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Forest fires, a historical perspective

Fire History of a Michigan Jack Pine Forest

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Fire has always been part of jack pine (*Pinus banksiana*) ecosystems. Jack pine is reported to have developed cone serotiny several million years ago (Yeatman 1967). Examination of lake silt in the Boundary Waters Canoe Area (BWCA) in Minnesota disclosed high charcoal levels associated with a predominance of jack and red pine between 6,000 and 9,000 years ago (Swain 1972). The sediments indicate gradually decreasing charcoal levels associated with the transition to the present day Great Lakes and boreal forest communities. Swain (1972), when examining sediments accumulated over the past 1,000 years, found charcoal maxima in the BWCA at 1300 and 1400 AD, an 80-year peak between 1670 and 1750, and a subsequent decline to present day low levels. From this, Heinselman (1973) concluded that "fire was a major factor in northern Minnesota's forest ecosystems long before the arrival of European man." There is every reason to believe that the same holds true for the northern half of the Lower Michigan peninsula.

Methods

Although jack pine is associated with fire, the species is fire sensitive. A fire of sufficient intensity to scar a jack pine tree is highly likely to kill the tree. Thus, long-term dendrochronological records are difficult to obtain in jack pine stands. The Mack Lake Fire of May 5, 1980, which burned nearly 24,000 acres in northern Lower Michigan, provided an opportunity to develop a 160-year fire history of a present-day jack pine stand. In addition to killing most of the jack pine, the fire also killed several scattered red pine (*Pinus resinosa*) trees that had been established in the 1820s.

In conjunction with the salvage operation in 1980, cross-sections (1 foot above the ground) of 20 red pine trees from eight groups were obtained. These groups of 2 to 3 trees each were taken from areas ranging from 1 to 10 acres in size. The eight groups were obtained from a 4 × 8 mile (20,000 acres) sample area (Figure 1). Fourteen cross-sections were sufficiently complete to provide usable data. The remaining six were used to cross-check the 14 trees, to the extent possible.

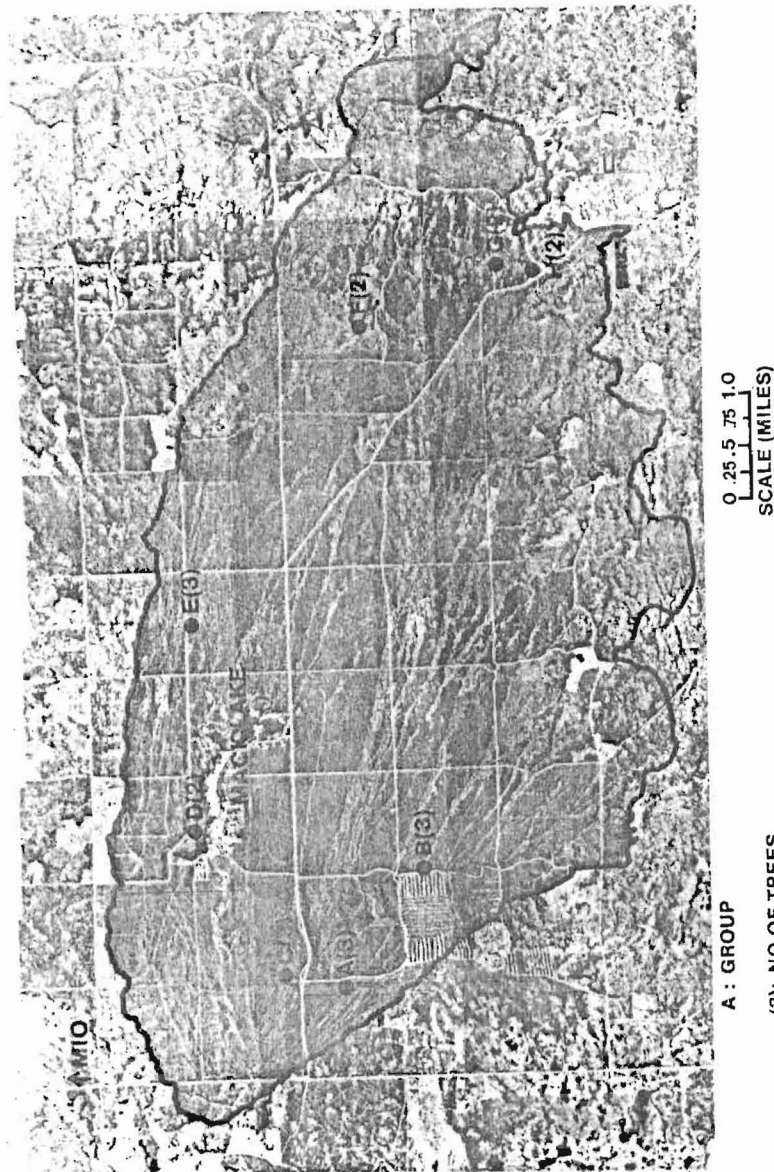


FIGURE 1. Location of red pine trees used for cross-sections.

