Managing Protected Areas in a Changing World

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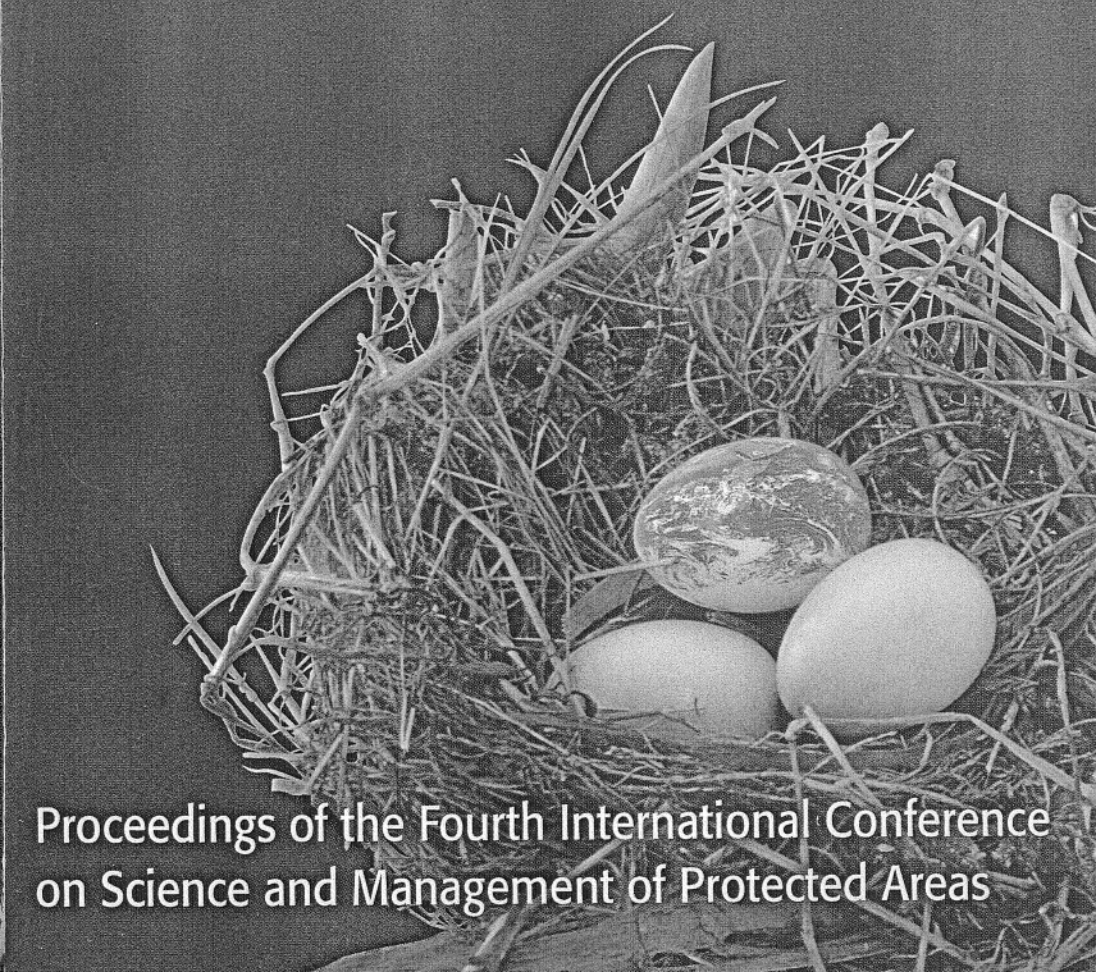

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SHEDDING LIGHT ON THE PROBLEM OF DEER OVERGRAZING IN CAROLINIAN FORESTS

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ABSTRACT

In nearly a decade of research we have carried out a multi-faceted study of the impact of deer grazing in three major Carolinian parks: Point Pelée National Park, and Rondeau and Pinery Provincial Parks. This research has had a direct impact on management policy. We will review key findings of the research program and highlight what we consider to be our most general research finding, namely that the state of the overhead canopy in Carolinian forests appears to have a major impact on the composition of understorey plant communities. We suggest that deer overgrazing has initiated a process that has significantly altered understorey light conditions. Our hypothesis is that increased canopy gaps, initially caused by deer preventing forest regeneration, have led to trees being more susceptible to wind throw. This further opens the canopy, leading to increased light levels in the understorey, which in turn drive changes in the vegetation. Non-native, invasive species can take advantage of the increased light conditions and appear to replace and suppress native woodland species, which are adapted to shade. The forest may then switch to some alternative stable state. Currently, analysis of long-term data sets is aimed at evaluating this hypothesis.

