

# Restoring Highly Fragmented Populations of Herbaceous Spring Ephemerals in a Severely Grazed Carolinian Forest

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## Abstract

*High deer populations at a number of provincial parks (e.g., Rondeau and Presqu'île Provincial Parks) throughout Ontario are seen to pose a threat to the natural state of the park. The effects of grazing by white-tailed deer (*Odocoileus virginianus*), on the structure of a forest canopy were investigated at Rondeau Provincial Park in southwestern Ontario in response to the lack of investigation into landscape level change incurred by these high populations. Canopy gap data was compiled from analysis of three sets of air photos (1955, 1972 and 1978) for the park. Overall, average area and frequency of gaps increased over the 23 year period.*

## Introduction

The effect of browsing by white-tailed deer (*Odocoileus virginianus*) on woody plant species has been well documented (Ross *et al.*, 1970; Sotala and Kirkpatrick 1973; Anderson and Loucks 1979; Tilghman 1989; Johnson *et al.*, 1995). Studies have linked intense deer browsing to changes in woody species composition (Ross *et al.*, 1970). For example, at extremely high densities (i.e., in situations of imminent starvation) deer will consume more than 99% woody plant materials (Dahlber and Guettinger, 1959 cited in Sotala and Kirkpatrick, 1973), which reduces rates of forest regeneration (Veblen *et al.*, 1989). Scarcity of preferred browse and starvation initiates shifts in deer diet to less preferable species (Veblen *et al.*, 1989). Additionally, saplings and shrubs 0.15 to 2.1m tall are targets for winter browsing (Ross *et al.*, 1970). When these two impacts are combined, entire cohorts of saplings and subcanopy shrubs are absent from forest understorey, which ultimately restricts canopy regeneration (Veblen *et al.*, 1989). Canopy gaps are locations in the forest that stimulate new growth, and when deer are present in large numbers they consume the newly germinating seedlings found there (Veblen *et al.*, 1989). Furthermore, weather and high wind events in particular, such as those that occur throughout southwestern Ontario several times per century, also affect canopy regeneration (Smith, 1981; Larson and Waldron, 2000).

Waller and Alverson (1997) state that white-tailed deer meet the criteria for a keystone species. They have been shown to selectively suppress or eliminate seedling and sapling growth and populations of palatable species like sugar maple (*Acer*

*saccharum*), creating a competitive advantage for less palatable species like american beech (*Fagus grandifolia*), which affects the forest composition when these young understorey trees replace trees in the canopy. Also, when deer populations are extremely high, the seedlings and saplings of all tree and herbaceous species are removed, leaving areas of park-like openness for plants like ferns and grasses to colonize (Waller and Alverson, 1997). Once established, ferns effectively out-compete native tree seedlings for available light, continuing suppression of tree regeneration. This is presently occurring at Prequ'ile Provincial Park in southwestern Ontario (Koh pers. comm.).

Few studies have demonstrated the impacts of individual species at the landscape level. Two examples include the impacts of beaver (*Castor canadensis* Khul and *Castor fiber* Linn.) (Snodgrass, 1997) and lesser snow geese (*Chen caerulescens caerulescens* [L.]) (Kerbes *et al.*, 1990). These animals modify plant community composition and ecological functioning at scales that can be detected on aerial photographs and landsat images. The impact of acute deer herbivory on forests has not been previously examined at a landscape level. This study attempts to link the effects of herbivory of a high population of white-tailed deer with the state of the forest canopy at Rondeau Provincial Park by tracking changes in the integrity of the canopy over a 23-year period. Specifically, quantifying long-term changes in the size and distribution of canopy gaps was done. The major prediction was that the number and total area of forest canopy gaps along with mean gap size, has increased with increased deer populations.

