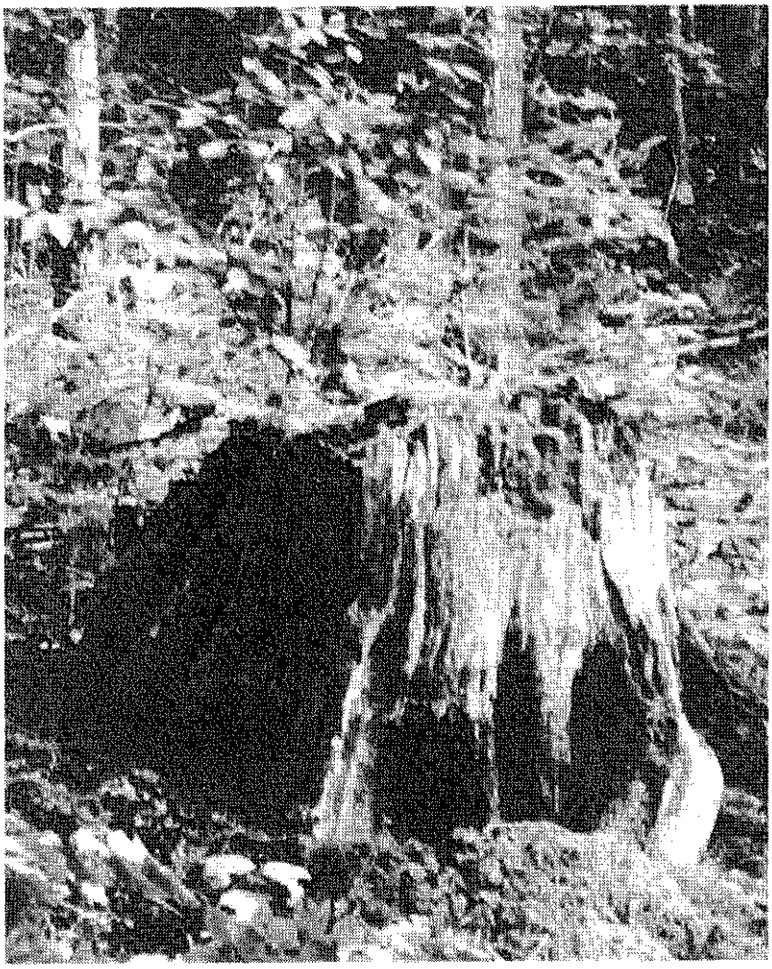
Ontario

Fire History Near an Historic Travel Corridor in Ontario



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Fire History Near an Historic Travel Corridor in Ontario

by

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Introduction

Human beings are one of the most important agents of ecosystem disturbance and have been for millenia (Pyne 1982, 1995). Until recently, fire was the major tool people used to alter vegetation to their benefit. The variability in the occurrence and influence of fire on forested ecosystems over long time periods is often the result of changes in human land use practices, population levels and migrations. For thousands of years, the St. Lawrence and Ottawa Rivers have served as a major travel route from the Atlantic coast into the upper Great Lakes region and boreal north for Native peoples. Until roads and railways were constructed throughout central Ontario, the Ottawa and Mattawa Rivers, Lake Nipissing, and the French River provided a direct route from the lower Ottawa and St. Lawrence valleys to the upper Great Lakes. This route was well used by Native peoples and later European fur traders, settlers and loggers.

The objective of this study was to document the fire history in a mixed-hardwood stand containing red oak (*Quercus rubra* L.) for a site located near one of the most heavily travelled corridors in Ontario - the Ottawa and Mattawa River route. This information can then be used to develop silvicultural prescribed burning techniques that emulate natural disturbance processes for regenerating or maintaining fire dependent forests such as oak-pine or old growth pine ecosystems.

Methods

Site location and characteristics

The study site is about 0.5 km^2 in size and is located about 44 km northeast of North Bay, Ontario. The site is about 2 km from the Jocko River and 13 km from the Ottawa River. Coordinates for the area center are: 46° 35′ 66″N, 79° 13′ 00″W.

The site is level to gently sloping with an elevation of about 320 m, and is surrounded by level to gently sloping terrain. The soil is sandy and moderately well drained, with an organic litter layer that overlays a charcoal layer that grades into gray and then red mineral soil layers with some clay content.