Our current research aims to quantify the relationship between understorey light levels and the plant community, and it will establish whether there is some threshold light level beyond which many vulnerable native understorey species cannot survive, and are suppressed by exotics. In this respect it is of general interest to anyone working in a degraded, highly disturbed forest, with an interest in habitat restoration.

1.0 INTRODUCTION

A substantial body of literature has been developed in the last 25 years in which the major impact of herbivory by both vertebrates and invertebrates on ecosystems and plant communities has been well-documented (1). One particular area of interest has been the impact of overgrazing by high populations of vertebrate herbivores such as lesser snow geese, *Anser caerulescens*, which have a major influence on ecosystem structure and functioning, plant community composition and may act as agents of natural selection (2).

2.0 WHITE-TAILED DEER IN CAROLINIAN FORESTS

Point Pelée National Park and Rondeau and Pinery Provincial Parks are some of the few remaining large fragments of Carolinian (Eastern Deciduous) forest in southwestern Ontario, where forest cover is less than 10% on a regional basis (3). The Carolinian zone also contains 65% of Ontario's rare plant species, with 40% restricted to this zone (4).

All of these parks have been severely overgrazed by white-tailed deer, *Odocoileus*

virginianus, in the recent past. Deer counts showed that densities were in excess of 40 deer km^{-2} and herd reductions were either conducted or planned, in an attempt to reverse the degradation (5, 6, 7, 8, 9). Some immediate effects of deer grazing could be seen in the loss of rare native species from these parks (8). These species are at the northern edge of their range in Ontario, and most of their habitat in the region is gone (3, 4). Common native species were also being affected by overgrazing. White trillium, *Trillium grandiflorum*, heights were found to decrease with increasing deer density at various sites (7). Because they are continuously grazed, older plants end up being smaller. In addition, in the most intensely grazed sites, trillium did not flower (5, 7).

Another effect of deer grazing has been an increase in exotic species. Many of these species persist in overgrazed sites because of physical defenses such as thorns on the Japanese barberry, *Berberis thunbergii*, or because they are very prolific reproducers, like garlic mustard, *Alliaria petiolata* (8, 9). In the following sections we describe the methods that we have used and some of our recent results about ecosystem and plant community level changes in the last two decades.

3.0 METHODS AND RESULTS

In 1991, we started to investigate the long-term impact of grazing by white-tailed deer on the plant communities of Rondeau, Pinery and Point Pelée parks. We took a multifaceted approach, focusing both on individual parks, and also placing them in a regional context, by including other sites in southern Ontario with much lower deer densities (7, 8, 9). We have studied the demography of individual plant species affected by deer, and have also tracked plant community composition and various ecosystem characteristics such as light and water. We have combined monitoring with field and greenhouse experiments. Our primary experimental tool is the use of permanent 2m x 2m deer exclosures built at Rondeau (n=60) and Pinery (n = 30) (8), and on occasion, temporary, one-season exclosures, which have been used at all of our study locations. All of this work has been written up in unpublished government reports and theses, and peer-reviewed journals (see references).

Rondeau Provincial Park has always been the main focus of our sustained research on deer overgrazing. At Point Pelée, the deer were one of a number of major disturbance factors, and over the last decade, our research there has broadened to investigate these other disturbances (3). Similarly, at Pinery, there are other considerations in addition to deer overgrazing. The forest was extensively planted with pine trees in the 1960s, which are now being removed, and is dominated by more open oak-savanna communities, which are heavily fire-dependent. Our research at Pinery is now focusing on the dynamics of oak savannas, rather than the smaller patches of closed canopy forest. The advantage of Rondeau was the presence of various series of plots dating back to 1978 and 1981. We could compare our exclosure and grazed control plots with two large exclosures (Bennett and Gardiner) built in 1978, when deer numbers were high (7) and with 1981 plots that we re-located (10).

Initially, in 1991, we predicted that removal of deer via exclosures would result in recovery of the flora in these plots, and that they would change over time to more closely resemble the plant community of the long-term (1978) exclosures. In 1992 at Rondeau, the grazed understorey plant community was significantly different com-

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pared with the plant community in Bennett and Gardiner exclosures (7). In the early 1990s, both before and after a deer herd reduction in winter 1993-94, the grazed control plots were characterized by grazing tolerant and non-native species (11, 12). Bennett and Gardiner contained more early spring-flowering forest plants such as trillium and jack-in-the-pulpit, *Arisaema triphyllum* (11). By 1995, the plant communities in the new (1991) exclosures had not become more similar to those in Bennett and Gardiner (13).

