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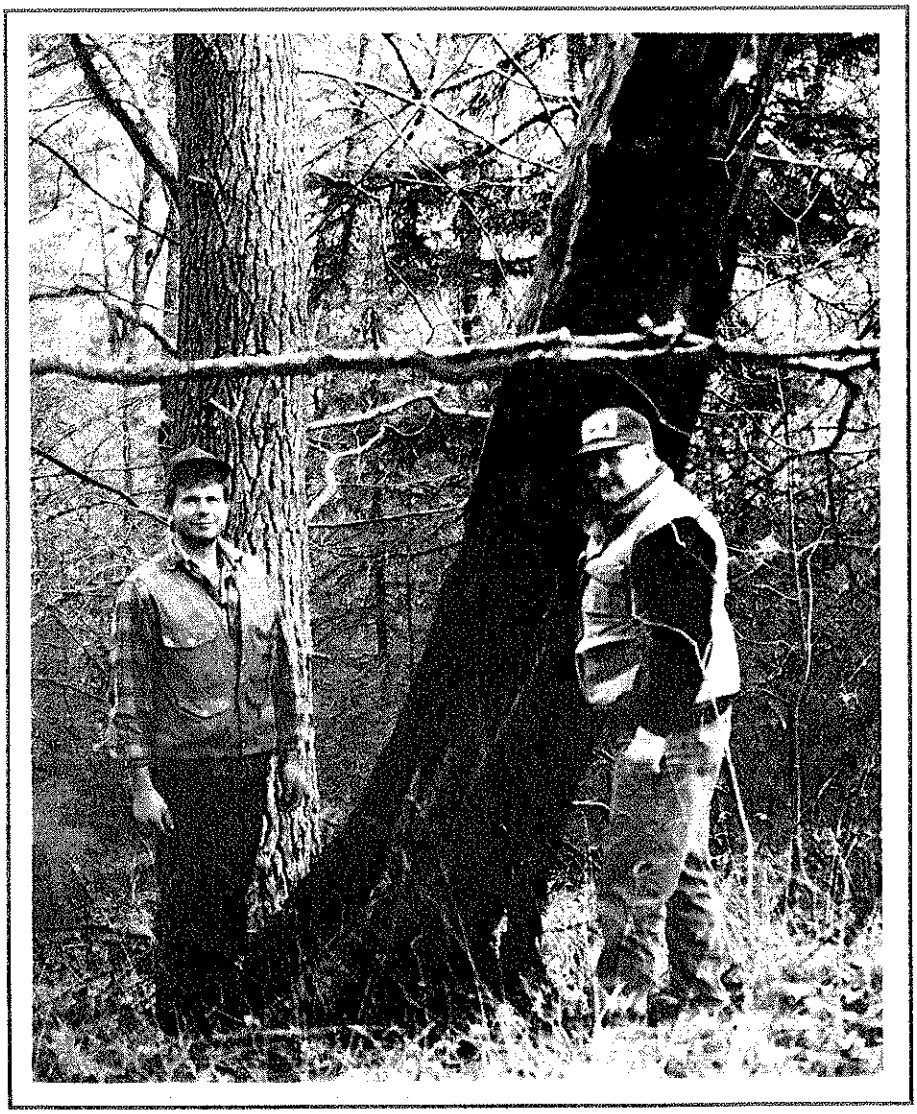

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# A Presettlement Fire History in an Oak-Pine Forest near Basin Lake, Algonquin Park, Ontario

by

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# Abstract

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Fire scars from natural remnants of red pine (*Pinus resinosa* Ait.) in an oak-pine forest near Basin Lake, Algonquin Park, Ontario, were dated using dendrochronological methods. A fire scar chronology was constructed from 28 dated fire scars on 26 pine remnants found in a 1 $km^2$ area of this forest. From pith and outside ring date distributions, 2 stand replacement fires are inferred. The composite fire scar chronology spanned 191 years from 1665 to 1856. The fire return interval between 2 stand replacement fires was about 200 years, while the return interval between fires of moderate or greater intensity was 68 years. For fires of low intensity or greater, the mean interval was 22 years. The period of the highest fire frequency was between 1733 and 1780, during which time the fire return interval for the area was 11.8 years.