The site is forested primarily with hardwoods such as sugar maple (*Acer saccharum* Marsh.) (70%), red oak (10%) and yellow birch (*Betula alleghaniensis* Britt.) (10%). White pine (*Pinus strobus* L.), although once dominant, has been almost eliminated from the stand. The distribution of red oak throughout the stand is spotty with high densities occurring in small pockets.

Sampling

All wood sampled was from the remnant stumps of white pines that were harvested sometime during the late 1800s. The sound wood at the ground level was dug out from under decayed wood and organic debris. Cross-sections of 32 white pine remnants were cut with a chain saw between ground level and 20 cm. Felling wedges and pry bars were often needed to remove the large, wet, heavy cut sections from the stump. A carpenters block plane was used on small, selected areas on the surface of each cross-section to better reveal fire scars, injuries, and tree characteristics such as annual ring number, width and variance. Half and quarter sections containing scars and ring-width dating series were then cut from the full cross-section. The samples collected for analysis were selected based on their soundness, completeness, and the number of rings. Many hollow stumps were not collected.

Fire scars

All pine remnants sampled had charcoal present in the surrounding soil and organic debris. Charcoal was only rarely found in the cross-sections. Fire scars were defined as the death of a cambial section occurring near ground level on the tree bole; were identified by callus tissue, local cambial growth disruption and traumatic resin canals; and were often associated with an abrupt change in subsequent diameter growth. Fire scars ranged from single basal scars to multiple (2 to 7) but separate injuries in single years. Scars with evidence of mechanical damage (wood indentations, etc.) or small point injuries were noted but were not recorded as fire scars. Injuries that may have resulted from fire were not classified as fire scars unless callus tissue was present.

Crossdating

Cross-sections were surfaced using an electric hand planer with a sharp carbide blade and sandpaper (220 to 600 grit) to reveal the annual ring structure and cellular detail, especially where rings were narrow or indistinct. Visual crossdating was used to identify years (signature years) in which climate limited the growth of all trees (Stokes and Smiley 1968; Guyette and Cutter 1991). Ring-width plots, with anatomical notes on ring structure (e.g., false rings and latewood characteristics), were used for visual crossdating and comparison. 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. Between 1 and 3 ring-width series from each sample were measured from pie-shaped wedges taken from the cross-section or from traced acetate overlays of ring-width radii. The radius was measured from the most undisturbed ring-width series on the cross-section to maximize climate related ring-width variation.

A floating chronology (undated in absolute time) was established from 16 samples which had a mean between tree correlation of 0.46. Absolute dating of the pine remnants was accomplished by ring-width comparisons with a white pine ring-width chronology from live trees near Hobbs Lake, 80 km west of the study site (Guyette and Dey, unpubl. data). This chronology fully overlapped all of the sample ring-width series from the Jocko site.

Maximizing nonclimatic ring-width variation in the Jocko chronology

A standard ring-width chronology from Hobbs Lake was used to minimize the effects of climate and maximize the influence of stand and site conditions on the Jocko white pine standard ring-width chronology. Both these chronologies were constructed to minimize ring-width variability due to aging and bole geometry, but retain the year-to-year variability due to climate, as well as the short-term (i.e., <20 years) stand-level growth trends. The Hobbs Lake chronology was robust with respect to variability at the individual tree level because it was derived from 31 ring-width series from 21 trees.

The ring-width plots of trees from which the Hobbs Lake chronology was derived showed very few abrupt changes in ring-width, indicating that climate was the dominant factor affecting growth and that disturbance related growth effects were minimal. Although we could not entirely eliminate microenvironmental influences on radial growth from the Hobbs Lake chronology, ring-width variability caused by environmental factors was low because:

(1) the lack of fire scars and soil charcoal, the abundance of lakes (i.e., natural fire breaks), and the remoteness of the area from known human travel routes indicated that the Hobbs Lake area had a historically low disturbance (i.e., fire) environment, and (2) individual tree-ring series from Hobbs Lake did not show any abrupt changes in ring-width that might suggest a growth response related to fire disturbance. In addition, the climatic influence on growth should be similar at both sites because of their close proximity and similar ecological site conditions.

Although environmental factors that affect radial growth, such as wind disturbances and insect outbreaks, still influenced both the Hobbs Lake and Jocko chronologies, we assumed that they were randomly distributed through time and affected radial growth minimally. Thus, subtracting the Hobbs Lake standard ring-width chronology from the Jocko chronology produced a ring-width difference series that reduced years of similar growth (caused by climate) toward a zero value and, in other years, enhanced the growth difference due to localized disturbances.

