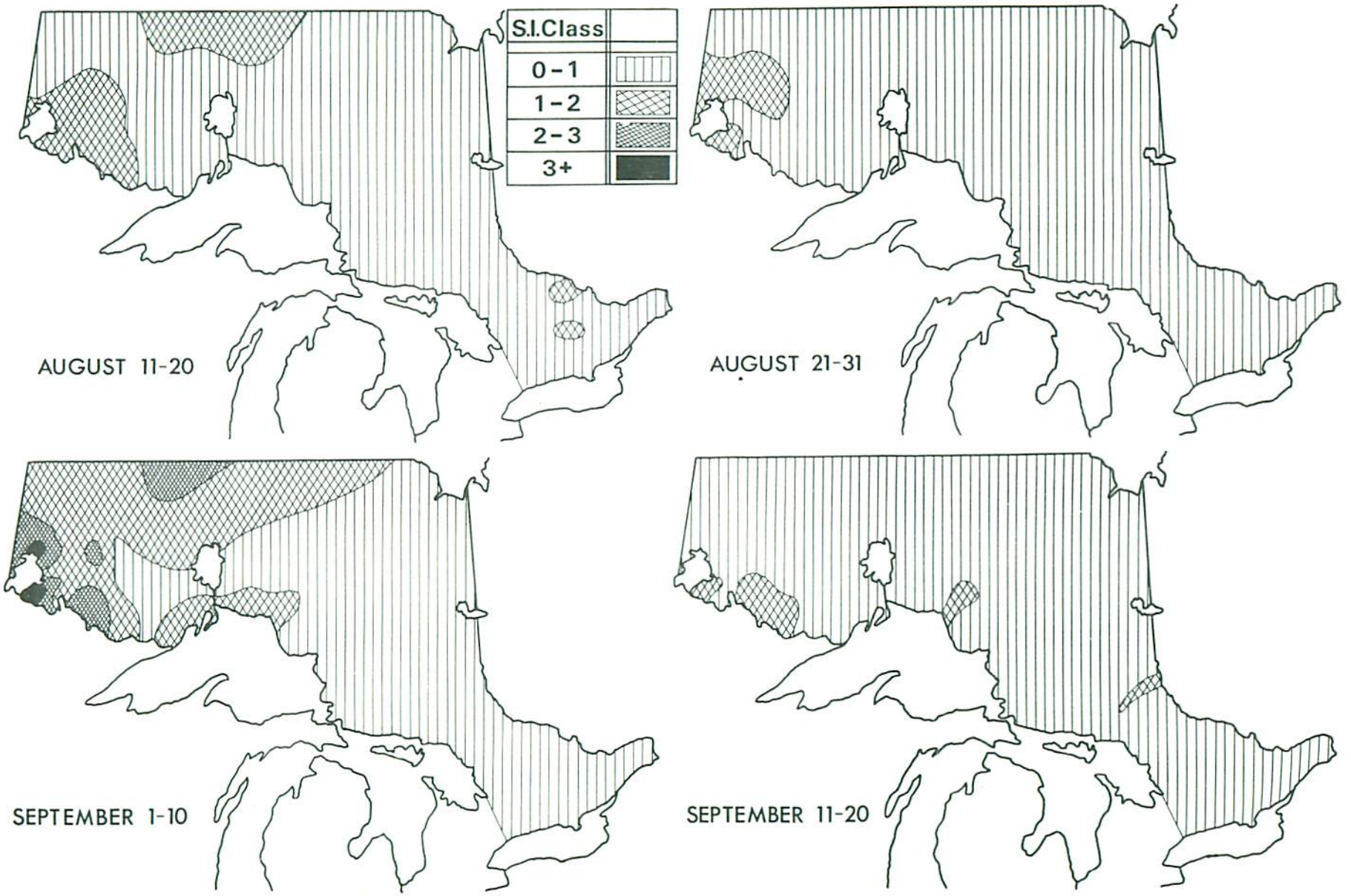

S.I.Class
0-1
1-2
2-3
3+
AUGUST 11-20
AUGUST 21-31
SEPTEMBER 1-10
SEPTEMBER 11-20

Figure A5. Average annual severity index distribution in Ontario for 1963, 1964, and 1965.

