

# **Protected Areas and Species and Ecosystems at Risk:**

## **Research and Planning Challenges**



### **Parks and Protected Areas Research in Ontario 2005**

Edited by:  
Gordon Nelson  
Tom Nudds  
Meghan Beveridge  
and Beth Dempster

with Leah Lefler  
and Elizabeth Zajc

Proceedings of the Parks Research Forum of Ontario (PRFO)  
and Carolinian Canada Coalition (CCC)  
Annual General Meeting May 5-7, 2005  
University of Guelph

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Cover Photo: Eastern Foxsnake (*Elaphe gloydi*), designated by COSEWIC as one of Ontario's "Treatened" reptiles, is primarily associated with shoreline habitats in the Long Point area, the Lakes St. Clair and Erie peninsula and archipelago, and the eastern shore of Georgian Bay. (Photo from East Sister Island Provincial Nature Reserve by T. Beechey).

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## Overview

### The Parks Research Forum of Ontario

The Parks Research Forum of Ontario (PRFO) encourages research applying to parks and protected areas. The objectives of PRFO are to:

- promote research to improve understanding, planning, management and decision making for parks and protected areas;
- encourage related educational and training activities;
- facilitate more cooperation in parks and protected areas research;
- encourage regular exchange of information on parks and protected areas research; and,
- monitor and report on such research.

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Carolinian Canada Coalition brings together landowners, local groups and partners from conservation, agriculture, forestry, education, planning and other sectors to enrich all life in Carolinian Canada. With more wild species than any other part of the country, Carolinian Canada stands out, naturally, as a unique area with North America's most vibrantly diverse natural neighbourhoods. The Coalition:

- strives for a healthy, balanced and sustainable landscape for the benefit of wild and human communities;
- focuses science-based programs on understanding our critical interdependence with nature for survival;
- finds common ground and voices a common vision with and for our members;
- works cooperatively with everyone who cares about our natural lands; and,
- looks for innovative ways to conserve wild places on southern Ontario's multi-use landscape.

See [www.carolinian.org](http://www.carolinian.org)

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# The Distribution and Abundance of Fire-scarred Trees in Pinery Provincial Park, Ontario, Canada

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## Abstract

*Pinery Provincial Park contains one of the largest remaining tracts of globally rare oak (Quercus) savanna habitat. A prescribed burn plan has reintroduced fire for conservation management. We asked how closely the burn plan mimics past fire history. Reconstruction of the fire history from tree ring analysis of fire-scarred trees was constrained by limits on tree-cutting. Therefore, we assessed the usefulness of non-intrusive data from fire-scarred trees for supplementing limited intrusive data. Fire-scarred trees in Pinery varied significantly in their scar height (cm), size (diameter at breast height), and density (no. of trees m<sup>-2</sup>), across the park. The tree species composition varied across the park, and certain species, such as red pine (Pinus resinosa), were more likely to be fire-scarred. However, fire-scarred trees were found everywhere. These results support the findings of a dendrochronologically-based fire-history which showed that since the 1880s fires in Pinery have been mostly small-scale low intensity burns.*

**Keywords:** dendrochronology, prescribed burning, fire-history, stand structure.

## Introduction

An extensive dendrochronology literature employs tree-ring analysis to date the frequency and intensity of fire events (Kipfmüller and Swetnam, 2001). This research, along with data on charcoal layers in sediments and anthropological studies, shows that fire has been a widespread and frequent ecological disturbance in North American and European forest ecosystems since the end of the last glaciation (Mellars, 1976; Brown and Seig, 1996; Lehtonen and Kolström, 2000; Pitkänen *et al.*, 2003). The use of fire by humans is well documented (Pyne, 1995). First Nation peoples in North America set fires for wildlife, hunting and habitat management (Mellars, 1976).

Fire is a particularly important disturbance in prairies and savannas, which once covered 77.5 million hectares of North America (Nuzzo, 1986). Savannas are open habitats characterized by low tree densities and continuous ground cover (Etwell and Bazely, 2004). Urbanization and agriculture have resulted in reduced cover of prairie and savanna ecosystems in North America to 0.02% of their original extent (Nuzzo, 1986). The practice of fire suppression has resulted in altered plant community composition in the remaining habitats (Etwell and Bazely, 2004).

