QUATERNARY RESEARCH 3, 397-407 (1973)

The Importance of Fire as a Natural Ecological Factor in Itasca State Park, Minnesota

SIDNEY S. FRISSELL, JR.[1]

Received April 16, 1973

During the period between 1650 and 1922 at least 32 fires occurred in Itasca State Park. Twenty-one of these fires were of major consequence. A fire occurred on the average of every 8.8 yr with "major" fires every 10.3 yr. Any specific location in the park was affected by fire about every 22 yr.

Individual burns varied in size from 580 acres to approximately 31,960 acres (99% of the park). Sixteen of the 21 "major" fires resulted in the regeneration of pine forests.

Management programs involving intensive fire control have resulted in a serious departure from natural conditions.

INTRODUCTION

The North American wilderness as it existed before the coming of European man has frequently been described as an endless expanse of undisturbed forest. It has become increasingly evident, however, that this is not an accurate representation of the situation. In fact, much of the forest was subject to and, indeed, dependent upon disturbance. Research results from almost every major forest region indicate that wildfire played a dominant role in forming and maintaining the character and pattern of the primeval biotic communities. This has certainly been the case in the Lake States.

Maissurow (1941), in an extensive study of the vegetation of northern Wisconsin, noted that 95% of the virgin forests had been burned within the last five centuries. He concluded that these fires were not "conflagrations of catastrophic proportions which destroyed the primeval forest and changed its climax formations into subclimax types of the present era." He suggested that more likely these fires were "periodic and ecologically normal events in the life of the forest."

In consideration of the apparent significance of fire in shaping the presettlement forests of the region, a portion of a major study of the management of Minnesota's Itasca State Park was devoted to detailed documentation of the role of fire.

THE STUDY AREA

Itasca State Park consists of 12,972 hectares (32,054 acres) of land and water within Hubbard, Clearwater, and Becker counties of northwestern Minnesota at approximately 47 degrees north latitude and 95 degrees west longitude (Fig. 1). The Park is located in an area of glacial moraine and is characterized by "knob and kettle" topography, with elevational variations of up to 91 m (300 ft). The maximum elevation is 517 m (1700 ft) above sea level at a point in the south-central part of the area. Lake Itasca and its tributaries form the headwaters of the Mississippi River.

EARLY INHABITANTS

Archaeological studies have revealed that the Itasca area was probably first occupied by man about 8000 y.a. These ancient

[1]School of Forestry, University of Montana, Missoula, Montana 59801.

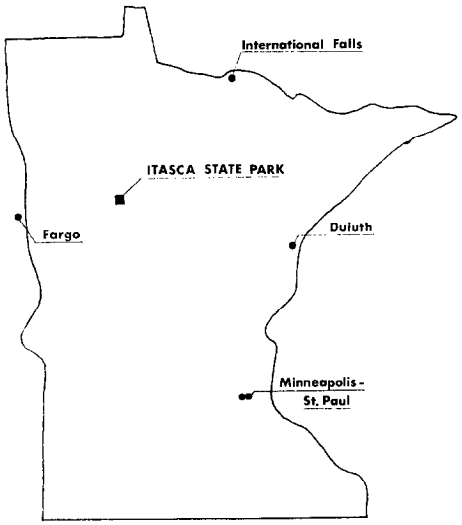

FIG. 1. Location of Itasca Park, Minnesota.

hunting and gathering people camped at various points near Lake Itasca and killed a now extinct species of bison (Shay, 1971). Whether the Itasca area was continuously occupied by Indians from 8000 y.a. until the coming of European man is not known. However, several habitation sites have been discovered which indicate that the area was occupied by the Sioux during the 18th century.

EXPLORATION

Some question exists as to the identity of the first whiteman to visit Itasca. The first to publish a written account of his visit was Henry R. Schoolcraft, who visited Itasca in 1832 (Schoolcraft, 1855). There is a good possibility that he was preceded by fur traders who were known to be in the area in the late 1700s.