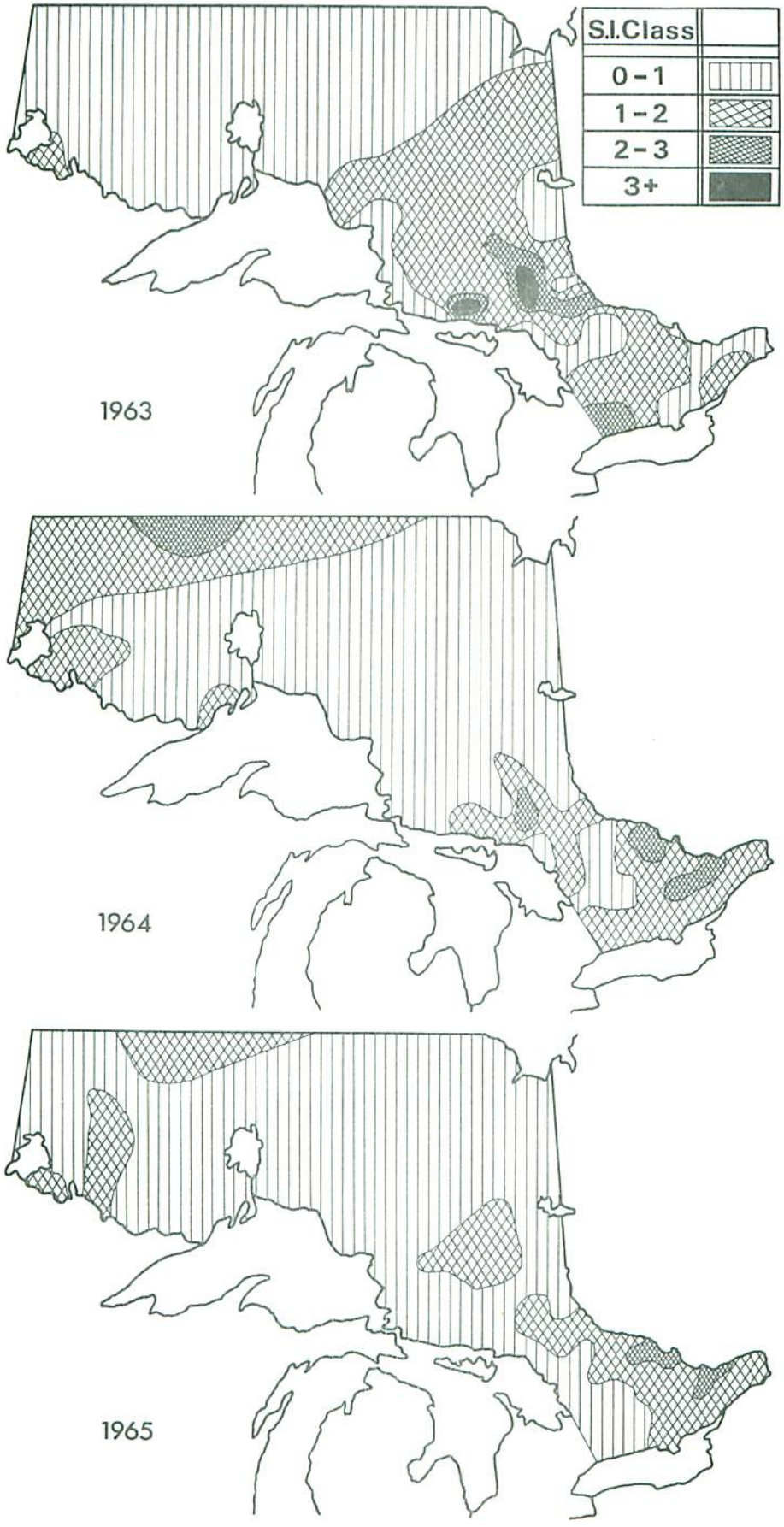
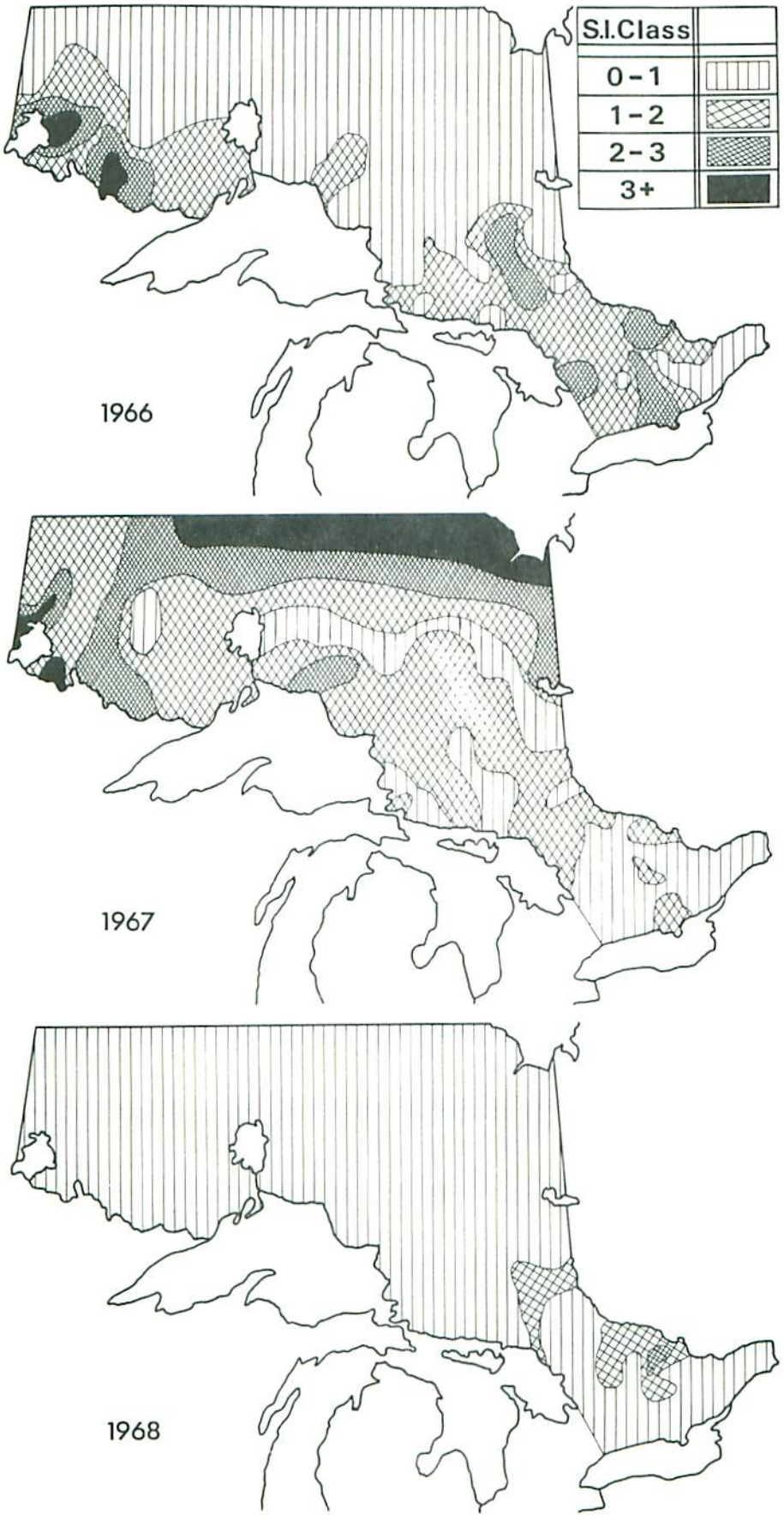

S.I.Class
0 - 1
1 - 2
2 - 3
3+
1963
1964
1965

Figure A6. Average annual severity index distribution in Ontario for 1966, 1967, and 1968.


S.I.Class
0-1
1-2
2-3
3+
1966
1967
1968