There have been three herd reductions at Rondeau in the last decade (fall 1993, 1998 and 1999). The lack of overall recovery of plant communities in 1991 exclosures suggests that deer overgrazing has had a more complex effect on the forest, which exclusion of deer alone cannot remedy. The evidence from Rondeau suggests that the grazing may have driven the community to an alternate state, which is now being sustained by other factors, and removal of the disturbance does not appear to be followed by significant recovery (9).

In 1993, we surveyed forest stand structure at Rondeau. There were relatively few large trees and low recruitment in smaller size classes (6). In 1996 and 1997, we resampled 19 of the 68 sites established in 1981 (10) and found that 40% to 80% of the large canopy trees were no longer standing (12). Thus, the forest at Rondeau has opened up considerably over the last 20 years. The reason for this is that one outcome of the deer grazing is a lack of forest regeneration. High numbers of deer in all of the parks were grazing and browsing everything in the understorey, including all of the tree seedlings which would normally grown to fill in naturally occurring canopy gaps (9). This process has been hypothesized to lead to the enlargement of gaps, as trees around the edges become more susceptible to wind throw (9).

Point Pelée National Park has also suffered from intense deer grazing in the past (5, 6, 7), but active habitat restoration has been ongoing for several decades, along with intensive deer control beginning in 1989. While many plant communities in the park have shown some signs of recovery and evidence of forest regeneration, one class of vulnerable native understorey species (spring flowering ephemerals with low dispersal capabilities), extirpated from cottage and road sites, have not recolonized restored sites after 30+ years, even though there are nearby populations (3, 6, 14).

4.0 MAKING THE LINK BETWEEN LIGHT AND THE UNDERSTOREY

Canham *et al.* (15) showed that understorey light levels significantly increase with canopy gap size. Others have noted a large increase in plant cover and a shift to early successional, shade intolerant species in clearcut areas, which reverses after several years once the canopy has closed (16). Where light is typically a limiting resource in a forest understorey (16, 17), the supply is abundant after clearcutting (16). One hypothesis arising from our work suggests that the extensive opening of the forest canopy as a result of deer overgrazing has caused understorey light levels to increase to the point where many native forest understorey species cannot reestablish once the original disturbance has been removed. This may be due to several reasons: (1) non-native, invasive species may take advantage of the increased light conditions by outcompeting and suppressing native woodland species, (2) light levels may be too

great for native woodland species to survive, (3) native species may be absent from the seed bank and their dispersal features may have effectively prevented colonization following local extirpation. If any of these processes are occurring, they have implications for restoration efforts in the parks. In particular, simply reducing the deer populations may not be enough to shift the community back towards its pre-deer state. Some active habitat restoration will need to be considered.

To investigate the possibility that increased light may be preventing the grazed and recently exclosed Rondeau plant community from moving towards that in Bennett and Gardiner, an artificial shading experiment was set up at Rondeau in 1997. Artificial shade was erected over exclosures and grazed control plots at several of the sampling stations originally established in 1991. The first two years of data showed no significant recovery of woodland species in the shaded plots (S. Koh unpubl. data). Interestingly, there are also few "weedy" species here. Other studies have shown a depletion of native seedbank in Rondeau (6), so recovery here may require intervention such as active re-introduction of native species.

This work is currently being extended in a study to quantify the influence of forest structure on light conditions and the understorey plant community. The overall working hypothesis is that the habitat quality in the understorey increases for native species as the canopy cover closes, and that this correlates with decreasing light (3). This will at least be the case as long as seed sources are available.

In 1999, we compared the understorey light levels at Rondeau and Pinery with sites in the region that have experienced lower deer densities. Preliminary analyses showed that light levels in the parks (PIN and RON prefixes indicate grazed (GR) and ungrazed (UG) Pinery and Rondeau sites) were significantly greater than most reference forest sites (PF = Port Franks, HS = Hillman Sandhills, GART = Gartshore, BACK = Backus Woods) (Figure 1). Sites with a more intense deer grazing history (Pinery and Rondeau) generally had greater light levels. In addition, light levels measured at ground level (Figure 1a) and at a height of 2m (Figure 1b) did not differ within most sites, indicating a lack of subcanopy layer to further intercept the light filtering through the canopy. Forthcoming analysis of forest stand structure data collected in 1999 is expected to show a relationship between this structure and the observed patterns in light between sites. Continued monitoring of the understorey species composition at our permanent plots for long-term trends will also be compared to recently measured light levels.