During the 19th century, Itasca was visited by a long series of explorers and adventurers, indulging in the then fashionable pursuit of the "true source" of the Mississippi. Many of these early visitors left us with written records that add to our knowledge of the appearance of the Itasca region prior to serious disturbance by modern man.

Lake Itasca and its environs were formally established as a state park on April 20, 1891.

VEGETATION

Itasca is uniquely located in an area where several major vegetation associations merge. Küchler (1964) shows the Itasca area as "Great Lakes Pine Forest." Actually, four of Küchler's vegetation types occur in the park. A major portion is in the "Great Lakes Pine Forest" type, consisting of jackpine (*Pinus banksiana*), red pine (*P. resinosa*), and white pine (*P. strobus*) as dominant species.

The second most prevalent type is the "Maple-Basswood Forest" dominated by sugar maple (*Acer saccharum*) and basswood (*Tilia americana*). Ironwood (*Ostrya virginiana*), red oak (*Quercus rubra*), bur oak (*Q. macrocarpa*), and American elm (*Ulmus americana*) are also common in the Maple–Basswood type.

In addition to these two major types, two more of Küchler's vegetation categories occur within the park. Both of these types are more common to the north and east of the Itasca area. The "Conifer Bog Type," consisting of tamarack (*Larix laricina*), black spruce (*Picea mariana*), and white cedar (*Thuja occidentalis*), is found in wet depressions and boggy areas, seldom in stands larger than one or two acres. The "Great Lakes Spruce–Fir Forest" of balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*) is present in small stand units and is also a common understory within the jack, red, and white pine forests.

Investigations of historic journals, land-survey records, and on-the-ground study of remnant virgin stands indicate that before settlement the forests of the Itasca area were composed primarily of a mixture of aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*) with red, white, and jack pine stands (Frissell, 1971). These so-called "subclimax" species have several ecological characteristics in common. Seeds of these species germinate most successfully on mineral soil. Within a mature as-

pen–birch or pine stand the conditions requisite for regeneration of these species are frequently lacking. Those seedlings that do develop generally soon die from drought as their slow-growing root systems attempt to penetrate the organic material and reach moisture sources in the mineral soil.

All of these species are rather intolerant of shade. Overstory trees in a mature forest cast sufficient shade to seriously inhibit the growth of aspen, birch, and pine seedlings and frequently preclude their survival.

Under the conditions described above, a stand of aspen, birch, red pine, white pine, or jack pine can seldom regenerate itself on an undisturbed site. Species with seedlings that can become successfully established on organic material and that are shade-tolerant generally begin to develop instead. In time the site is taken over by these more adaptable species. In the Itasca Park area these are ironwood, red maple (*Acer rubrum*), sugar maple, and red oak, or an intermediate shrub stage that is then followed by hardwoods. In some situations white spruce and balsam fir may develop (Buell and Martin, 1961; Buell, 1955; Buell and Gordon, 1945).

In presettlement time this successional trend toward northern hardwoods or spruce-fir was arrested by periodic natural catastrophies. These catastrophies created the conditions necessary for successful regeneration of aspen, birch, and the pine species. It is these natural disturbances that account for the mixture of types and variety of age classes typical of the forests of Itasca State Park.

In the presettlement forest of Itasca Park the predominant factors responsible for catastrophic disturbances were wind, insects, disease, and fire. With the exception of white pine blister rust, a recently introduced exotic, there is no record available of major insect or disease epidemics that would have seriously affected the successional patterns in Itasca. Catastrophic winds have been reported in the Park both in the early years and in recent times. A severe windstorm could cause considerable damage to overstory trees in aspen, birch, and pine stands. This blowdown, ranging from a removal of individual trees to the destruction of sizable areas of forest, could result in increased light at the forest floor. This increased light would then stimulate the growth of seedlings. However, wind throw could provide the necessary mineral seed beds only in the spots where the soil was turned over. This slight disturbance of the organic soil cover would hardly result in the perpetuation of extensive even-aged stands of subclimax species. It thus would appear that wind has not been the major factor controlling the occurrence of these stands in Itasca. The only remaining form of disturbance to be considered is fire.