Fire indirectly affects diameter growth by altering stand and site conditions, such as intensity of competition and soil nutrient status. Subtracting the chronologies minimizes the climatic influence on the radial growth of Jocko white pines and highlights the effects of fire. The resulting ring-width difference chronology represents a record of radial growth response to factors such as stand competition and soil nutrient status.

Results and Discussion

Crossdating

A high percentage (e.g., > 90%) of the white pine samples were successfully crossdated and collectively they provided a chronology that dated from 1721 to 1937 for the Jocko site. Of the 31 samples, 28 were crossdated based on an average of 128 rings per cross-section. The average between-tree correlation of ring-width series from white pine at the Jocko site was 0.46, after it was detrended and modeled to remove auto-correlation. Ring-width series from the inner portion of the trees did not correlate as strongly as portions from the outer sections, indicating that the wood formed by juvenile white pines is less climate dependant than is wood produced by older pines.

The Jocko ring-width chronology was significantly correlated with the nearby white pine chronology from Hobbs Lake. The chronologies were more highly correlated ($r=0.60$, $p=0.001$) for the period 1770 to 1870, which was well represented by more than 10 sample trees, than for the whole period ($r=0.49$, $p=0.001$).

Fire frequency

A composite fire scar chronology was constructed between 1721 and 1937 from 24 dated fire scars found on 16 of the tree stumps sampled, and graphed (Figure 1) using the FHX2 fire history software (Grissino-Mayer 1996). Less than 11% of the dated pine stumps were scarred in any given fire year, indicating that fires were typically low intensity surface burns. The lack of moderate intensity fires at the Jocko site was similar to the fire behaviour observed in a Bracebridge oak-pine stand (Guyette et al. 1995) but different than that recorded at Opeongo Lookout (Guyette and

Dey 1995a) and Basin Lake (Guyette and Dey 1995b). For the entire 216 year chronology, more than half of the dated samples had fire scars. Of these, 6% of the pines had 3 fire scars each, 38% had 2 scars and 56% had 1 fire scar, which attests to the resistance of white pine to injury by low intensity fires.

Based on identified fire scars, 14 fires occurred during the 216 year period (Figure 1). The mean fire-return interval for the period is 15 years, with fire-free intervals ranging from 4 (1765 to 1769) to more than 38 years (1899 to 1937). The mean fire-free interval for the period 1739 to 1900 was about 11 years, based on more than 5 sample trees. There were 5 fires between 1810 and 1841 or about 1 fire every 8 years.

Fewer fires in the late 1800s and early 1900s may be due to initial efforts to suppress fire in Ontario (Lambert 1967). Also, commerce along the nearby Nipissing Passageway declined after 1850 (Kennedy 1961), which may be linked to reduced human activity in the study area. However, unlike several previous fire histories (Guyette and Dey 1995a; Guyette et al. 1995) studied in central Ontario, there were no abrupt changes in fire frequency at the Jocko site.