In recent years the reintroduction of fire through prescribed burning management programmes has become increasingly common as a restoration tool for prairies and savannas (Etwell and Bazely, 2004). One approach is to base burn prescriptions on historical fire patterns (Fulé *et al.*, 2003). This approach is most effective in forests, where tree-ring analysis can be carried out on large sample sizes obtained by cutting down fire-scarred trees or removing large wedges from trunks (e.g., Brown *et al.*, 2001; Guyette *et al.*, 2002). Fire scars are triangular burned areas rising up from the base of the trunk that form when fire does not kill a tree (Gutsell and Johnson, 1996). However, such intrusive sampling (cutting) may not be allowed in protected areas (Goldblum and Veblen, 1992). Reconstructing fire history will, therefore, be challenging and will benefit from inclusion of other sources of fire history data.

This was the case at Pinery Provincial Park, Ontario, Canada, one of the largest extant tracts of globally rare black oak (*Quercus velutina*) savanna community (Etwell and Bazely, 2004). Following management to reduce high white-tailed deer (*Odocoileus virginianus*) densities in the 1990s, a

prescribed burn management plan was introduced in 2000, in which small blocks are burned in rotation over 20 years. Bravo (2004) reconstructed a fire history for the park using dendrochronological techniques that combined increment cores from living fire-scarred red pine (*Pinus resinosa*) trees and cross-sections, or “cookies”, from recently fallen and young trees that were planted during the 1950s in a misguided attempt to “fill in” the forest. Past fires occurred in Pinery at 17-year intervals on average and were patchily spread within the park (Bravo, 2004). Bravo (2004) also carried out a preliminary investigation using non-intrusive data from fire-scarred trees to supplement her intrusive data, and results from a small sample of trees supported the observation, based on tree-ring analyses, that fires were low-intensity and patchy.

By expanding non-intrusive sampling of fire-scarred trees in Pinery, this study aimed to:

1. describe the stand structure of the fire-scarred tree community in the park in 2004; and,
2. assess whether burning small blocks will mimic the past spatial distribution of fires.

Although different plant communities have been identified at Pinery, the forest composition across the oak savanna communities is homogeneous across large sections of the park (Tagliavia, 2002). We assessed whether the historical pattern of patchy, low-intensity fires described by Bravo (2004) has resulted in a heterogeneous, patchy distribution of fire-scarred trees, and if this would be reflected by the non-intrusive data.

We predicted that:

- a. proportions of fire-scarred trees and their scar heights would vary across the park;
- b. densities and size distributions of fire-scarred trees would vary across the park, as well as their species composition; and,
- c. scarred trees would be clumped at small scales.

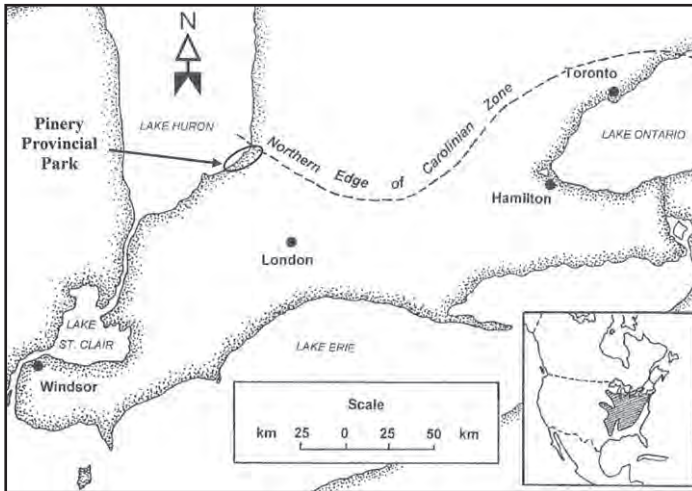
## **Methods**

### ***Study Area***

Pinery Provincial Park (2 532 ha) is located on the southern Ontario shoreline of Lake Huron (43° 15' /81° 51') (Figure 1). The park contains much of the remaining oak savanna habitat in North America (Tagliavia, 2002). This ecosystem has developed on undulating sand dunes that are a classic example of a primary succession chronosequence. Early successional

foreshore communities give way to oak savannas and oak-dominated forest communities on 6 500 year-old dunes (Morrison and Yarranton, 1974). The overstorey is 89% black oak (*Quercus velutina*) and also includes eastern red cedar (*Juniperus virginiana*), black cherry (*Prunus serotina*), white oak (*Quercus alba*), chokecherry (*Prunus virginiana*) and white pine (*Pinus strobus*) (Tagliavia, 2002).