The importance of fire was given little recognition in early research in Itasca. Lee (1924) and Kell (1938) concentrated on the nature of the climax forest communities and the relation of subclimax species distribution to soil texture. While fire received passing mention, it was considered only as a deterrent to the attainment of the true climax and as such not worth further study. Spurr (1954) was the first to give recognition to fire as a major ecologic factor in the forests of the Itasca area. More recently Ahlgren and Ahlgren (1960) prepared an extensive review of the literature on the ecological effects of fire in the Lake States. The evidence they have summarized substantiates further the importance of fire in the establishment and development of even-aged stands of pine, aspen, and birch.

METHODS

In order to evaluate successfully the importance of fire in the presettlement park, information was obtained on (1) the frequency with which fires occurred in the area, (2) the location and areal extent of these fires, and (3) the influence each burn had on the biotic communities.

Several methods were used to determine the frequency and extent of fires in Itasca. Some information on historic fires was

found in the journals of the early explorers and settlers. The primary source of information, however, was the forest itself. Fire scars on living trees provided evidence of past burns and made it possible to determine fairly accurately the year each fire occurred. Areal extent of a specific fire was calculated by mapping the occurrence of scars of the appropriate age.

After some field study, it was determined that the most useful tree species for fire-scar dating was the red pine. The northern hardwoods, tamarack, and lowland spruce-fir types are generally too moist to carry anything but the most severe fires. The aspen and birch are very thin-barked species and are easily killed back to the ground surface by the first fire to occur in the stand. Jack pine stands may survive one or two surface fires but more typically are completely destroyed by crown fires. However, even in these cases unburned trees or islands of trees frequently remain.

Red and white pines are quite resistant to fire injury. In addition, red and white pines generally grow in somewhat open stands and, as such, can carry only creeping surface fires. Each of these surface fires may leave its mark in the form of a fire scar. However, white pine is extremely susceptible to rot after fire injury. This rot destroys the wood in the wound area and makes aging of the scar impossible. We are thus left with red pine as the one species most suitable for fire dating. It is on this basis that the bulk of the fire history data from Itasca have been derived from study of selected red pine trees.

Aerial photographs and vegetation maps were used to locate all pine stands within the Park. Each of these stands was then examined in the field. In every case the age of the stand or of each stand age class was determined. These figures allowed computation of the date of stand origin. During this field reconnaissance particular effort was made to locate the oldest fire-scarred red pine on the site. These trees provided the most complete record of fire occurrence.

The dates of the individual fire scars were determined by analysis of a select number of cross sections and a considerable number of wood cores from increment borings. The counts from the stump cross sections provided data for the construction of the basic fire chronology. More voluminous, but less accurate, data from the increment cores provided information on areal extent of each burn and, in some cases, additional fire dates.

In the course of the field work cross sections were obtained at 14 locations and increment core data at 68. Additional data were obtained by examining fire scars on old red pine stumps and dead snags.

RESULTS

Fire Chronology

The dates of 32 fires known to have occurred in Itasca State Park between 1650 and 1922 are listed on Table 1. This table provides a master chronology useful as a reference for future studies in the area.

However, it should be noted that every recorded fire scar is listed, regardless of the number of observations available to verify it. As a result, the fire of 1864, identified at almost all sample points, appears no more significant than the fire of 1843, which was verified at only one site.

Fires that occurred prior to 1700 have been clearly documented at only a handful of locations in the park. Only a very few trees remain that are old enough to have been scarred by fire in the 1600's. Consequently, the true areal extent of these early fires is not known.