Another current experiment is investigating whether there are minimum understorey light levels required for the successful reintroduction of vulnerable species that have been locally extirpated by deer (14). A successful afforestation experiment planted in 1994 in a post-agricultural field at Sturgeon Creek, near Point Pelée, is now at the point where the trees are creating shade (3). We are presently carrying out test re-introductions of native herbaceous and woody species in several open and shady patches in this field, in order to determine the relative importance of light conditions and inter-specific competition for their establishment. In the future, we plan to investigate seed dispersal.

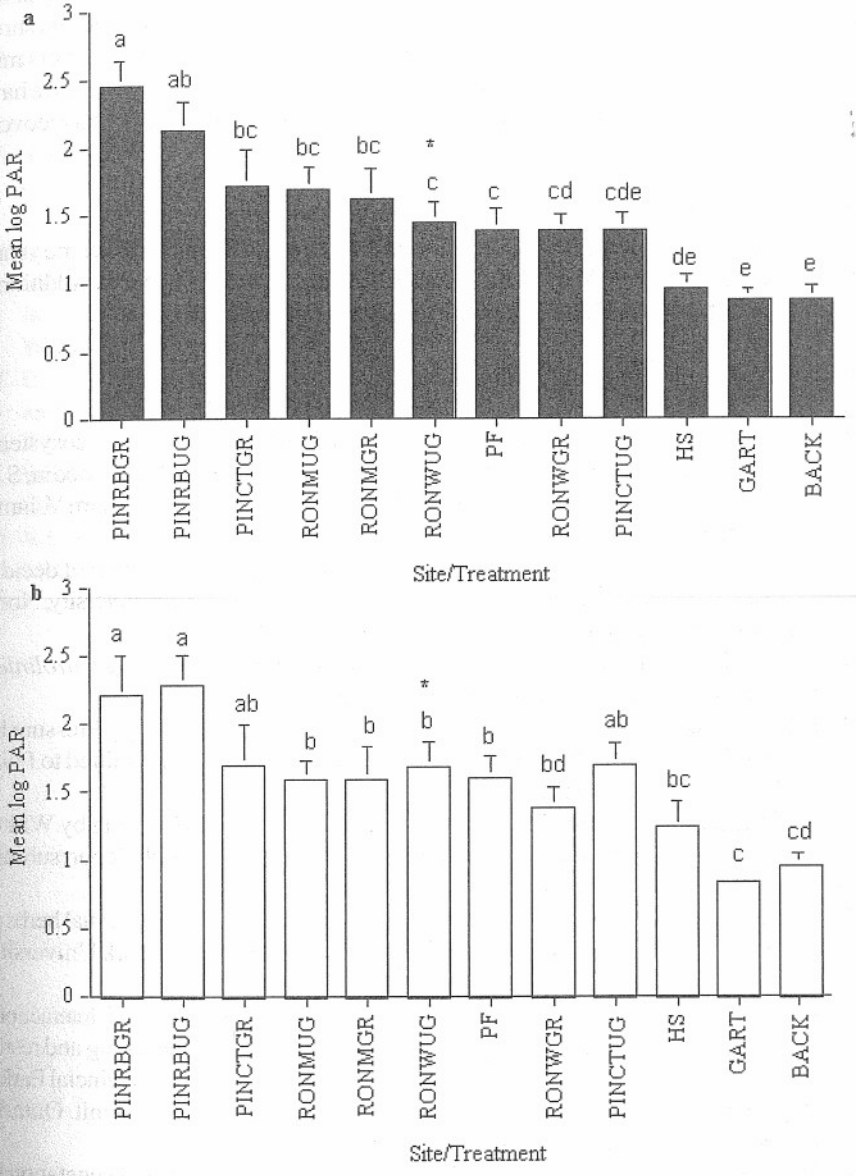

Figure 1: *Mean log PAR (Photosynthetically Active Radiation) measured at ground level (**a**) and 2m height (**b**) in summer of 1999. Sites with different letters are significantly different (p=0.0001). Sites where ground level and 2m light readings were significantly different (p=0.0258) are indicated (*).*

5.0 SUMMARY

Chronic deer overgrazing at Rondeau resulted in the loss of native spring- flowering species from plant communities in the 1990s, which became dominated by grazing tolerant and non-native species. The forest is more open, due to lack of tree and shrub regeneration, and native species were depleted in the seed bank. These factors may be hindering recovery following deer control. Nevertheless, in the last year, we have observed increased levels of native species in grazed areas, indicating that recovery may now be happening.

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