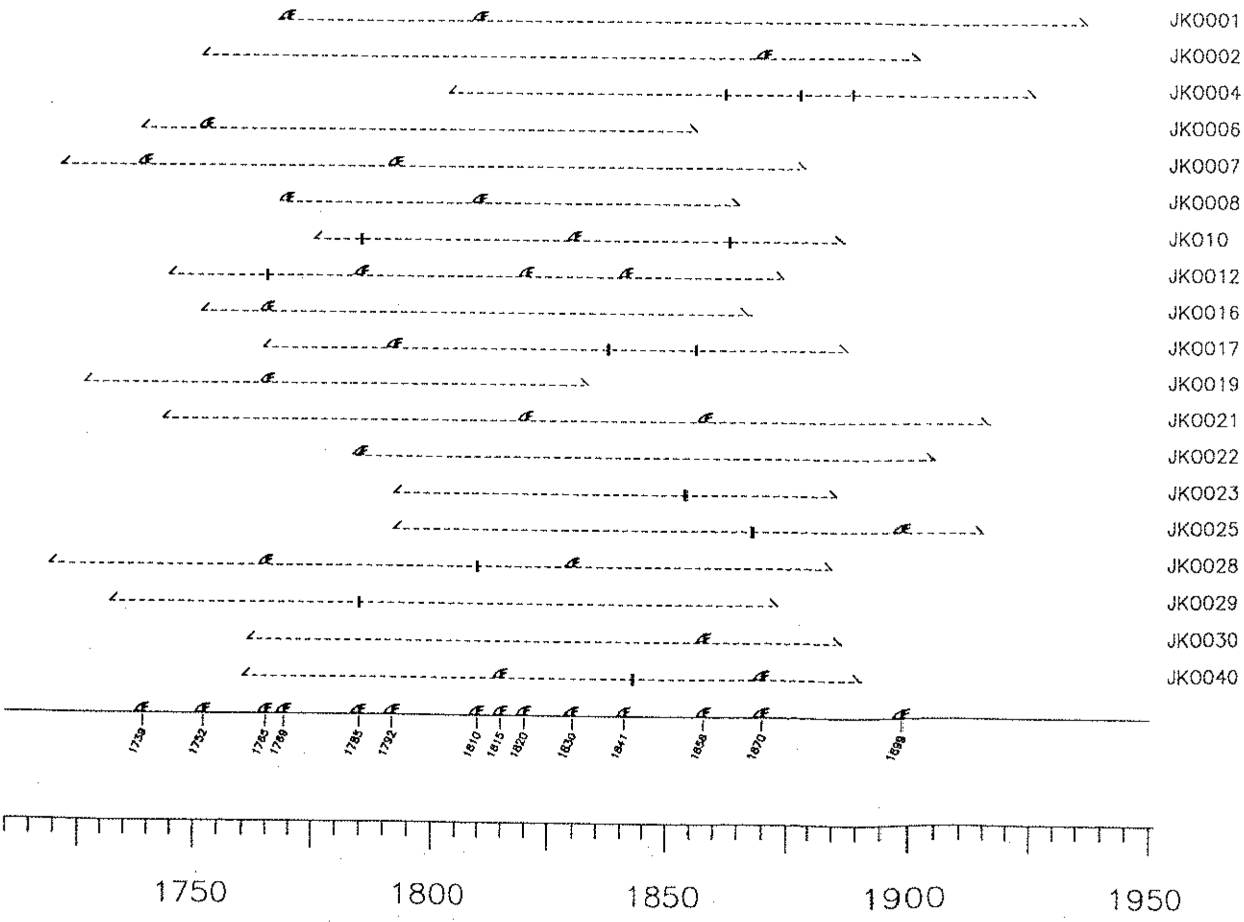

Figure 1. A plot of dated white pine samples and their associated fire scars, injuries, and period of record. A composite fire chronology is given at the bottom. Unfilled flames represent fire scars. Short vertical bars indicate injuries which may or may not have resulted from fires. Slanted thin bars are the inside and outside ring dates of the sample.

Fire frequency and travel corridors

Frequent fires at the Jocko site between 1721 and 1937 probably resulted primarily from anthropogenic ignitions. Jocko township has never been "settled", as were portions of southern Ontario, because the climate and land are not suitable for agricultural development. Thus, it is not surprising that the Jocko site lacks the anthropogenic fire pulse often associated with European or indigenous agricultural development.

Jocko township is, however, within a travel corridor used by the Huron, Nipissing, Cree, Kipawa, Iroquois, French, and English among others, for trade, seasonal migrations, and warfare for hundreds of years (Harris 1987). The Kipawa lived about 30 km to the northeast of the Jocko site in historic times. They practiced some agricultural burning as well as burning to promote the growth and fruiting of blueberries (Moore 1982). Fires were usually set during the first sunny days of spring to prevent the fire from spreading outside the area they wanted burned.

Also, the core area of the Nipissing Nation was located about 50 km southeast of the Jocko site. The Nipissings numbered between 500 and 1000 people in the 1630s. Although non-agricultural (Harris 1987), they were highly mobile, crossing the Jocko River when traveling between Lake Nipissing and Lake Temiscaming where they traded furs with the French. Fires ignited near Kipawa and Nipissing villages or along the Ottawa, Jocko and Mattawa River travel routes could easily spread to the Jocko study site. For example, a 1922 fire that began less than 3 km northeast of the Jocko site burned for 20 to 25 km to the Ottawa River (Donnelly and Harrington 1978).

Perhaps most important, the Jocko site is near the confluence of 2 major travel routes, the Ottawa and Mattawa Rivers. These were the main passageways used in the fur trade that linked the western interior with Montreal. Along these routes, both French and indigenous people traveled to and from Montreal, the St. Lawrence, and the Atlantic. Because the Jocko site is adjacent to travel and trade routes, the flux of human population and anthropogenic ignitions may have been more stable than at sites located near transient villages and hunting camps such as at Opeongo Lookout, Algonquin Park, where abrupt changes in anthropogenic fires have been observed (Guyette and Dey 1995a).