Certain scar dates in the master chronology have been identified in Table 1 as "major" fires. Fires that appear to have been confined to very small areas or that cannot be adequately evaluated because of scanty information have been eliminated.

Frequency of Natural Wildfires

Time intervals between all documented fires and between all "major" fires are also

shown in Table 1. These data provide a picture of fire frequency for Itasca Park in its entirety. In addition fire-scar data have been summarized by individual land-survey sections and for individual trees that were subjected to repeated burns. The average fire frequencies for each of these data bases are presented in Table 2.

During the 272-yr period from 1650 to 1922, a fire occurred in Itasca Park on an average of every 8.8 yr, with so-called major fires every 10.3 yr. However, the average frequency with which fire affected any specific location in the park seems to be about every 22 yr.

Intervals between fires have not been constant over time. Table 3 provides average fire-interval figures for 50-yr segments of the total period of record. Because of the high risk of missing data, the average interval for the 1650–1699 period should probably be disregarded.

Extent of Burned Areas

Fire-scar studies produced sufficient data to allow mapping of the approximate boundaries of 19 major burns in Itasca. Reduced versions of these fire maps are presented in Fig. 2. A summary of the estimated area of each burn and the percentage of the park involved is contained in Table 4.

Influence of Fires on Forest Composition

Most of the major pine stands of the Park were visited and data collected on the age of the stand or of the various stand components (many stands were made up of several age classes). In nearly every case, the date of origin of the stand or stand component corresponded closely with the year in which a burn had occurred on the site.

The burn-area maps presented in Fig. 2 also show the major pine stands (jack and red pine) that appear to have been established as a result of each fire. The size and ages of these stands are summarized in Table 5. It is apparent that not all of the recorded fires resulted in the establishment

TABLE 1

FIRE SCAR DATES AND INTERVALS BETWEEN FIRES IN ITASCA STATE PARK

Date of fire	Interval since last fire (years)	Major fires	Interval since last major fire (years)
1922	4		
1918	5	*	5
1913	2	*	2
1911	2	*	4
1909	2		
1907	2	*	2
1905	6	*	6
1899	4	*	4
1895	4	*	4
1891	2	*	2
1889	2	*	4
1887	2		
1885	10	*	10
1875	4	*	11
1871	7		
1864	21	*	44
1843	5		
1838	18		
1820	9	*	9
1811	8	*	8
1803	7	*	7
1796	9	*	24
1787	15		
1772	13	*	13
1759	17	*	17
1742	15	*	15
1727	15	*	15
1712	10	*	
1702	32		
1670	9		
1661	11		
1650			

TABLE 2

AVERAGE FREQUENCIES OF FIRES IN ITASCA STATE PARK

Data base	No. of observations	Average frequency (years)	Range (years)
All recorded fire scars	32	8.8	2–32
All "major" fires	21	10.3	2–44
Fires occurring within any surveyed section[a]	33	21.1	8–52
Multiple fire scars on single trees	23	22.7	13–38

[a] These data are for all fires recorded.

TABLE 3

INTERVALS BETWEEN FIRES IN ITASCA PARK, BY 50-YR PERIODS

Time period	Average interval		Maximum interval		Minimum interval		No. of fires	
	All fires	Major fires	All fires	Major fires	All fires	Major fires	All fires	Major fires
1900–1922	3.3	3.5	6	6	2	2	7	4
1850–1899	6.2	11.3	21	44	2	2	9	7
1800–1849	9.4	8.0	18	9	5	7	5	3
1750–1799	13.5	18.0	17	24	9	13	4	3
1700–1749	18.0	15.0	32	15	10	15	4	3
1650–1699	6.6	—	11	—	9	—	3	—