**Figure 1.** Location of Pinery Provincial Park in southwestern Ontario.



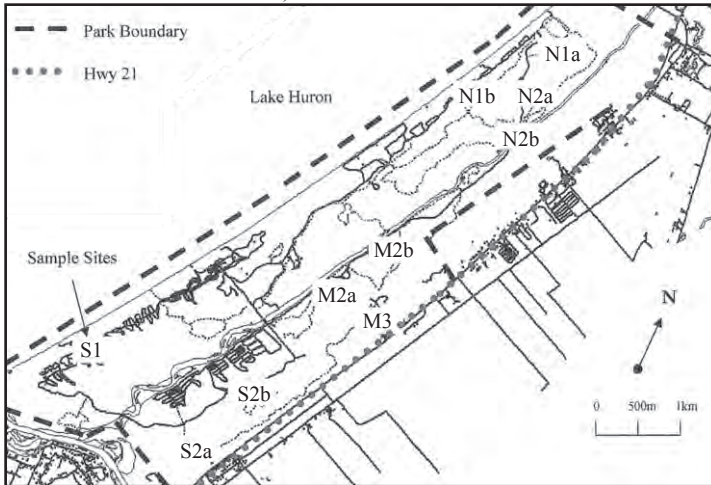
Pinery soils are of low agricultural value and therefore the area has had a history of minimal European anthropogenic disturbance after the extensive disturbance – in Pinery and all of southern Ontario – created by the widespread logging that took place, post-European settlement (A. Woodliffe pers. com.). Pinery Provincial Park was first opened to the public in 1959 (Killan, 1993). From the 1950s to the 1970s habitat management included the planting of red pines (*Pinus resinosa*) to fill in canopy gaps between naturally occurring individuals and the suppression of fire. High deer densities resulted in the cancellation of a prescribed burn program in the early 1990s. The deer herd was reduced in the late 1990s, an extensive planted pine removal program undertaken, and the current 10-year prescribed burn programme re-introduced in 2000 (Tagliavia, 2002).

### ***Stand structure of trees with and without fire scars***

Trees were sampled from December 2003 to May 2004 and Bravo's (2004) preliminary data were greatly extended (Figure 2). The park has a rectangular shape with the rectangle oriented along a northeast-southwest axis. For sampling purposes, it was divided into three sections: (1) northeast, (2) mid-

dle and (3) southwest, and three sections running parallel to the shoreline to yield a 3 x 3 matrix. Fire-scarred trees were sampled in six of the nine cells. Five cells were sampled in December 2003 (Table 1), with sample sites located from drive-by observations of fire-scarred red pines. All fire-scarred trees in areas of 25 x 25 m were flagged, their location marked with a hand-held global positioning system unit, and the height of each fire-scar was measured from the base of the tree to the top of the scar. Each tree was identified to species and its diameter at breast height (DBH) measured, in addition to the distances (m) to the nearest scarred and unscarred trees (DBH > 5cm, and species was recorded). In May 2005 an additional two new cells were randomly selected. Two cells with known high occurrences of fire-scarred trees, sampled in December, were also selected. Sites were randomly located in each cell and a 100 x 100m quadrat established. A team of 14 field workers surveyed each plot for all fire-scarred trees. The location of each scarred tree was flagged, marked with a GPS unit and measured as in December 2003.

**Figure 2.** Locations of sites sampled for fire-scarred trees in Pinery Provincial Park. (See Table 1 for site details.)



### Statistical Analysis

Depending upon the analysis, data were analysed either by plot within each of the six cells, or, if appropriate, were pooled at the cell level. Data were tested for homogeneity of variance and normality. A variety of statistical software was used: StatXact 6, Systat and Statview.

Tree densities were calculated in two ways: (1) using total counts of scarred trees in each 100 x 100m plot, and (2) using nearest neighbour plotless sam-



**Table 1.** Non-intrusive data from fire-scarred trees and standard structure analyses for trees in Pinery Provincial Park.