In Ontario, fire frequencies also varied regionally in the presuppression era due to differences in the amount and distribution of large lakes and rivers, and the diversity in topographic relief. Regions with large lakes and rivers and rugged topography, such as Barry's Bay, Huntsville and the west side of Algonquin Park, were more likely to have experienced abrupt changes in fire frequency over the past 200 to 300 years than areas without these features. Broken topography, lakes and streams are natural fire breaks that limit the extent of fires in all but the driest years. Fires in areas with fewer natural fire breaks (e.g., the Jocko site) are more likely to be relatively large in size, resulting in a more stable fire frequency for any given location.

Fire effects on white pine radial growth

Fire can reduce radial growth in surviving mature white pines by causing direct injury to cambial and foliage tissues. Alternatively, increases in radial growth are possible when fire reduces competition and releases nutrients bound in organic litter on the forest floor.

The pattern of radial increment in the white pines at the Jocko site after more than half of the fires is characterized by 1 or 2 years of average growth, then a period of above average growth, which is followed by below average growth (Figure 2). In general, growth is also below average in the years preceding a fire. However, growth after some fire years did not follow this pattern. For example, after the 1810 and 1899 fires, radial growth declined. Both time since the previous fire and fire intensity influence white pine diameter increment.

The average pattern of growth before and after a fire at the Jocko site is illustrated in Figure 3. Below average growth before a fire may result from competition that has developed since the last fire. Of course, there must be adequate time between fires (e.g., ≥10 years) for competitors to regenerate and develop, or overstory canopies to expand into gaps created by fire-caused mortality of mature trees. Also, available nutrients become more limiting as the time since the last fire increases because they are sequestered in organic matter.

In the fire year and immediately thereafter, the pines may sustain damage to their roots and crowns that would slow growth initially. After this initial recovery period, pine growth is enhanced for up to 13 years after the fire because the intensity of

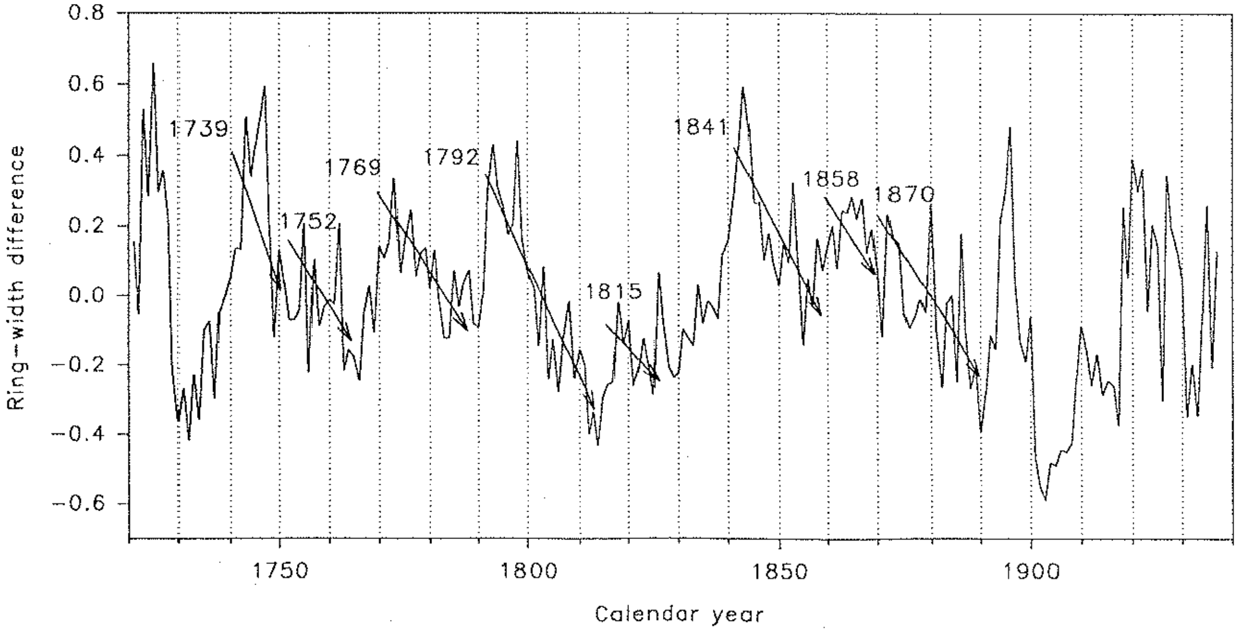

Figure 2. The difference (Jocko minus Hobbs) between standard ring-width chronologies from white pine sampled at the Jocko site and Hobbs Lake. This type of comparison minimizes the climatic component of the Jocko ring-with chronology and maximizes non-climatic influences on growth such as competition, fire and stand dynamics. Notice the pattern of growth increase after the specified fire years, which is followed by a slow growth decline.