Each section was sanded and some were coated with polyurethane to highlight the growth rings. At least three persons counted rings along three radii; then individual results were compared. Discrepancies were resolved by recounting until a consensus was achieved. For unusually difficult cross sections, tree growth was correlated with annual precipitation to check counting accuracy. When fire scars on trees in the same group were offset by one or two years, growth patterns on the trees were cross-matched to verify dates. All consecutive dates within a group (e.g., 1885, 1886, Group E, Table I) were verified by multiple scars on the same tree. Even when years matched, however, it was not possible to differentiate between a fall fire after growth stopped and a spring fire before growth started. In view of the methodology, the accuracy of fire scar dates should be ± 1 year.

Dendrochronological Record

Eighty-three scars were found on the 14 trees (average = 5.9 scars per tree). The mean fire interval for an individual tree was determined by

TABLE I
YEARS WITH FIRE SCARS IN THE MACK LAKE AREA BY TREE GROUP

	Group							
	A	B	C	D	E	F	G	H
Seedling*	1824	1826	1877	1890	1824	—	1826	1860
Fire	1839	1854	1886	1908	1872	1914	1857	1873
Scar	1852	1862	1926	1946	1883	1924	1862	1874
Years	1862	1874	1946	1980	1885	1938	1874	1886
	1874	1890	1958		1886	1946	1888	1892
	1886	1892	1980		1890	1980	1899	1899
	1895	1902			1903		1914	1913
	1899	1909			1948		1926	1914
	1907	1917			1980		1946	1980
	1913	1926					1950	
	1980	1980					1980	
Intervals†	10	10	5	3	8	4	10	8
Group Age‡	159	157	106	93	159	66	157	123
Mean Interval	15.9	15.7	21.2	31.0	19.9	16.5	15.7	15.4

*Average seedling year for all trees within each group.
 †Including the interval between seedling year and first scar, if known.
 ‡1980 - seedling year + 3 years.

dividing the period of record for each tree¹ by the number of intervals on the tree (including the interval between seedling establishment and the first scar, if known). The range in individual tree fire intervals was 15.1 to 33.2 years. The mean was 24.7 years with $s = 5.8$ years. These results are similar to the 29-year mean fire interval between 1727 and 1877 found by Alexander et al. (1979) for a single red pine tree near Sault Ste. Marie, Ontario.

Group fire scar data are listed in Table I and plotted in Figure 2. Because most fires did not scar every tree in a group, the number of fire scars per group is larger than that per tree. Thus, the mean small area (5 acre) fire interval is 18.9 years with $s = 5.4$ years.

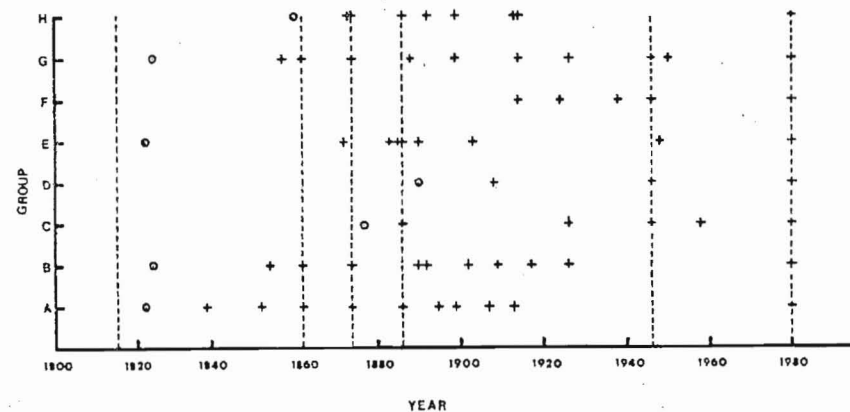


FIGURE 2. Fire scar years by group. Crosses are fire scars, circles are average seedling date, and vertical dotted lines are probable large fires.