Plot	Fire Scar Height (cm) mean (SE) n	Diameter at Breast Height: Scarred Trees Mean cm (SE) n	Density Scarred Trees (no./m <sup>2</sup> ) 100 m plots	Density of scarred trees (nearest neighbour) A	Overall tree density (nearest neighbour) B	% scarred trees (A/B)	Distance to nearest scarred tree Mean (SE) n	Distance to nearest unscarred tree Mean (SE) n
N1a*	53.7 (5.8) 19	30.5 (1.6) 19	0.0019	0.005	0.047	10.6	8.1 (1.33) 19	3.4 (0.53) 19
N1b†	123.7 (10.7) 7	44.0 (2.4) 7		0.013	0.037	35.1	5.2 (1.26) 7	5.1 (0.95) 7
N2a†	108.85 (10.5) 10	33.5 (1.5) 10		0.025	0.048	52.1	3.8 (0.82) 9	4.2 (0.39) 9
N2b†	68.8 (12.0) 6	30.7 (6.6) 6		0.018	0.092	19.6	4.5 (1.41) 6	2.9 (0.90) 6
M2a*	52.0 (4.4) 72	8.9 (1.2) 72	0.0052	0.025	0.214	11.7	3.8 (0.35) 71	1.4 (0.08) 71
M2b†	66.8 (8.2) 11	27.2 (5.0) 11		0.002	0.068	2.9	13.5 (3.05) 10	2.4 (0.27) 10
M3*	88.0 (10.5) 47	20.2 (2.3) 48	0.0048	0.007	0.076	9.2	7.3 (0.80) 48	2.6 (0.19) 48
S1†	39.75 (8.6) 4	28.0 (7.2) 4		0.022	0.095	23.2	4.0 (1.2) 3	1.9 (0.58) 3
S2a*	78.4 (8.5) 34	26.1 (2.8) 35	0.0034	0.009	0.028	32.1	6.3 (0.79) 35	4.9 (0.47) 35
S2b†	107.75 (41.1) 4	16.9 (3.3) 4		0.018	0.177	10.2	4.5 (2.74) 4	2.4 (0.62) 4

†Sampled December 2003, \*Sampled May 2004, Plot size of 100 x 100m

pling. The formula  $1/(1.67 \times \text{mean nearest neighbour distance})^2$  was used to estimate density of fire-scarred and all trees (both scarred and unscarred) (Mueller-Dombois and Ellenberg, 1974).

## **Results and Discussion**

### ***Tree Species Composition and Tree Size***

The three most commonly occurring fire-scarred tree species in Pinery were black cherry at 27.8% (n=64), red pine at 26.5% (n=61) and black oak at 25.2% (n=58) (Figure 3). Black oak was the most common unscarred species at 43.8% (n=92).

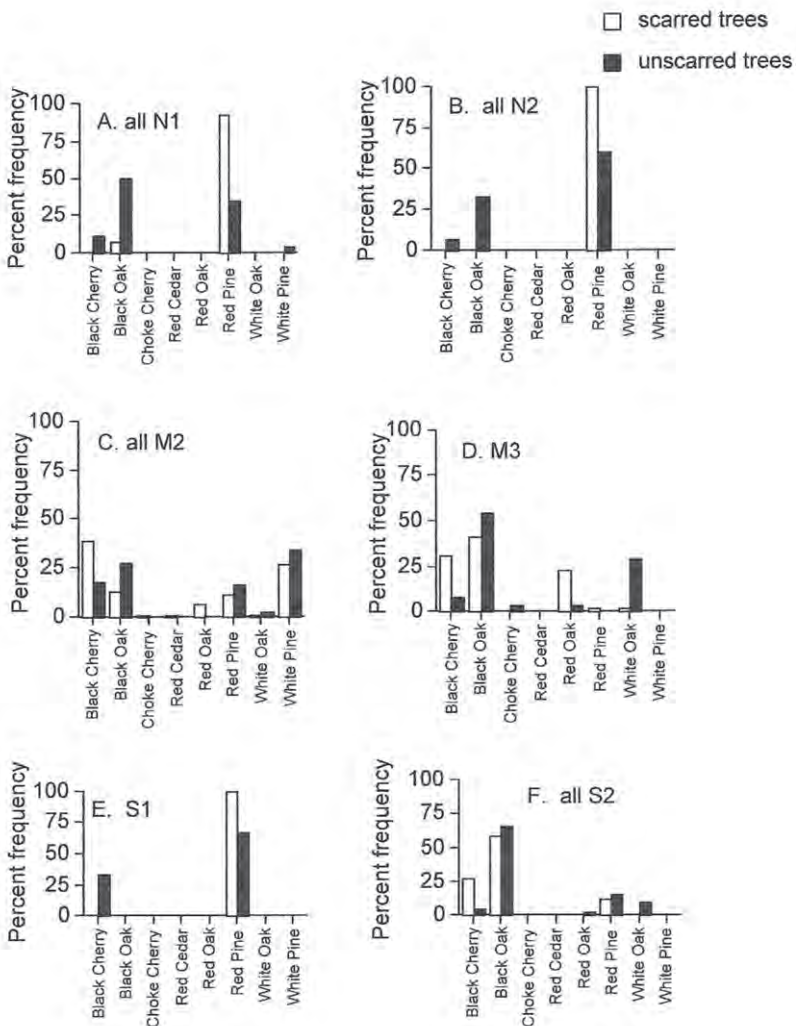
In Rows x Columns contingency table analyses of associations among the species composition, plot location within Pinery, and the status of trees (whether scarred or unscarred), two associations were significant but one was not. The first test looked for an association between plot location and the species present in the plot, controlling for burn scar status. The Cochran-Mantel-Haenszel Test on Unordered Stratified RxC Data, yielded a Monte-Carlo simulation value of 317.8,  $p = 0.000$ . Thus, species composition varied significantly among plots. In a second Cochran-Mantel-Haenszel Test, controlling for plot location, a significant association was found between scarring status and species (Monte-Carlo simulation: 55.74,  $p = 0.000$ ). Thus, certain tree species tend to be more associated with fire scars. In a final test, the association between plot location and likelihood of finding scarred trees, controlling for species, was examined, and was not significant (Monte-Carlo simulation: 3.036,  $p = 0.7026$ ). Thus, the distribution of fire-scarred trees, in general, was constant across the park.

