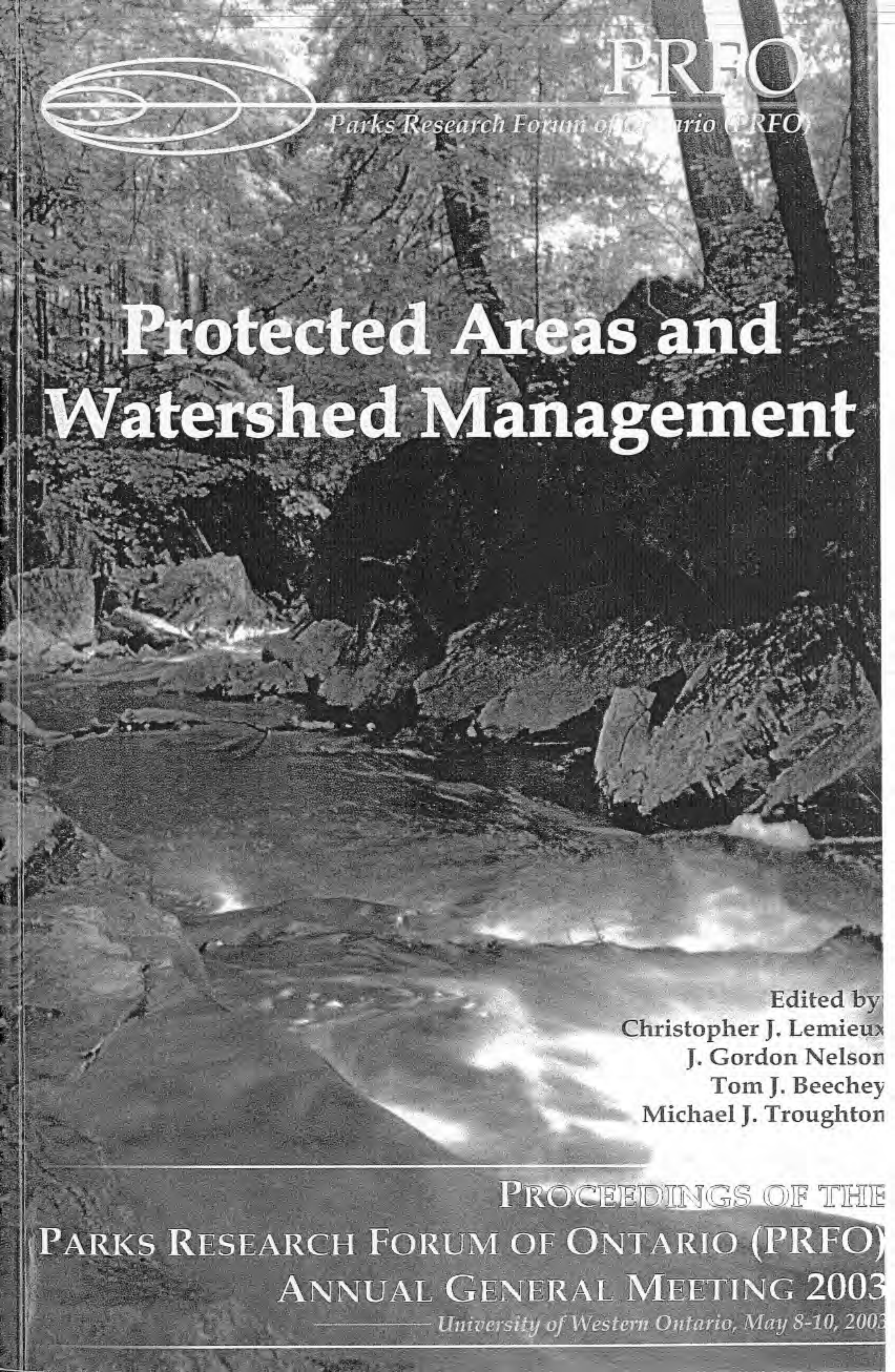

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Cover Photo: Cascades and valley woodlands on Spencer Creek below Webster Falls, Webster Falls Conservation Area, Hamilton Region Conservation. By: Tom J. Beechey.

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Determining Appropriate Fire Frequencies for Oak Savannas in two Ontario Provincial Parks

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Abstract

Prescribed burning is a popular management tool in many prairie and savanna restorations. In Ontario's globally rare oak savanna plant communities it is viewed as a means of restoring historic disturbance regimes essential for the maintenance of native species. Prescribed burn plans have been implemented at two Carolinian provincial parks, Rondeau and Pinery. Our goals are to establish a framework for the restoration of oak savanna communities that is based on the principles of restoration ecology and adaptive management. Since burning has both short and long-term effects, effective monitoring of plant community responses is essential. A key to success will be ensuring that protocols for measuring long-term plant community responses to burning, that are designed to be carried out by researchers with varying levels of field expertise yield sound data.