TABLE 4

FIRE SIZE DATA FOR ITASCA STATE PARK, MINNESOTA, 1700 TO 1922

Fire date	Approximate size (acres)	Percent of Park burned	Summary period	No. of years in period	Avg. size of fire (% of park burned)	Avg. % of park burned/year	Avg. area burned/year Hectares	(acres)	No. of fires
1918	1730	5	1900–1922	23	7	0.30	39	(96)	6
1913	580	2							
1911	4295	13							
1907	1425	5							
1905	2435	8							
1899	3175	10	1850–1899	50	34	0.68	88	(218)	7
1895	2370	7							
1891	7630	24							
1889	4040	13							
1885	21,030	66							
1875	7245	23							
1864	30,930	96							
1820	22,760	71	1800–1849	50	80	1.60	202	(500)	3
1811	22,120	69							
1803	21,765	99							
1796	5130	16	1750–1799	50	53	1.06	138	(340)	3
1772	31,960	99							
1759	14,145	44							
1727	12,855	40	1700–1749	50	40	0.80	101	(250)	1

of significant acreages of pine. Considerable pine type originated following the fires of 1712, 1772, 1803, 1811, and 1820. These age classes make up the bulk of the existing old growth red pine in the Park. Other burns, particularly in the northeastern portion of the Park, regenerated sizable stands of mixed jack pine and red pine. Such stands date from 1885, 1889, 1891, 1895, and 1899.

It is of interest to note that several fires that burned widely over the Park failed to result in any great amount of pine reproduction surviving today. The fire of 1864 was one of the most extensive burns recorded, yet little evidence was found of an age class of pine dating from 1864. Similar circumstances hold for the fires of 1759, 1875, and 1885, which were also large.

It is not at all surprising that pine stands have not become established after all wildfires. The successful regeneration of a stand is contingent upon the satisfaction of several environmental and biotic criteria.