Thirty-two fire scar years were found, indicating at least 32 fires in the sample area during the 160-year period of record. To determine fire frequency for the 20,000-acre sample area, however, fire scars resulting from more than one fire in a single year have to be identified. Scars in 4 years (1874, 1886, 1946, and 1980) were noted in four or more groups and were assumed to be caused by a single fire.² Scars in 1862 and 1914, which were noted in three groups, were also assumed to result from single fires because they occurred in a majority of groups (1862) or in adjacent

¹The age of the tree (seedling age plus 3 years) if the center was sound or the period since the first fire scar if there was no center.

²Although records indicate that five separate fires were reported in 1946 totaling 14,350 acres, they all resulted from debris burning and burned on the same day. We therefore classed them as one large fire.

groups (1914). Those in 1899 and 1926, however, were assumed to have resulted from two fires (widely separated groups). Finally, the 3 years with two scars (1890, 1892, 1913) were in widely separated groups and were assumed to have resulted from two fires. Therefore, there were probably 5 years in which fire scars resulted from two fires, bringing the total number of fires to 37. Thus, the mean fire frequency for the Mack Lake area for the period of record is 1 fire/4.2 years/20,000 acres.

To determine whether the fire interval varied during the period of record, the length of the interval between fire scars for each group³ was plotted against the midpoint of the interval (Figure 3). The data were stratified into seven 20-year time groups; also, an average small area interval and standard deviation were determined for each group (Table II). The results agree with what would be expected based on the area's

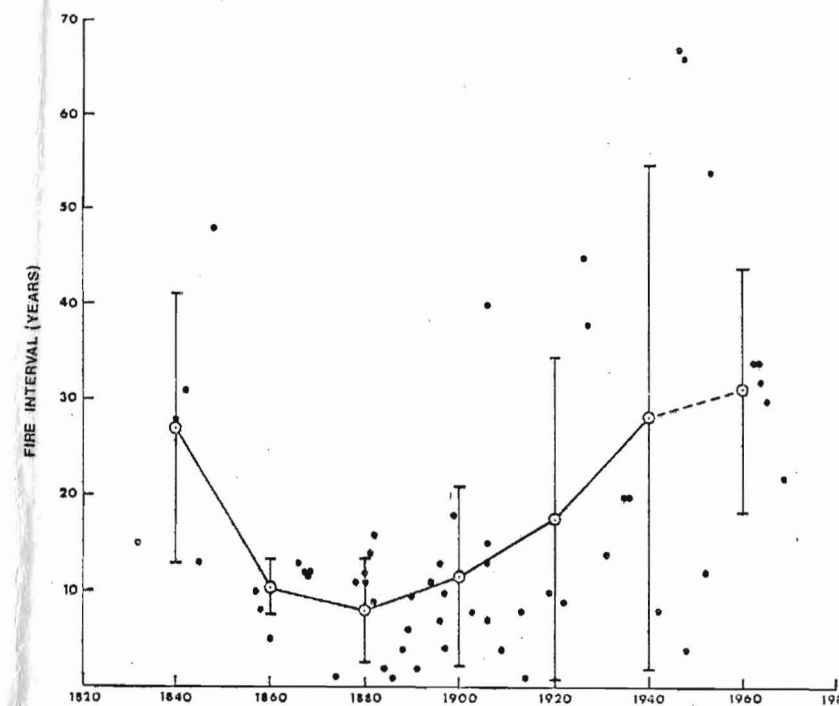


FIGURE 3. Length of fire interval versus midpoint of interfire interval. Circles are averages for each 20-year period. Vertical lines indicate the standard deviation for each 20-year period.

³Group data were used because they are considered more reliable than individual tree data. The latter would yield the same general pattern, but with a longer average interval and larger s .

TABLE II
AVERAGE FIRE INTERVAL ON A 5-ACRE SITE
IN THE MACK LAKE FIRE AREA

Period	Number of Fire Intervals	Fire Interval (Years)	Standard Deviation (Years)
1830-1849	5	27.0	14.1
1850-1869	7	10.3	2.9
1870-1889	11	8.0	5.4
1890-1909	14	11.6	9.4
1910-1929	7	17.6	16.8
1930-1949	7	28.4	26.7
1950-1969	7	31.1	12.8
Total/Average	58	19.1	

settlement and fire suppression history. Four fire occurrence periods can be identified: presettlement, settlement, early suppression, and recent.