Introduction

Wilson (1985) stated that loss of biodiversity will be the most important biological issue of the 21st century. The main cause of species loss is habitat destruction (Diamond, 1989). A case in point is that of tallgrass prairies and savanna ecosystems. Savannas once covered 77.5 million ha in the U.S., but by 1985 only 0.02% remained (Nuzzo, 1986). In southern Ontario, 2100 ha of prairie woodland and savanna remain, which is less than 3 percent of the pre-European settlement cover of prairie and savanna (Bakowsky and Riley, 1994).

What is Savanna?

Savanna is generally agreed to be the ecotone between prairie and forest, with a tree canopy cover of 10-35% (Bakowsky and Riley, 1994; Packard, 1993). Broadly speaking, savannas have open-grown trees and/or shrubs growing over a continuous ground-layer of herbaceous vegetation (Leach and Ross, 1995). Various plant species are unique to this herbaceous layer (Packard, 1988). In Canada, the range of oak savanna is restricted to Ontario's Carolinian Ecozone which contains many species at the northern limit of their distribution (Rodgers, 1993). Many rare-in-Ontario and rare-in-Canada plant and animal species occur in this habitat (Rodgers, 1998).

Study Sites

Rondeau and Pinery Provincial Parks contain significant areas of oak savanna. There are two commonly recognized types of savanna: oak (*Quercus spp.*) and red cedar (*Junipenus vinginana*), which are characterized by a high proportion of these specific tree species in the canopy, although this is more of a qualitative than a quantitative distinction (Falkenberg, 2000; Tagliavia, 2002). The black oak (*Quercus velutina*) and black and white oak (*Q.velutina and Q.alba*) savanna associations in Pinery are not statistically distinguishable, and are variations along a continuum (Tagliavia, 2000).

Both parks have been greatly affected by high populations of white-tailed deer (*Odocoileus virginiana*) (Koh, 1995). Ground level light was a significant abiotic factor in determining plant community composition and reduction of deer densities resulted in a significant shift towards greater cover of typical savanna plant species (Tagliavia, 2002). While light and deer herbivory have been extensively studied in Rondeau and Pinery, relatively little quantitative data are available on the impact of fire.

Fire as a Disturbance in Oak Savanna

Fire is an ecological disturbance that can have many different outcomes, and the extent to which its role is understood is variable. Its significance as a disturbance that shapes and maintains savannas is known primarily from the many historical records, as well as dendrochronology and charcoal patterns in the soil (Batek *et al.*, 1999; Lorimer, 2001). These studies have concluded that fires were frequent and constrained the conversion of savanna to other community types, mainly forest.

Periodic fire maintains a semi-open canopy of oak trees and understorey grasses (Bond and Van Wilgen, 1996). Oaks appear to be physiologically adapted to fire (Olsen, 1998). Grasses tend to have most of their biomass below-ground, and their meristems are close to the ground. Thus, grass plants easily produce new leaves following a burn (D'Antonio and Vitousek, 1992). Fire is, however, a major mortality factor for seedlings of many woody species. Additionally, many non-native plans are out-competed by the dry sands, high wind exposure and high light conditions of oak savannas and also die when burned (Peterson and Reich, 2001; Anderson and Brown, 1996).

Some researchers have suggested that fire suppression by humans (European colonizers) is a leading cause of the decline in both the range and total area of savannas. The exclusion of fire due to habitat fragmentation and land-use change, along with fire prevention and suppression has led to significant structural changes in areas that were once savanna, including increased tree density, and to succession towards more fire-sensitive and shade-tolerant overstorey species (Peterson and Reich, 2001). There is evidence of a feedback cycle that maintains savanna by continual fire disturbance, which in turn affects soil development, and consequently, vegetation (Arabas, 2000).

Fire Frequency

While the significance of fire in oak savannas is well established, there is ongoing debate about the relationship between burn regimes and plant community composition and how this may vary among habitats and along environmental gradients (Packard, 1993). One approach to determining appropriate fire frequency is to try to reconstruct historical patterns. An alternative approach is to carry out long-term experiments examining the outcomes of different fire frequencies.