**Keywords:** fire history, red oak, red pine, dendrochronology, climate, disturbance

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# Introduction

We know that fire disturbances favour oak regeneration (Swan 1970, Little 1974, Heinselman 1981, Lorimer 1985, Crow 1988, Abrams 1992, Weber and Taylor 1992, Guyette and Dey 1995). In the Great Lakes Region, presettlement forests varied widely from sugar maple-beech-hemlock to hardwood-white pine-red pine to jack pine (Howe and White 1913, Spurr 1954, Cwynar 1977, Swain 1978, Whitney 1986, Abrams 1992), and forest composition was determined partly by soil conditions and fire regimes. Many of these ecosystems were subject to burning resulting from either natural occurrences (i.e., lightning strikes) or Native American-set fires (Day 1953; Niering 1970; Cwynar 1977; Dorney 1981; Pyne 1982; Lorimer 1985, 1993; Lynham 1985; Dorney and Dorney 1989). Knowledge of these past fire regimes provides an ecological basis for silvicultural prescriptions and management plans that use fire to regenerate hardwoods and conifers, manipulate wildlife habitat, and maintain fire-dependent forest communities.

In Algonquin Park, Ontario, past fire regimes have contributed much to the present mosaic of vegetation and diversity of species (Cwynar 1977, 1978; Chandler et al. 1983; Pyne 1984). Knowledge of these regimes is necessary to understand the present state of vegetation in Algonquin Park. In this study, the objective is to document the fire regime in an oak-pine forest on the northern edge of the distribution of northern red oak (*Quercus rubra* L.) in Algonquin Park using dendrochronological analysis of fire scar dates (Stokes and Dieterich 1980). Results will help lay the foundation for stand-level prescriptions or landscape-level plans to maintain, conserve or regenerate diverse forest communities.

# Methods

## Site Location and Characteristics

The red pine (*Pinus resinosa* Ait.) samples were obtained from an 1 $km^2$ area located about 6 km north of Basin Lake, Algonquin Park, Ontario. Boundary coordinates for this triangular area are: (1) 45° 47′ 90″N; 77° 47′ 47″W, (2) 45° 47′ 69″N; 77° 46′ 51″W, and (3) 45° 46′ 52″N; 77° 47′ 89″W.

Topography has a profound effect on the spread rate and size of wildland fires (Chandler et al., 1983). In this study, the site is 274 to 350 m above sea level and is elevated above the surrounding landscape, with few, if any, natural fire breaks. This xeric, droughty site is level to gently sloping and has well-drained, sandy soils.

The site ranges from open woodlands with less than 100% canopy closure and a diverse ground flora of herbaceous and graminoid plants to full canopy closure. Dominant tree species are northern red oak (40-50%), red pine (<10%), white pine (*Pinus strobus* L.) (10-20%), sugar maple (*Acer saccharum* Marsh.) (20%), and red maple (*Acer rubrum* L.) (10%). The present stand of trees is classed at 90 years in age and averages about 20 m tall (OMNR, Forest Resources Inventory).

## Sampling

Cross-sections of 45 red pine remnants were selected for sampling based on their soundness, degree of entirety, and presence of fire scars. These remnants were cut with a chain saw between ground level and 30 cm. Compass orientation of the cross-section, slope, and aspect were recorded for each sample. Samples were obtained from wind-fallen stems and standing snags.

**Figure 1.** Natural remnant pine snags and downed trees were used to reconstruct the presettlement fire history at Basin Lake, Algonquin Park.

## Fire Scars

In this study, fire scars are defined as wounds occurring low on the tree bole, identified by the presence of callus tissue and a growth response to the death of a cambial section. All remnants sampled have charcoal present on the bole and fire scars (Figure 1), much of which resulted from a stand replacement fire and subsequent fires. Snags were often deeply and extensively charred to the top (6 m) of the bole. Large sections of wood were burned out of many of the standing snags.