The mean fire interval (27 years) during the presettlement period (1830-1849) was significantly longer (at the 95 percent confidence level) than that during the settlement period. Note, however, that presettlement data are limited—only one fire scar (in 1839) was found before 1850. Further, the samples suggest that existing trees would have been young before settlement and therefore more subject to being killed rather than injured by fire. Thus, it is reasonable to hypothesize that the small area fire interval before settlement may have been shorter than is indicated by the data.

During the settlement period (1850-1909) the mean fire interval (10 years) was shorter than those during the 1930-1949 and 1950-1969 periods (at the 90 and 99 percent confidence levels, respectively). During the early suppression period (1910-1929) the average fire interval (18 years) was longer than the shortest settlement interval (8 years) and shorter than the longest recent interval (31 years), at the 90 percent confidence level. Although other differences between the early suppression period and the preceding and succeeding periods are not statistically significant, they were felt to be large enough to warrant a separate classification (transition period). The recent (1930-1969) small area fire interval (30 years) is not significantly different from that before settlement. Note, however, that the latest interval (1950-1969) is biased downward since all samples were taken in the Mack Lake Fire area. A similar sample taken from outside the burned area at some future date

would probably indicate a longer interval between fires than the data show.

Although fire frequency is inversely related to fire interval, the two measures of fire occurrence are not mirror images. Fire frequency is based on a smaller sample (in this case, 37 fires) than is fire interval, for which each scar represents a data point (in this case, 83 scars). The effect of the difference in samples is particularly evident during the presettlement period. That four groups originated in the 1820's and that the earliest individual seedling date found was 1817 indicate that there was probably a large fire c. 1815. Adding this fire to the 1839 fire scar yields a presettlement fire frequency of 1 fire/17 years/20,000 acres. This is only one-sixth of the settlement frequency (1 fire/2.6 years/20,000 acres). In contrast, there were five fire interval observations (not counting the probable 1815 fire) during the presettlement period, which yields a mean interval only three times greater than that during settlement. The authors believe that fire interval represents the presettlement/settlement fire occurrence ratio better than does fire frequency.

The early suppression (transitional) fire frequency (1 fire/2.9 years/20,000 acres) is nearly the same as the settlement frequency, in contrast to the transitional fire interval, which is nearly 80 percent greater than that during settlement. The recent fire frequency (1 fire/8.3 years/20,000 acres) is one-third that during settlement. This ratio is the same as that for fire interval.

A 250-year fire history of the Boundary Waters Canoe Area (BWCA) in Minnesota (Heinselman 1973) provides further evidence of a changing fire occurrence pattern (Table III). Between 1730 and 1869, there were 33 years in which at least one fire occurred somewhere in the half-million-acre BWCA study area (2.4 fire years/decade). Between 1870 (when settlement began) and 1929, 25 fire years were noted (4.2 fire years/decade). Finally, only 3 fire years occurred between 1930 and 1971 (0.7 fire years/decade). In the Mack Lake area, 2 fire years were noted between 1815 and 1849 (0.6 fire years/decade); 25 years between 1850 and 1929 (3.1 fire years/decade); and 6 fire years between 1930 and 1980 (1.2 fire years/decade).

Although the two data sets are not comparable in an absolute sense,⁴ the relative trend in fire-year frequency (low during presettlement, high during settlement and early suppression, and low during recent decades) is similar in both areas. Current frequencies are one-sixth (BWCA) and just over one-third (Mack Lake) of the settlement frequencies. Heinsel-

⁴The fire-year frequency per unit area is much higher at Mack Lake than in the BWCA. Extrapolation of fire years from small to large areas is constrained by the fact that at some finite area, the probability of a fire year is 1.0. Extrapolation from large to small areas is complicated by multiple fire occurrence in a single year.

TABLE III
NUMBER OF FIRE YEARS BY 20-YEAR PERIODS

Time Period	Boundary Waters Canoe Area (Minnesota)	Mack Lake (Michigan)
1730-1749	3	—
1750-1769	5	—
1770-1789	2	—
1790-1809	8	—
1810-1829	6	1
1830-1849	4	1
1850-1869	5	4
1870-1889	11	7
1890-1909	6	9
1910-1929	8	5
1930-1949	1	3
1950-1969	1	2
1970-1980	1 (1971)	1 (1980)

man's data indicate a threefold decrease in fire-year frequency in the BWCA today relative to presettlement, whereas the recent frequency at Mack Lake is double the presettlement level. The presettlement data at Mack Lake are limited (implying a probable higher frequency), while bias results from sampling in the Mack Lake Fire area (implying a lower recent frequency), so the real ratios in the Mack Lake area are probably between those indicated by the data of this study and those of Heinselman.