## Methods

Air photos of Rondeau from 1954, 1972 and 1978 were interpreted on acetate overlays to identify tree canopy gaps. Each year contributed one layer to a GIS database and years were compared for changes in total gap area. Air photos were flown by the OMNR (Ontario Ministry of Natural Resources) at two scales 1:15840 (1954 and 1972) and 1:10000 (1978). Major roads and hydrographic features were outlined to link interpreted overlay scans to the Rondeau base map when overlay scans were brought into the ArcView environment. For each year's air photos, canopy gaps were interpreted for the maximum forest cover extents and were identified as such, if they met one of three criteria: i) areas where there were obvious breaks in the canopy (no trees existed) and the ground could be seen; ii) areas with a low density of trees (i.e., individual trees could be identified within the forest profile and the ground could be seen within that site); and iii) areas where there was a break in the consistency of the height of the canopy (i.e., appeared to be a gap with shorter trees below). The completed overlays were scanned and imported into the ArcView environment where separate layers were digitized for each year. The area and perimeter of each canopy gap overlay for each year were calculated using an ArcView 3.2 Script File.

Statistical analysis of the canopy gap data was carried out using SPSS (Statistical Package for the Social Sciences). Once perimeter and area data were determined for each of the three years, using the ArcView 3.2 Script File for area calculations, a summation of the total number of gaps, mean gap area, median gap area and total gap area was calculated for each of the three years.

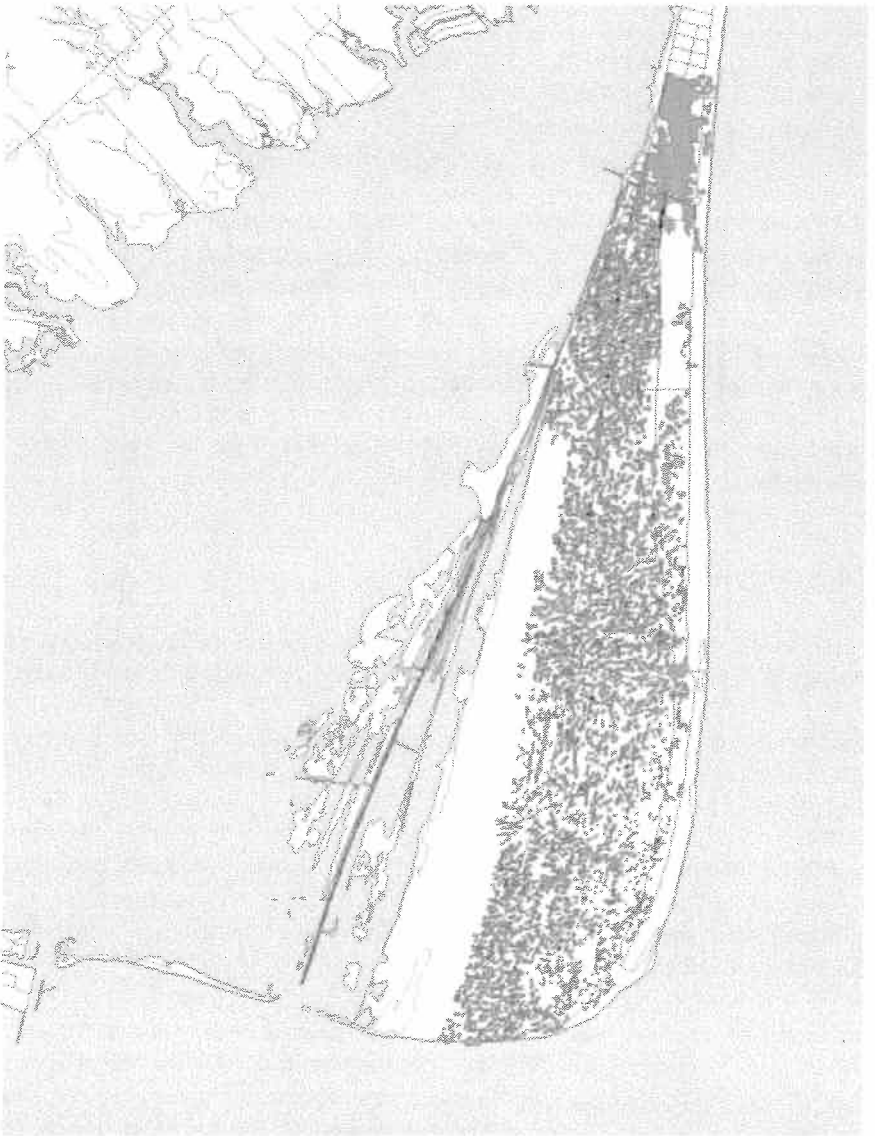
The total forest cover measured at Rondeau was 1100 ha as estimated by the forest delimitation set out by the digital map provided by OMNR. Visually, canopy gaps appeared to increase from year to year (shown as an increase in grey areas) (Figures 1-3). Overall, there were a higher number of smaller gaps and the distribution was skewed to the right (Figure 4). The canopy gaps increased both in total number and in median size from 1955 to 1978 (Table 1). There were more small gaps ( $\leq 1250 \text{ m}^2$ ) in 1955 than in 1978. In contrast, in 1955 there were fewer large gaps ( $> 1250 \text{ m}^2$ ) compared to 1978. In the intervening period, the 1972 data showed a brief reduction in the frequency of small gaps and an increase in the number of large gaps. This may have been due to some smaller gaps coalescing into large gaps. Total gap area increased by 26.6% from 1955 to 1978. The percentage of the forest occupied by gaps increased from 24.1% in 1955 to 30.5% in 1978.