competition may have been reduced, the pine's roots and foliage have recovered, and soil nutrient availability has increased from the breakdown of organic matter or changes in soil pH. Even low intensity fires are capable of releasing mature white pines from competition resulting in improved diameter growth (Guyette et al. 1995). The below average pine growth that occurs 14 or more years after a fire may be associated with an increase in competition and a reduction in the availability of soil nutrients, which are tied up in organic matter production.

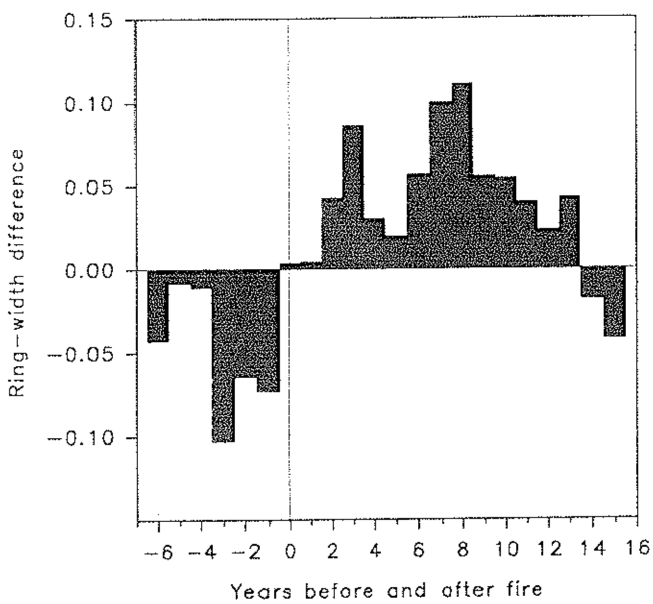

Figure 3. Average growth difference before and after 13 fires at the Jocko site, derived from the data presented in Figure 2. Notice the increase in pine radial growth from 2 to 13 years after a fire (represented by the zero value on the x-axis).

Conclusion

A fire chronology spanning the period 1721 to 1937 was developed for a mixed-hardwood site near the Jocko River using old white pine stumps. The frequency of fire during this 216 year chronology was relatively constant, with an average mean fire-free interval of 14 years. Fires at the Jocko site were typically low intensity surface burns.

Most of the fires at Jocko were probably of anthropogenic origin. Although never as intensively settled as other parts of southern Ontario, the Jocko site was close to major travel routes used by indigenous peoples and Europeans for hundreds, if not, thousands of years. The proximity of the study site to these travel corridors accounted for the stability in human-caused fires for the past several hundred years preceding the modern fire suppression era. Fires were common at the Jocko site even during periods when fire frequencies at more remote sites in central Ontario were in decline due to depopulation caused by disease epidemics and emigration resulting from Iroquois invasions (circa 1640s to 1700s). Also, the relative abundance and distribution of natural fire breaks (e.g., topographic and hydrologic) probably influenced the stability of fire frequency over the past several hundred years at the Jocko site.

White pine can have a positive growth response to low intensity fires. After climate effects on radial growth were removed from the Jocko ring-width chronology, a common pattern in pine growth was observed following many of the fires that occurred from 1739 to 1899. Radial growth was near normal for several years after a fire before it began increasing at above average rates, which were sustained for an extended period (i.e., up to 13 years). The positive effects of fire on white pine diameter growth may be the result of release from competing vegetation and/or an increase in nutrient availability.

Before the modern fire suppression era, fire was a relatively common disturbance factor in Ontario oak-pine forests. Fire suppression and timber harvesting over the past 50 to 100 years have drastically altered historic disturbance regimes. In the absence of fire, succession has led to forest conditions that have not existed for the past 300 years or more. The new disturbance regime has made it more difficult for managers to regenerate or maintain fire dependent and old growth forest communities. Fire histories, such as this one near the Jocko River, quantify the natural role of fire in oak-pine and old growth pine forests, and provide managers with an ecological basis for developing silvicultural practices that maintain these important ecosystems.

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