Heinselman found that the average interval between "major" fire years (which he defined as 100 or more square miles burned in one year) was 28 years before settlement and 21 years during settlement. A major fire has not occurred in the BWCA since 1910. At Mack Lake, the definition of "large" fire is limited by the size of the sample area. A fire which covered half of the area would have burned 10,000 acres. Because the total area burned outside of the study area was not determined, a "large" fire was defined as 10,000+ acres. There are six probable large fire years at Mack Lake (1815, 1862, 1874, 1886, 1946, and 1980). The mean large fire interval over the past 165 years is 27.5 years. The trend in large fire interval at Mack Lake before settlement (35 years) and during settlement and early suppression (27 years) is similar to that in the BWCA. The interval for the recent period (25 years) contrasts markedly with the BWCA.

TABLE IV
AVERAGE ANNUAL AREA BURNED ON THE HURON
NATIONAL FOREST BY DECADE

Decade	Annual area* burned (acres)	No. of years with 10,000+ acres burned
1910s	13,000	7
1920s	4,730	3
1930s	1,951	1
1940s	2,423	1
1950s	224	0
1960s	243	0
1970s	384	0

*Data for 1962-1978 are estimates based on 43 percent of the total area burned for the Huron and Manistee National Forests.

Historical Record

Records of wildfires on the 415,000 acre Huron National Forest indicate the dramatic impact that organized fire control has had on area burned (Table IV, Figure 4, USDA Forest Service 1980, USDA Forest Service Annual Report). The average annual area burned decreased from 13,000 acres during the first decade of the transitional period to 4,700 acres during the second decade. The number of years per decade in which 10,000 or more acres burned in one year decreased similarly from 7 to 3.

The historical record indicates a tenfold decline in average annual area burned between the first two decades of the suppression period (2,200 acres) and the next two decades (230 acres). Although this appears to contrast with the insignificant increase in the small area interval noted during the same period (28 to 31 years—Table II), adding the 23,800 acre Mack Lake Fire to the total area burned during the past 31 years increases the average annual area burned since 1950 to 1,042 acres. Noting further that the current fire interval is probably longer than that indicated by the data, these results are not as dissimilar as they appear.

The fire size-class distribution for the Huron-Manistee National Forests between 1960 and 1977 is typical of Northeastern forests (Table V). The vast majority of fires (98.7 percent) are less than 100 acres in size. Past data indicate that slightly less than half (43 percent) of the total area burned is on the Huron side of the Huron-Manistee National Forest. Thus, only four 100-acre or larger fires occurred between 1960 and 1977 on the Huron National Forest, or an average of one every 4.5 years.

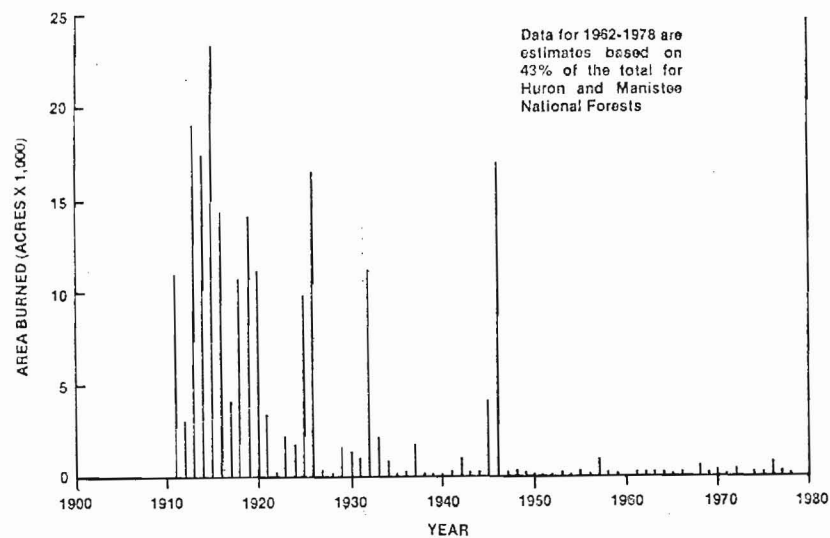


FIGURE 4. Area burned on the Huron National Forest by year.