There was significant variation in the size (DBH) of fire-scarred trees at the plot level: N1a etc. (one-way ANOVA:  $F_{9,206} = 12.8$ ,  $p < 0.001$ ) (Table 1). When the diameters of all fire-scarred trees were pooled within each of the six matrix cells (N1, N2, M2, M3, S1, S2), there was still significant spatial variation in size (one-way ANOVA:  $F_{5,210} = 16.1$ ,  $p < 0.001$ ). The largest fire-scarred trees occurred in the northeast of the park, the smallest trees in the middle section and intermediately sized trees in the southwest (Table 1). Thus, the more recent fires have occurred in the middle and southern parts of the park. This reflected the fact that one plot was located in a prescribed burn block from 2001. (The western cluster of trees labelled M2b were in a 2001 burn plot.)

In general, the largest fire-scarred trees were red pines and black oaks, while fire-scarred black cherry trees were smaller in diameter (Figure 4). How-

ever, when fire-scarred trees of the same species were compared across Pinery, there was size (DBH) variation within species (Figure 4). A nested or split-plot ANOVA was carried out to determine whether this species effect on size was significant. In the ANOVA, tree species was considered a main factor and park location or cell (plots were pooled within the same cells) were nested within species. Since scarred white pines occurred in only one

**Figure 3.** Species composition of plots (percent frequency) in which fire-scarred trees and their nearest neighbour unscarred trees were identified.

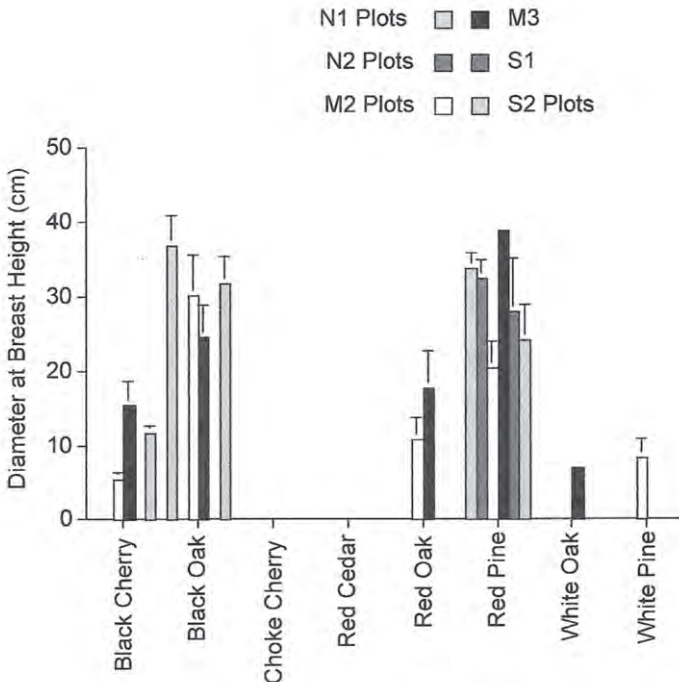


cell (M2), this species was excluded from the analysis and white oak, with only two scarred trees samples in M3 was also excluded. In the analysis of four species, the main factor (tree species) was significant ( $F_{3,10} = 8.7$ ,  $p < 0.01$ ), indicating that different tree species with fire-scars were significantly different in size. The nested factor (cell location within species) was also significant ( $F_{10,180} = 2.4$ ,  $p < 0.05$ ) indicating that observed size (DBH) variation of fire-scarred trees was significant. Therefore, fire-scarring of the same tree species was occurring at different times across the park.