## Discussion

These results show that the impact of deer herbivory on forest plant communities can be observed at the landscape level at Rondeau Provincial Park for the period of 1955-1978. The increase in the number and size of canopy gaps at Rondeau Provincial Park can be attributed to the effect of intense deer herbivory on tree recruitment. When forest stand structure plots established in 1981 were re-recorded in 1996-7, 50-80% of trees were gone and had not been replaced (Timciska, 1997). Hynes (2002) found that shrub and sapling density was significantly lower in Rondeau and Pinery Provincial Park compared with forests having lower deer densities. Hynes (2002) also showed greater light levels in these parks. These studies combined with the results presented here create a strong case for decreased canopy integrity due to deer grazing pressure.

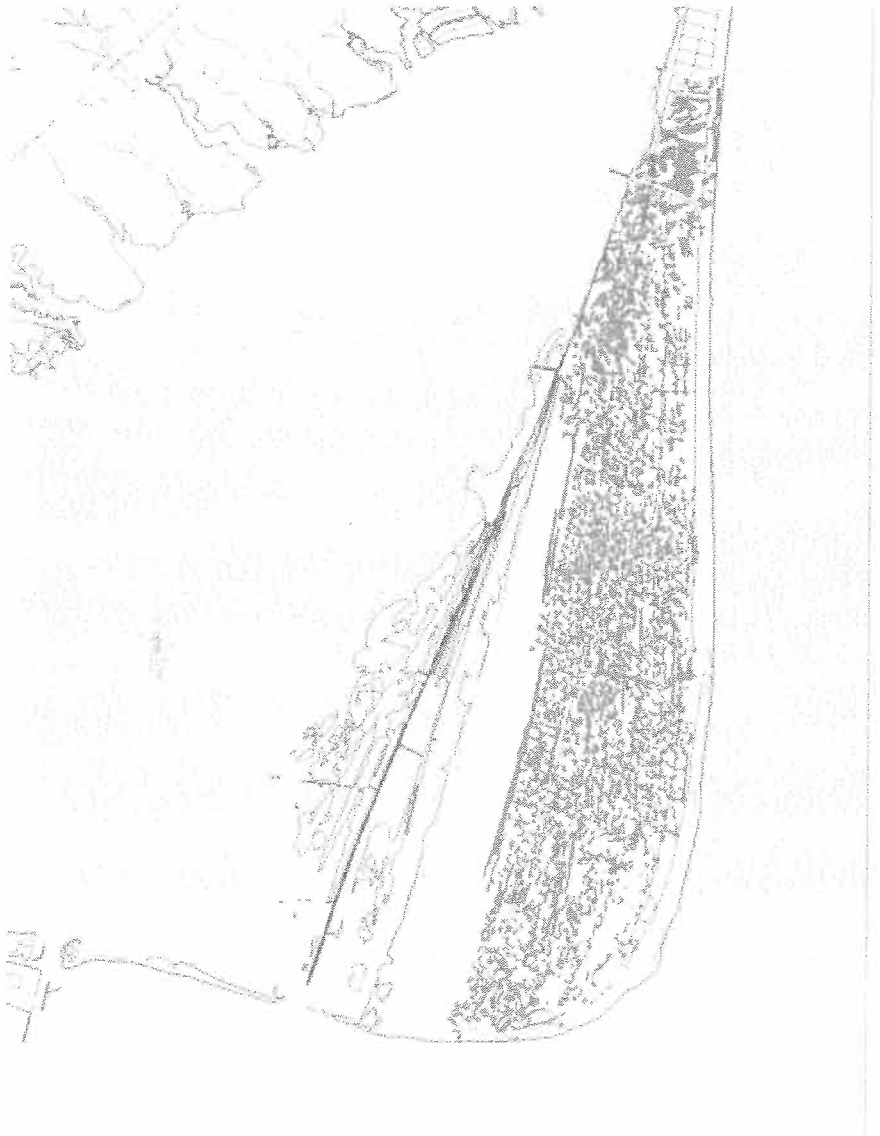
These results are in line with other research showing that mammalian herbivores including moose (Bergerud and Manuel, 1968; Bradner *et al.*, 1990), beaver (Johnston and Naiman, 1990; Snodgrass, 1997), greater snow geese (Kerbes *et al.*, 1990) and elephants (Ben-Shahar, 1996) can affect stand density, and therefore canopy, in forests around the world. However, to our knowledge, this is only the third study (after the beaver and snow geese) demonstrating a landscape level effect of herbivores.