The seasonal distribution of area burned by jack pine crown fires from 1964 to 1975 in a four-county area surrounding the Huron National Forest is shown in Figure 5.⁵ There are three pronounced features of the seasonal pattern:

1. Four times more area has burned during the second week of May than in any other week of the year. There have been more than twice as many large crown fires in this week than in any other. Fires in this week account for 58 percent of the total area burned by crown fires throughout the entire season. Note that the Mack Lake Fire (which is not included in the preceding statistics) occurred on May 5th.
2. There have been no crown fires during June and the first three weeks of July. This coincides with the period when living surface vegetation is "green."
3. Throughout the remainder of the fire season, crown fires have occurred in about half of the weeks. Each has burned from a few hundred to a few thousand acres.

Summary and Conclusions

Fire has been part of jack pine ecosystems for millions of years. Fire scars on scattered red pine trees from a predominantly jack pine forest in

⁵Data provided by the Michigan Department of Natural Resources.

TABLE V
FIRE SIZE-CLASS DISTRIBUTION FOR THE
HURON MANISTEE NATIONAL FOREST (1960-1977)

Class	Size (acres)	Number	Percent
A	0.00- 0.25	261	37.7
B	0.25- 9.00	350	50.6
C	10.00- 99.00	72	10.4
D	100.00-299.00	5	0.7
E	300+	4	0.6
	Total	692	100.0

Northern Lower Michigan indicate that over the past 160 years, the mean interval between fires for an individual tree was 25 years and for a small area (5 acres), 19 years. The fire frequency during the period of record for the sample area was 1 fire/4.2 years/20,000 acres.

The small area fire interval was 27 years before settlement, 10 years during settlement (1850-1909), 18 years during early suppression (1910-1929), and 30 years since 1930. The settlement interval is significantly less, at the 95 percent confidence level, than the presettlement and recent intervals. Although the current fire interval does not differ significantly from that before settlement, the former is likely longer and the latter shorter than indicated by the data. Fire frequency has varied from 1 fire/17 years/20,000 acres prior to settlement, to 1 fire/2.7

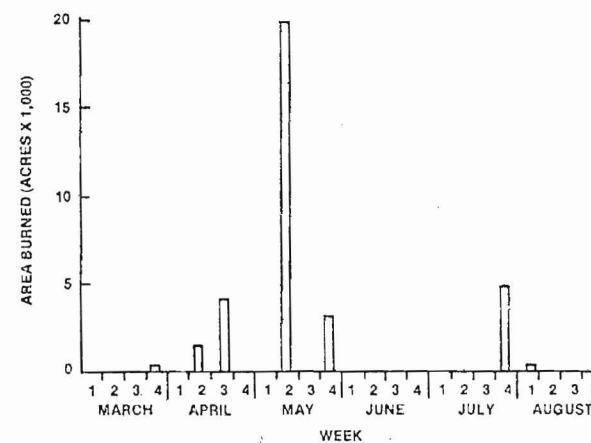


FIGURE 5. Area burned by jack pine crown fires larger than 175 acres in four counties surrounding the Huron National Forest (1964-1975).

years/20,000 acres during settlement and early suppression, to 1 fire/8.3 years/20,000 acres since 1930.

There have probably been six large (10,000+ acres) fires in the Mack Lake area since 1815, or one every 27.5 years. The large fire interval has varied only slightly from 35 years before settlement, to 27 years during settlement and early suppression, to 25 years during recent decades.

From a historical perspective, large wildfires in the Mack Lake area are not rare. From a human perspective, however, even moderately large fires are so infrequent that local fire managers have little opportunity to gain experience with fire control operations beyond routine small fires. The problem is exacerbated by personnel transfers which sometimes occur more frequently than do 100-acre fires. Therefore, the need for preplanning and frequent training in controlling large fires in this region is critical, perhaps even more so than in areas where large fires are more frequent. Further, the period from May 5 to 15 appears to be particularly critical in terms of the probability of occurrence and extent of crown fires. Additional fire management precautions during this period may be warranted.

Large crown fires have always been and probably always will be an intermittent fact of life in jack pine ecosystems. Fire managers must plan on a scale appropriate to the phenomenon. Community evacuation plans and quarter-mile-wide fuel breaks cannot be developed when a fire starts to run. Fire managers must also maintain a historical perspective. For three and one-half decades, the area burned by wildland fire on the Huron National Forest was held to the lowest level in recorded history. It may have been the lowest level since the glaciers retreated more than 9,000 years ago. Nature, however, has a way of reasserting itself. On May 5, 1980, more acreage was burned in twelve hours than in any single year since 1911. The Mack Lake Fire burned more than three times the total area that had been burned in the previous 34 years. We must not allow the passage of time to cloud the memory of the fire potential of Michigan's jack pine forests.

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