The physical nature of the particular

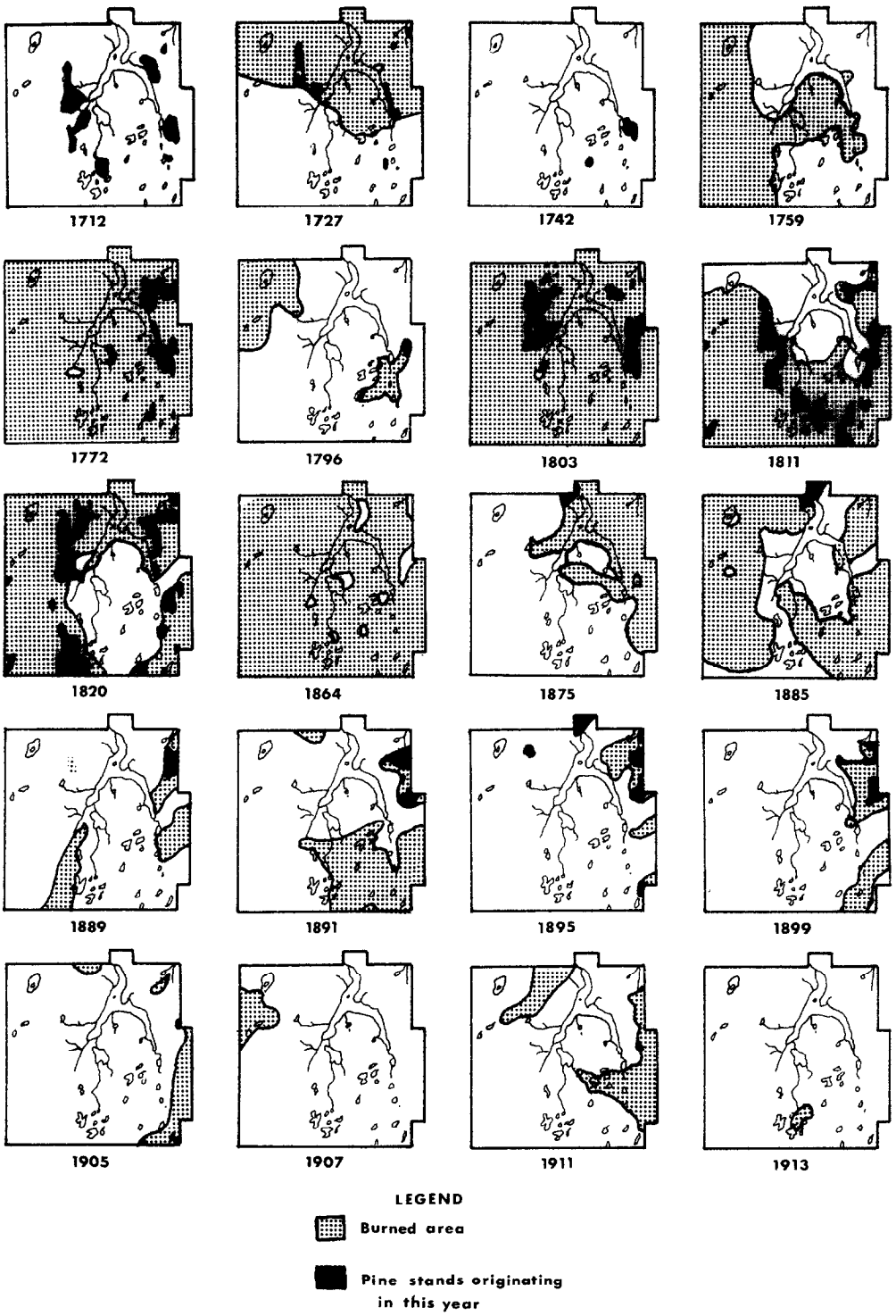

FIG. 2. Maps of major fires known to have occurred in Itasca State Park between 1712 and 1913 and the pine stands originating at the time of these fires.

TABLE 5

AREA OF PINE TYPE REGENERATED BY INDIVIDUAL FIRES IN ITASCA STATE PARK

Fire date	Age (in 1972) of pine regenerated by fire	Approximate area of pine regenerated by fire	
		Hectares	(Acres)
1918	*	*	*
1913	*	*	*
1911	61	10	(30)
1907	*	*	*
1905	67	65	(160)
1899	73	156	(385)
1895	77	310	(770)
1891	81	310	(770)
1889	83	75	(190)
1885	87	130	(320)
1875	97	25	(65)
1864	*	*	*
1820	152	790	(1955)
1811	161	1530	(3780)
1803	169	1065	(2630)
1796	176	55	(130)
1772	200	690	(1700)
1759	*	*	*
1742	230	115	(290)
1727	245	260	(640)
1712	260	750	(1860)

* Indicates that no significant pine regeneration can be identified as having resulted from this fire.

burn can be critical. The fire must be intense enough to destroy the litter and humus and expose the requisite mineral-soil seed bed. In addition, it may be important that the fire remove a shrub layer or reduce the density of an overstory that might compete with the new seedlings.

A fire of too great an intensity can reduce the chances of successful regeneration. A very severe crown fire may destroy the seed crop. Jack pine has fire-resistant cones that will protect the seed from all but the most intense flames, but this is not the case with red and white pines.

Successful regeneration is, of course, directly dependent upon the presence of a seed supply. The surviving trees on the burn or adjacent to it may fail to have a good seed crop for several years following the fire. This time lag may be sufficient for the establishment of a dense shrub and herb cover, which could preclude successful reproduction.

Assuming an adequate fire intensity and a well-timed seed crop, the survival of the seedlings is dependent upon the climatic conditions prevailing during the years immediately after germination.

Another important factor is the length of time until the area is burned over again. If this interval is too short, the seedlings may be too young to withstand the heat and will be destroyed.

The failure of pine species to regenerate following the fires of 1759, 1864, 1875, and 1885 could be the result of a failure of any one or combination of the criteria discussed above. There is no way at this time to identify the causal factors.