## Cross-Dating

To reveal the annual ring structure, cross-sections were surfaced using an electric hand planer with a sharp carbide blade. If rings were very narrow or indistinct, the ring structure and cellular detail were revealed using sandpaper (220 to 600 grit), fine steel wool, or razor cuts.

Ring-width series from each sample were measured and plotted, and these plots were used for visual cross-dating (Stokes and Smiley 1968, Guyette and Cutter 1991). The computer program COFECHA (Holmes et al. 1986) was used to insure the accuracy of both relative dating among the samples and absolute dating of the samples. A floating chronology (undated in absolute time) was established from the samples with the highest common ring-width variance. To provide absolute dating of the pine remnants, ring widths were compared with a red pine dating chronology from Trap Bay on Lake Opeongo, 39 km northwest of the study site (Guyette and Dey, unpublished) and another from Dixon Lake, 26 km northwest of the study site (Cook 1982).

# Results and Discussion

## Fire Intensity

The percentage of trees scarred in a fire varies greatly with fire intensity (Figure 2). In oak stands, low intensity ground fires often scar only a small percentage of the trees (Paulsell 1957). Thus, a complete fire record of low intensity fires requires sampling many trees in a small area.

In this study, low intensity fires scarred less than 10% of the sample trees. In the moderate intensity fires of 1733 and 1780, 46% and 42% of the trees were scarred, respectively. Additional evidence of tree injury in the red pine cross-sections (Figure 3) could not be definitely attributed to fire. Some of these injuries took place in years

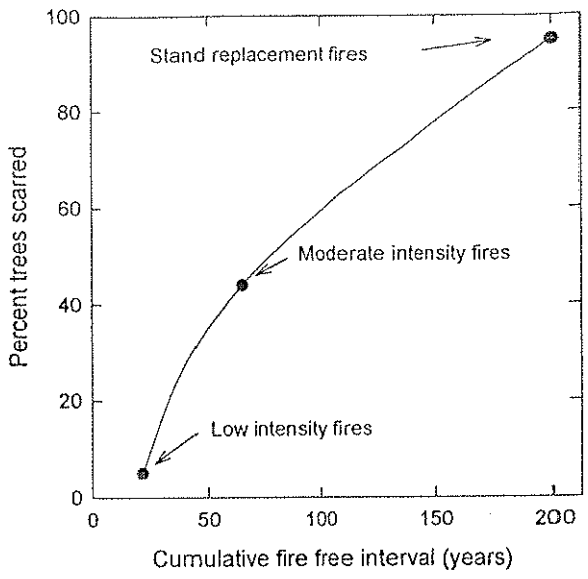


**Figure 2.** Plot of the cumulative fire-free interval in relation to fire intensity classes. Fire intensity class is based on the percentage of sample trees scarred or killed in any given fire year.

(e.g., 1769 and 1824) when low intensity fires burned the study site; however, most occurred in years when no other fire scars were recorded. If light surface fires did cause these injuries, then from 1665 to 1856, more fires occurred at the Basin Lake site than are reported. In moderate intensity fire years (e.g., 1733 and 1780), no record exists for these unspecified injuries. Moderate intensity fires likely burned hot enough to leave a definite fire scar, whereas low intensity fires damaged the cambium without leaving an obvious fire scar. Further sampling is needed to determine what caused these unspecified injuries.

## Fire Frequency

According to fire scar evidence, 8 fires occurred during the 191-year period of record from 1665 to 1856 (Figure 3). Indirect evidence indicates severe fires from stand initiation (about 1665) and stand destruction (about 1860), i.e., all pith dates were between 1665 and 1680. This distribution of pith dates reflects an even-aged stand of red pine that severe fire could have initiated. For 3 of the trees, the outside ring date was close to the year of tree death (about 1860). Thus, at this study site, probably 10 fires occurred in about 200 years (1660-1860).