**Figure 1.** Interpreted canopy gap profile for 1955 at Rondeau Provincial Park.



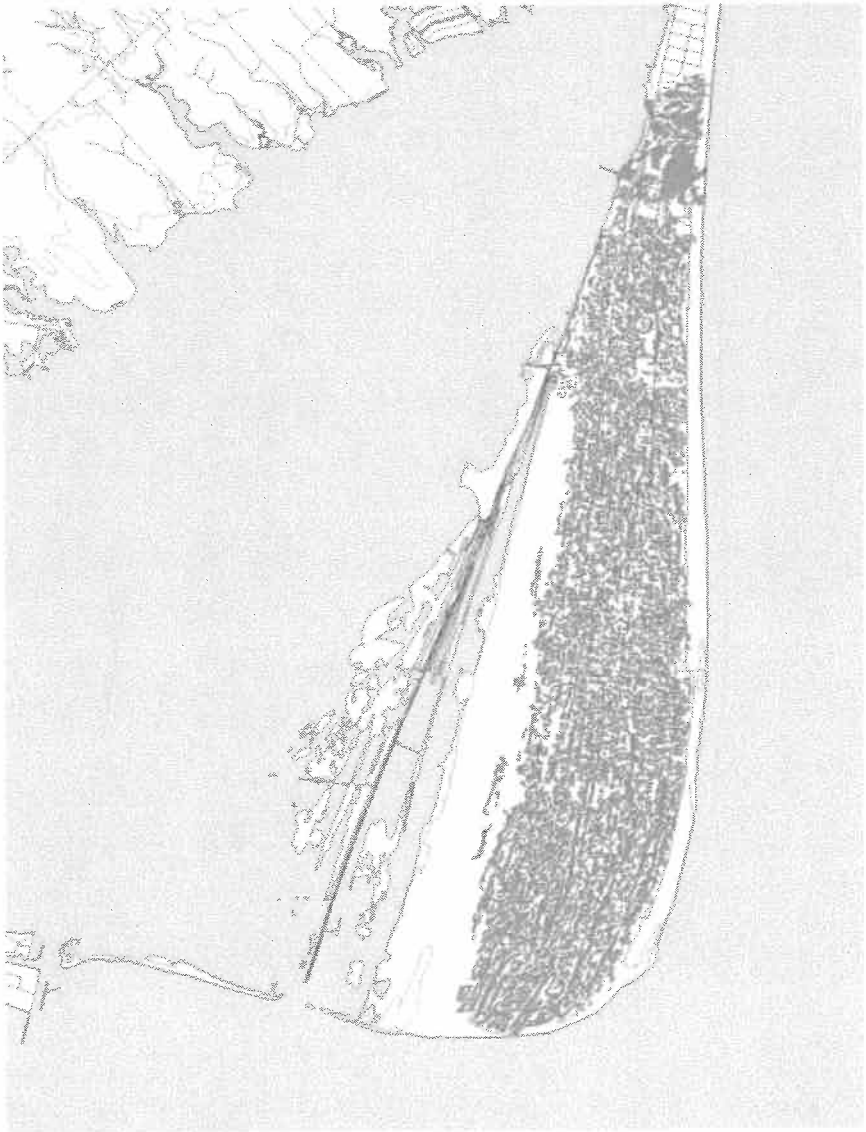
SCALE: approximately 1.5 cm = 1 km

**Figure 2.** Interpreted canopy gap profile for 1972 at Rondeau Provincial Park.



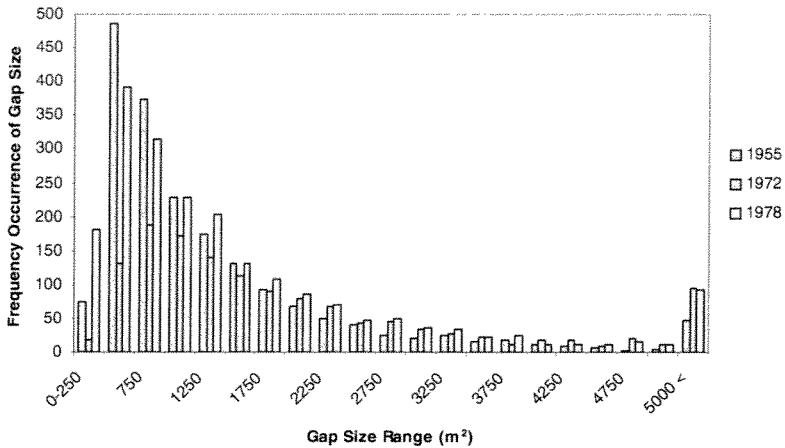
SCALE: approximately 1.5 cm = 1 km

**Figure 3.** Interpreted canopy gap profile for 1978 at Rondeau Provincial Park.



SCALE: approximately 1.5 cm = 1 km

**Figure 4.** Canopy gaps for the 23-year air-photo period at Rondeau Provincial Park.



**Table 1.** Canopy gap statistics for Rondeau Provincial Park.

	1955	1972	1978
<b>Deer Herd Count</b>	60	130	390
<b>Total Number of Gaps</b>	1901	1358	2087
<b>Gap Area Mean (m<sup>2</sup>) (SE)</b>	1396.6 (157.47)	2162.2 (111.51)	609.9 (71.94)
<b>Gap Area Median (m<sup>2</sup>)</b>	765.4	1296.2	915.9
<b>Total Gap Area (km<sup>2</sup>)</b>	2.65	2.93	3.35
<b>Percent of total forest</b>	24.1%	26.6%	30.5%

These results are in line with other research showing that mammalian herbivores including moose (Bergerud and Manuel, 1968; Bradner *et al.*, 1990), beaver (Johnston and Naiman, 1990; Snodgrass, 1997), greater snow geese (Kerbes *et al.*, 1990) and elephants (Ben-Shahar, 1996) can affect stand density, and therefore canopy, in forests around the world. However, to our knowledge, this is only the third study (after the beaver and snow geese) demonstrating a landscape level effect of herbivores.

Despite the fact that 1972 data show fewer gaps, the overall trend remains the same. Deer populations were controlled at Rondeau during the 1960s. The respite of deer grazing allowed small gaps to be filled in, while the large gaps remained open. The exact reason for the change in the gap size spectrum remains unclear.

While previous studies at Rondeau have examined the effect of deer on plant community composition and individual species (Koh, 1995; Koh *et al.*, 1996; Bazely, *et al.*, 1996, Koh, 2002; Hynes, 2002), none of them examined the forest ecosystem from a broader landscape scale. This investigation is unique in its approach to this seemingly frequent forest problem.

Interpretation of more current air photos was not done because recent air photos are now being photographed in infrared, which greatly reduces the effectiveness of the 3-dimensionality of the stereo-paired photos. This would ultimately affect the results as gaps may be misinterpreted. However, we would predict that since 1978 even more gaps would have appeared in all sizes, especially the larger ones, since herd populations during the 1980s and early 1990s were extremely high. Although there has been a reprise in the last five years in the size of the herd through mitigated population controls, a delayed response would be apparent in the forest canopy that would be manifested through gap coalescence.

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