The fire-area maps, which show stands of fire origin, aid us in understanding the importance of fire in the development of vegetation patterns. In areas where a pine seed source was available, fire frequently resulted in pine reproduction. Each successive fire resulted in a new or additional pine age class.

If an area is reburned several times at frequent intervals, the pine reproduction is destroyed and aspen, birch, or upland brush species take over. In some areas, fires occurred so infrequently that succession (on suitable soil types) preceded to northern hardwoods or white spruce–balsam fir types. Such conditions apparently prevailed between the east and west arms of Lake Itasca, on the east shore of the lake near Bearpaw Point, and at several other locations in the Park.

The combination of irregular burn areas and frequencies, differing seed sources, varying reproductive success and soil textural differences resulted in a complexity of vegetational patterns. The presettlement Park area was a patchwork of forest stands of different sizes, species composition, and age structure. Such a patchwork appearance is still visible on the 1967 vegetation cover map (Fig. 3). It should be noted that

FIG. 3. Forest type pattern of present-day Itasca State Park. (After Meyer, 1967.)

the extensive hardwood areas in the western one-third of the park and along the eastern boundary are the result of logging operations which removed the pine forest before the park was established.

DISCUSSION

The presettlement biotic communities of Itasca Park have been shown to be predominantly subclimax and dependent upon periodic disturbances by fire. While attempting to preserve these biotic communities by protecting them, man has actually interfered with natural processes. This interference has resulted in serious deviation from natural conditions.

Itasca State Park was officially established in 1891. Fire control was a primary concern of the Park Commissioner, but full protection was not immediately attained. In spite of all efforts, fires of considerable size occurred in 1895, 1899, 1905, 1911, 1913, and 1917, all within the official Park boundary as established at that time.

By 1920 considerable progress had been made in fire-protection programs. This progress is evidenced in Itasca Park by a drastic decrease in fire incidence. Records of the District Forester at Itasca Park indicate that between 1938 and 1963 only ten fires occurred. Two of these fires were caused by lightening and the rest by man. Quick action was taken to control each of these fires. Seven fires were contained within 1 hectare (2.5 acres), and the largest burned only 2 hectares (5 acres).

This drastic reduction in fire occurrence is attributable to several factors. Indians apparently had been a major cause of fires, and by this time Indians no longer freely roamed this area. Agricultural land uses in the prairie areas to the south and west perhaps reduced the incidence of prairie fires, which would move eastward and enter the Park. Also, forest removal and land clearing had surrounded the Park with a relatively fireproof zone. By 1920 the period of major land clearing and lumbering operations had passed and the fires resulting from these activities consequently diminished. This was also a time of increasing public awareness of the need for fire protection on managed forest and agricultural lands.

Such highly successful fire protection as attained in Itasca State Park could only result in considerable change in the character of a prodominantly subclimax vegetation. The changes that appear to have occurred are in evidence in many similar parks across the Nation.

All of the pine species occurring in Itasca Park are more or less dependent on fire to produce suitable conditions for reproduction (Ahlgren and Ahlgren, 1960). Without periodic burns the necessary combination of mineral seed beds, reduced shrub competition, and thinned overstory have not been attained. As a consequence, there has been a marked decrease in pine regeneration. With a few exceptions, seedlings are to be found in quantity only in road cuts and gravel pits.

Currently in Itasca Park we have a pine forest of primarily older age classes in which considerable mortality is occurring with little or no establishment of younger stands for replacement. Hansen and Duncan (1954) reported that of 2665 hectares (6585 acres) of red and white pine in Itasca Park, some 1326 hectares (3276 acres) were to be considered "over-mature" (200 yr or older). Most of the remaining pine acreage was in stands over 100 yr of age.

The fire maps contained in Fig. 2 illustrate the locations of stands originating from fires of various dates. Most of the pine stands were established following fires in 1712, 1727, 1772, 1803, 1811, and 1820. These stands now (1972) are from 152 to 260 yr old (Table 5). Trees of age 200 and over are extremely susceptible to wind throw, breakage, and insect damage. Many of these trees are blown down each year.