These fires can be classed by their effect on the stand and the percentage of trees scarred. Table 1 gives fire interval data by fire class. On average, low intensity fires burned every 26 years, moderate intensity fires every 47 years, and stand-replacing fires every 200 years. Between low intensity or greater fires, the mean fire return interval was 22 years; between those of moderate or greater intensity, it was 68 years. The period of the highest fire frequency was between 1733 and 1780, during which time the fire return interval for the area was 11.8 years (Figure 3).

This fire regime typifies Heinselman's (1981) classical presettlement, red pine fire cycle for xeric sites in the Lake States. He generalized that red pine forests experienced frequent light surface fires (e.g., every 1 to 25 years), infrequent severe surface fires (e.g., >25 year intervals), and long-term interval crown fires and severe surface fires in combination (e.g., every 100 to 300 years).

## Fire and Climate

In Ontario, major fires of moderate to high intensity that burn large areas occur in years of subcontinental drought (Cwynar 1977, Heinselman 1981). At the Basin Lake site, fires of moderate intensity burned in years in which narrow rings were observed in ring-width chronologies of tree growth in central Ontario. In 1733 and 1780, the narrow rings averaged 78% of the mean of 5 chronologies from Ontario: red pine (3 chronologies), white pine (1 chronology), and

**Figure 3.** Plot of dated samples and their associated fire scars, injuries, pith dates, outside rings, and a composite fire chronology. Long thick vertical bars indicate fire scars. Short vertical bars indicate injury. Thin vertical bars indicate pith dates. Slanted thin bars indicate inside and outside rings of sample.