The Most Frequent Fire Hypothesis suggests that burning as frequently as fuels will allow is the best strategy for maintaining species richness and abundance in savannas (Glitzenstein and Streng, 2003). A number of experimental studies support this hypothesis. At Cedar Creek (Minnesota), species richness, and cover of grasses, sedges, and forbs increased significantly with increasing fire frequency (Tester, 1989; White, 1983). Peterson and Reich (2001) and White (1983) examined the relationship between fire frequency and woody stand structure. They found that as fire frequency increased, the density of woody seedlings and sprouting from boles declined, that the canopy showed no further expansion, and that tree density and basal area was reduced.

At Konza Prairie (Kansas) decreasing tree density was correlated with increasing fire frequency (Briggs *et al.*, 2002). However, the abundances of some selected species showed a positive relationship with fire frequency. Collins (1992) used data from this site to test the predictions of the Intermediate Disturbance Hypothesis. This hypothesis suggests that species richness will be greatest at sites experiencing intermediate fire frequencies. He found that species richness and heterogeneity were actually lowest at the intermediate burning frequency. He later (Collins, 2000) studied the effect of fire frequency on stability in plant communities. His results suggested that plant community stability decreased with increasing fire frequency, with areas burnt once in 20 years being the most stable. His results also showed that mean species richness and annual turnover were lowest on the annually burned sites, and highest on the 4-year burned sites, which might be taken as supporting the intermediate disturbance hypothesis. Thus, results are not always completely clear-cut (see also Gibson, 1988).

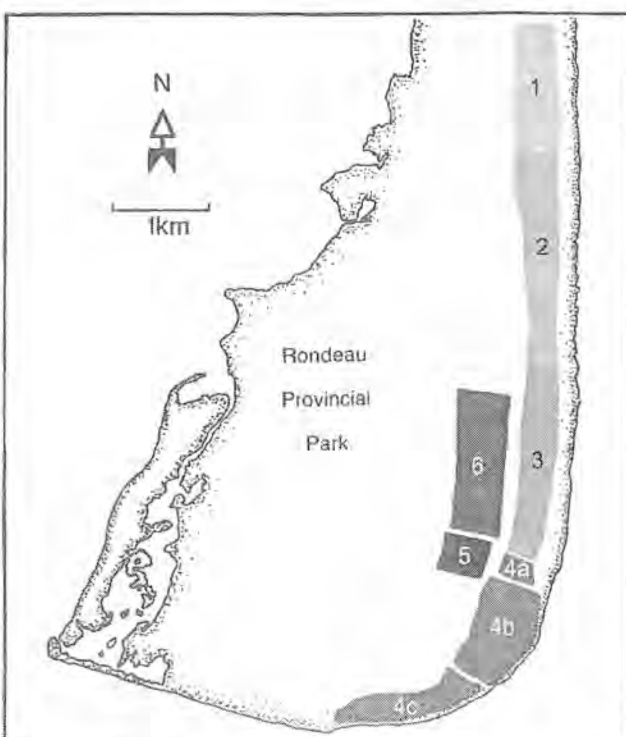
There are a few other studies of the impact of varying fire frequency in other sites. At Missouri Prairie, the grass cover was greatest in annually burned sites, although, burns every two years provided the broadest representation of native species including grasses (Kucera and Koelling, 1964). In the Alison Savanna (Minnesota), canopy cover increased, even at a one in 3 to 5 year fire frequency, and declined only at the once in 1–2 year burn frequency (Faber-Langendoen and Davis, 1995). In long leaf pine (*Pinus palustris*) savannas, species richness increased with increasing fire frequency (Glitzenstein and Streng, 2003; Varner *et al.*, 2003).

Overall, a majority of these papers appears to support the Most Frequent Fire Hypothesis. However, burn frequencies in the 1–4 year range sometimes produce variable results. This may be due to various reasons, such as different experimental designs, patchiness in availability of propagules (seed bank), and variation in fire characteristics such as the intensity of the burn. Additionally, there is a gap in the literature of quantitative studies from southern Ontario savannas. Nevertheless, we can predict, based on the literature, that frequent prescribed burning, as often as every one to two years, will produce the highest native diversity in Ontario's oak savanna communities.

Ecological Restoration of Oak Savannas at Rondeau and Pinery Provincial Parks

Ecological restoration is *"the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed"* (SER, 2002). With high deer densities under control, prescribed burning of oak savannas is proceeding. In the past, post-burn vegetation at Pinery, was promptly grazed by deer. Prescribed burn plans currently guide park managers at both parks in their restoration of oak savannas. The plans divide the parks into blocks which are either to be burned on a 10–20 year rotation (Pinery) or, initially, annually at Rondeau (Figure 1), if possible, giving way to less frequent "maintenance burns". In general, prescribed burning is an expensive and unpredictable management approach since it is subject to stringent safety protocols and is highly weather-dependent. Those practitioners with a great deal of knowledge have often not published or completed quantitative studies based on their experience, although this is now starting to be done (OMNR, 2001).