### Fire Scar Height

Scar heights varied significantly across all plots within Pinery (Table 1) ( $F_{9,204} = 4.3$ ,  $p < 0.001$ ). The shortest fire scars occurred in the middle and southern end of the park, where more recent burns had taken place. The trees with the tallest scars, greater than one metre in height, tended to occur at the northern and southern end of the park, indicating more intense burns.

**Figure 4.** Size (diameter at breast height) of fire-scarred trees by species, across Pinery.



### ***Tree Densities: all trees and fire-scarred trees***

The mean distances from fire-scarred trees to the nearest scarred and unscarred trees varied across the park (Table 1). The mean distance to the nearest fire-scarred tree was less than that to the nearest unscarred tree in only one plot (N2a), suggesting that sampling here had occurred within a single burned patch. In all other plots, the mean distance to the nearest fire-scarred tree was greater than the distance to the nearest unscarred tree, indicating that scarred trees were more widely scattered among unscarred trees. The distances to scarred and unscarred trees were analyzed with a nested ANOVA, in which scar status of the nearest tree was treated as a main grouping factor, and plot was treated as a within-group factor. The mean distance to the nearest tree did not differ significantly according to whether it was scarred or unscarred ( $F_{1,18} = 4.2, p=0.055$ ), although it verged on being significant. The mean nearest neighbour distances to both scarred and unscarred trees varied significantly among plots ( $F_{18,405} = 6.8, p<0.001$ ) reflecting the large variation in tree density across the park.

Evidence for the locally patchy nature of fires within Pinery came from tree density estimates, which varied both across the park and according to the calculation method (Table 1). The use of nearest neighbour distances between fire-scarred trees gave slightly higher densities for scarred trees than densities obtained from 100 x 100 m quadrats, and this difference approached significance (paired *t*-test:  $t = 1.87, df = 3, p=0.079$ ). Thus, fire-scarred trees were somewhat patchily distributed at a scale smaller than 100 x 100 m so that densities based on nearest neighbour distances reflected the fact that fire-scarred trees tended to be clumped and to give slightly higher densities.

Overall tree densities (for all trees, both fire-scarred and unscarred trees) were calculated by taking the smallest value of each of the two nearest neighbour distances (to the nearest fire-scarred and unscarred tree) for each scarred tree (Table 1). Densities varied widely from 0.028 trees m<sup>-2</sup> in S2a (one tree per 35.7 sq. m) to 0.214 trees m<sup>-2</sup> in M2a (one tree per 4.7 sq. m), which contained many small black cherry trees (Figures 3c and 4). As expected, the overall density of scarred trees was always less than that of all trees (both scarred and unscarred).

### **Conclusion**

This study of tree composition and size and the height of fire scars showed that the most recent fires have occurred in the middle and southern parts of Pinery Park, whereas the oldest fires have occurred in the northern part. Fire

scar height indicated that the more intense fires occurred in the northern part of the park. The more recent fires, in the middle of the park, were probably low-intensity burns, since this was the only location with high frequencies of fire-scarred black oaks, a species that will form fire scars during such burns (Smith and Sutherland, 1999). Oak is a hardwood, and hardwood species were found to have higher mortality than some pines after a higher intensity burn (Guyette and Spetich, 2003). A subsequent low-intensity fire scarred the small black cherry trees in this part of Pinery. Since tree density varied across the park, the historical pattern of patchy, low-intensity fires has resulted in a heterogeneous, patchy distribution of fire-scarred trees at local scales. However, the entire park reflects a history of fire, since scarred trees were found in all study plots.

This larger survey of fire-scarred trees in Pinery showed that the prescribed burn plan, in which small blocks are burned over a 10-year rotation across the park, is in line with the high level of variation observed across the park in terms of the impact of past fires. Although Bravo's (2004) fire-history showed a 17-year burn interval, it only extended back to 1880 and it is possible that pre-European colonization fires were more extensive and widespread. This fire-history pattern has been found in other North American ecosystems: the Grand Canyon (Fulé *et al.*, 2003), South Dakota (Brown and Seig, 1996), and New Mexico (Brown *et al.*, 2001). Future work might involve comparing tree composition, if such data are available, between the time of European colonization and the present, to determine how the overall ecosystem structure has changed.

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