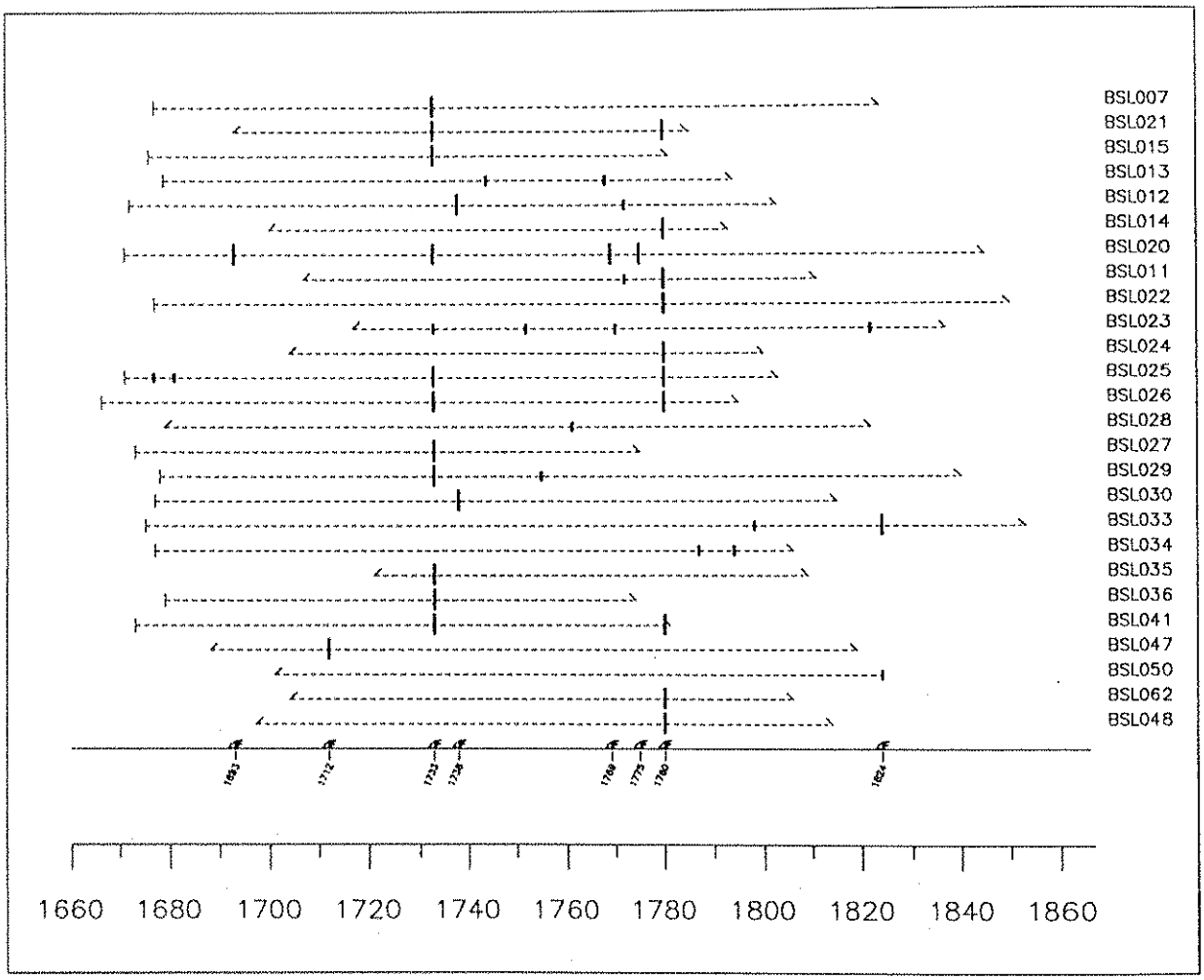

Table 1. Fire intervals at the Basin Lake site. The fire interval is the number of years between fires for that class. The cumulative fire interval is the number of years (mean) between fires of that class and fires from more intense fire classes. Fire intensity classes are defined by the percentage of trees scarred or killed (e.g., in the stand replacement fires).

| Fire intensity | Number | Fire interval | Cumulative fire interval | Range |
|---|---|---|---|---|
| | | | ---------- years --------- | |
| Stand replacement | 2 | 200 | 200 | --- |
| Moderate (>40%) | 2 | 47 | 68 | 47-68 |
| Low (<40%) | 6 | 26 | 22 | 5-49 |

hemlock (1 chronology). These results indicate that widespread and severe drought occurred during these years. Scars dating from 1733 indicate that the fire occurred during the growing season, while those from 1780 indicate a dormant season fire. No relationship exists between low intensity fires and climate.

## Fire Extent

The fire of 1780 has been documented in 2 other studies. Cwynar (1977) found evidence of a 1780 fire at 4 sites in nearby Barron Township, which lies 15 km to the northwest of the Basin Lake site. He concluded that the fire of 1780 burned at least half of Barron Township and that these extensive fires occurred every 45 years. At Costello Bluff, about 48 km west of the study site, fire scars dating to the year 1780 were found on 11 red pine remnants (Guyette and Dey, unpublished). Thus, the 1780 fire or fires probably burned a large area of Algonquin Park.

# Summary

A fire scar chronology was constructed from natural remnant red pine snags and downed trees found in a 1 $km^2$ area of oak-pine forest near Basin Lake, Algonquin Park, Ontario. The composite fire scar chronology spanned 191 years from 1665 to 1856. During this period, 10 fires were recorded, including the 2 stand replacement fires that occurred circa 1660 and 1860. The presettlement red pine forest was presumed even-aged because all pith dates were between 1665 and 1680. Fire intensity was determined based on the percentage of sample trees scarred or killed by fire. Low intensity fires burned on average every 26 years, moderate intensity fires every 47 years, and stand-replacing fires every 200 years. Between low intensity or greater fires, the mean fire return interval was 22 years; between those of moderate or greater intensity, it was 68 years. The period of the highest fire frequency was between 1733 and 1780, during which time the fire return interval for the area was 11.8 years.

Fires of moderate intensity burned in the years 1733 and 1780. The 1780 fire coincided with other recorded fires (Cwynar 1977, Guyette and Dey, unpublished), some of which burned large areas of Barron Township in Algonquin Park. In Ontario, major fires have been related to periods of severely dry climate. At the Basin Lake site, fires of moderate intensity have been correlated with periods of below average tree ring growth, and hence, periods of widespread and severe drought. However, at this site no relationship exists between low intensity fires and climate.

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