From all indications, much of the forest in Itasca Park is evolving into stands of aspen, birch, northern hardwoods, or bal-

sam fir. The subclimax types such as red, white, and jack pine are slowly but surely passing out of the picture. The evidence available indicates that this shift is attributable to the fire-protection policy of the past 60 yr.

The presettlement biotic communities in Itasca Park occurred in a patchwork pattern of many age classes and structural combinations (Frissell, 1971). We can attribute this ecologic variety to frequent periodic disturbances by fire, which continually reinitiated new secondary developmental sequences. This variety of vegetative types and age classes, and the many ecotonal areas that result, provide habitat for an equally varied collection of mammals and birds.

One likely result of successional development to climax hardwood or spruce-fir types is a reduction in vegetational variety. This development involves moving from even-aged types in small groups (individual burns) to all-aged types spread over extensive areas. Diminished variety in plant communities results in a reduction in the availability of ecological niches and a consequent reduction in diversity of wildlife species. Animals and birds that thrive in successionally early vegetation stages (such as recently burned areas) find much less suitable habitat in a climax forest.

The evidence presented in this study indicates that fire was a dominant factor in the establishment and maintenance of the natural biotic communities of Itasca State Park. Management programs involving intensive fire control have resulted in a serious departure from natural conditions. If the preservation of natural biotic communities is the objective of Itasca Park, then a more active management program must be adopted that recognizes the role of fire and takes steps to return this all-important natural factor to the system.

REFERENCES

Ahlgren, I. F. and Ahlgren, C. E. (1960). Ecological effects of forest fires. *The Botanical Review* **26**(4), 483–533.

Buell, M. F. (1956). Spruce–fir, maple–basswood competition in Itasca State Park, Minnesota. *Ecology* **37**, 606.

Buell, M. F. and Gordon, W. E. (1945). Hardwood-conifer forest contact zone in Itasca Park, Minnesota. *American Midland Naturalist* **34**, 433–439.

Buell, M. F. and Martin, W. E. (1961). Competition between maple–basswood and fir–spruce communities in Itasca Park, Minnesota. *Ecology* **42**, 428–429.

Frissell, S. S. Jr. (1971). An analysis of the maintenance of presettlement biotic communities as an objective of management in Itasca State Park, Minnesota. Unpublished Ph.D. dissertation, University of Minnesota, St. Paul.

Hansen, H. L. and Duncan, D. P. (1954). The management of the Itasca State Park forest to meet recreational objectives. *Proceedings, Society of American Foresters,* pp. 123–125

Kell, Lucille L. (1938). The effects of the moisture-retaining capacity of soils on forest succession in Itasca Park, Minnesota. *American Midland Naturalist* **20**, 682–694.

Küchler, A. W. (1964). The potential natural vegetation of the conterminous United States. *American Geographical Society Special Research Publication No.* **36**.

Lee, S. C. (1924). Factors controlling forest successions at Lake Itasca, Minnesota. *Botanical Gazette* **78**, 129–174.

Maissurow, D. K. (1941). The role of fire in the perpetuation of virgin forests of northern Wisconsin. *Journal of Forestry* **39**, 201–207.

Meyer, M. P. (1967). "Vegetation Map of Itasca State Park." School of Forestry, University of Minnesota.

Schoolcraft, H. R. (1855). "Summary narrative of an exploratory expedition to the sources of the Mississippi River in 1820: resumed and completed by the discovery of its origin in Itasca Lake, in 1832." Lippincott, Grambo and Co., Philadelphia. 596 pp.

Shay, C. T. (1971). "The Itasca Bison Kill Site: An Ecological Analysis." St. Paul, Minnesota Historical Society. 133 pp.

Spurr, S. H. (1954). The forests of Itasca in the Nineteenth century as related to fire. *Ecology* **35**, 21–25.