Figure 1. *Rondeau savanna blocks included in the burn plan (1-4) and those to the west of the major fire break, which will not be burned (5-6).*



At both Rondeau and Pinery, planned burns have not occurred in their entirety, since their implementation, due to various logistical problems such as weather (wind and smoke control), and time frames before spring green-up. Future burn plans will need to reflect the lack of completion of the 2002 plans. In 2001, Rondeau park managers developed a Fire Management Monitoring Program in consultation with North-South Environmental Inc. (2002). An adaptive management process is recommended for meeting the goals and objectives of the park burn plan. (Table 1), and the protocol is aimed at measuring the success of the management objectives over time. Belt transects have been established for the collection of data on the various indicator plant species. At this point in time, Pinery does not have specific vegetation and fire objectives laid out in the same way as those for Rondeau.

Table 1. *Fire management goal, objectives and corresponding indicators for Rondeau Provincial Park (North-South Environmental, 2002).*

To restore the ecological functions and attributes of the savanna and woodland habitats in Rondeau Provincial Park through the reduction of woody plants and exotic species, while at the same time stimulating the production of native forbs, grasses, sedges, and trees (oaks and pine).	
FIRE MANAGEMENT OBJECTIVE	FIRE MANAGEMENT INDICATORS
1. Increase the abundance of native graminoids (grasses and sedges) and forbs typical of oak savanna and woodland.	indicator species, grasses and sedges
2. Decrease the ab undance of non-native cool season grasses.	grasses and sedges
3. Decrease the abundance of woody species (especially exotic species).	tree saplings, shrubs, stand composition
4. Increase the plant and animal diversity of the oak savanna and woodland habi tats	species diversity

How do we Know if Prescribed Burning is Working?

Restoration ecology is the science that supports the practice of ecological restoration (SER, 2002). Determining whether prescribed burning at Rondeau and Pinery is successful involves collecting quantitative data that can be analyzed to address specific restoration goals. Supplying data on native species richness in relation to burning frequency, to park managers will enable them to do adaptive management.

Adaptive management is generally perceived, as the most effective way to deal with ecosystem variability and unpredictability such as the variable impact of burning on plant community composition. A simplistic definition of adaptive management is that it involves trial and error learning (Walters, 1986). Walters (1986) describes conventional management approaches as seeking precise predictions based on detailed understanding, emphasizing short-term objectives, seeking to minimize conflict, and searching for scientific consensus. In contrast, adaptive management looks at the longer term, highlights difficult trade-offs and embraces alternative, while explicitly admitting that there are ranges of possible outcomes. Walters (1986) views the adaptive management approach as a difficult one to implement because it emphasizes uncertainty, and the need to constantly be learning about the way that a natural system behaves, and "tweaking" the management approaches used. This is exactly what park managers at Rondeau and Pinery would like to be able to do, particularly because of the operational uncertainties of prescribed burning.

Specific questions that we are asking about prescribed burning at Rondeau and Pinery are:

1. How do plant communities respond over different lengths of time since burning? A positive response following prescribed burning would be reflected in overall higher native species diversity and abundance in permanent plots in burned blocks (e.g., Rondeau 1–4) compared with that in unburned blocks (e.g., Rondeau 5–6) in both parks.

Determining the fire frequency that will maximize and maintain these communities relative to their existing conditions will involve comparing species composition in plots based on the time-since-burning (fire return interval in years). Our broad, stratified plot design incorporates historical blocks burned as early as 2001, and will enable a chronosequence of plots with different times since last burning to be established at both parks. Initially, we expect the mostly recently burned plots to have the highest native diversity and abundance, which will likely decline significantly as time-since-burning increases. These data may lead park managers to burn more frequently than initially planned or to be confident about missing burns in some years.

2. What is the germinable seed-bank composition of permanent plots? This research assesses the potential for regeneration of native species. Depending on results, park managers may plan to incorporate reintroductions of particular species in oak savanna communities to some areas to promote more rapid recovery.

3. How well do the Rondeau within-park monitoring protocols aimed at assessing plant community change after prescribed burning, and which are designed to be carried out at a less intense level by less qualified summer staff, reflect results of our more detailed studies of plant community com position?

This question will be addressed by sampling the same areas, using two different protocols. If the results are comparable, the less labour-intensive protocol can be taken as a reliable indicator of plant community change over the long-term. If the two approaches show different results then informed decisions can be made about whether to refine or alter the protocol.

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