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Vegetation management in forestry, amenity and conservation areas:
Managing for multiple objectives

Impact of herbivory of white-tailed deer (*Odocoileus virginianus*) on plant community composition

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Summary

The woodland ground flora of permanent quadrats in dry, wet and mesic habitats in Rondeau Provincial Park, Ontario, Canada was recorded in 1992. This park is a premier example of Carolinian or deciduous forest, but is heavily grazed and browsed by white-tailed deer (*Odocoileus virginianus*) . Within each habitat type there were both grazed and year-old fenced plots. In addition, the flora was recorded in 14-year old deer exclosures in the woodland. The long-term ungrazed plots contained greater amounts of species characteristic of Carolinian woodland (e.g. *Arisaema triphyllum* and *Trillium grandiflorum)*, whereas the grazed plots had higher levels of invasive weeds (e.g. *Stellaria media* and *Berberis thunbergii*). These data provide a baseline against which recovery of ground flora may be assessed following the herd reduction which took place in winter 1993 . Over-grazing by deer is a problem also found in southern English woodlands where roe, fallow, muntjac and sika deer numbers have increased in recent years.

Key words: DCA, Carolinian forest, understorey plant communities.

Introduction

Herbivory by deer can have a major effect on the structure and composition of plant communities. A low level of deer grazing provides a greater diversity in vegetation structure and species composition than either overgrazing or the absence of grazing in fenced woods (Mitchell & Kirby, 1990). As well as damaging trees (Gill, 1992a) a high density of deer may lead to a reduction in palatable ground flora species and an increase in unpalatable ones (Gill, 1992b). During the last fifteen years, white-tailed deer (*Odocoileus virginianus*) populations in Canada and north-eastern U.S.A. have increased greatly and deer browsing has resulted in reduced regeneration of woody plants in forests (Tilghman, 1989; Trumbull, Zielinski & Aharrah, 1989). At a number of sites along the north shore of Lake Erie, heavy browsing has caused reduced seedling recruitment to populations of tulip tree, *Lirodendron tulipifera*, *Sassafras albidum* and other woody species characteristic of the Carolinian or deciduous forest zone (Allen, Eagles & Price, 1990). Since white-tailed deer also feed on spring-flowering forest herbs (Skinner & Telfer, 1974; McCaffrey, Tranetski & Piechura, 1974; McCullough, 1985) it is likely that understorey herbaceous plants are also affected. The Carolinian zone contains a high proportion of

rare and endangered species (Oldham, 1994). In Southern Ontario natural habitats are also under pressure from intensive agriculture and increasing urbanisation, so that there is only an average of 10% forest cover with as little as 3% in some areas (Bretz, 1995).

Deer populations in four of the few remaining tracts of Carolinian forest have reached densities of up to 56 deer km^{-2} in the last decade (Koh, Bazely & Voigt, in press) compared to levels of 1 - 7 deer km^2 found in other areas (Fryxell, Hussell, Lambert & Smith, 1991). In two sites, Point Pelee National Park and Long Point National Wildlife Area, extensive herd reductions have been carried out during the last five years. In Rondeau Provincial Park in the Carolinian zone of southern Ontario's forests, the numbers of white-tailed deer (*Odocoileus virginianus*) increased steadily until a herd reduction was carried out in 1993. Here we examine differences in the ground flora recorded in 1992, when deer numbers were very high, between grazed plots in dry, wet and mesic sites in the woodland and adjacent plots within ungrazed exclosures erected 14 years previously and make management recommendations.

Materials and Methods

In 1991 three permanent north-south transects (each 1000m in length) were established in each of the major habitats (dry, mesic and wet) of Rondeau Provincial Park in S.W. Ontario, Canada.. Ten sites were randomly chosen along the three transects to give a total of thirty sites per habitat (Fig.1).

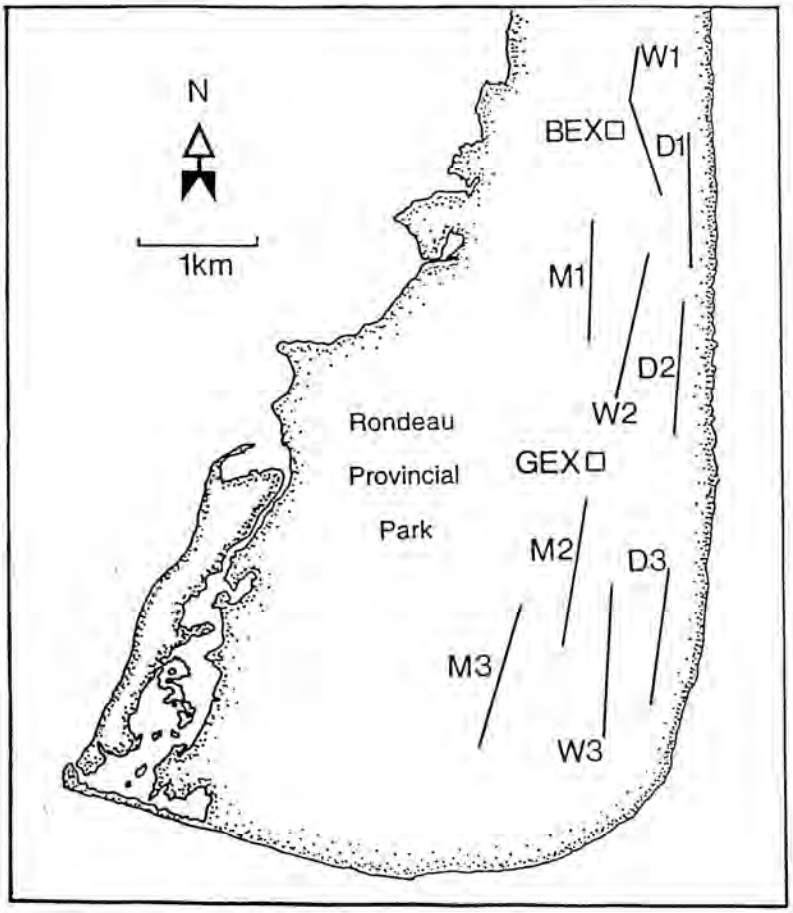

Fig. 1. Locations of transects in the three habitat types and the Bennett and Gardiner exclosures at Rondeau Provincial Park.

At each site a set of plots was established: one 1m x 1m plot accessible to grazing by white-tailed deer (*Odocoileus virginianus*) and two newly-established 2m x 2m exclosures located 5m north and 5m south of the grazed plot. Within these new deer exclosures, a 1m x 1m quadrat was placed in the furthest corner from the door and 10cm in from the exclosure fence.

In 1978, two large deer exclosures (Bennett: 50m x 40m and Gardiner: 80m x 30m) were established in the Park. In 1991, ten permanent quadrats (1m x 1m) were laid out at random intervals along two transects running parallel to and 5m within the north and south fences of each exclosure. Corresponding paired plots were located 5m outside of these large exclosures. The percentage cover of all higher plant species in the ground flora of grazed and exclosed quadrats was recorded seven times in 1992 within two days of the following dates: May 4th, May 20th, June 4th, June 23rd, July 10th, August 3rd and August 26th. Here we analyse the maximum percentage cover recorded for each species in 1992.

Detrended Correspondence Analysis was carried out twice. Firstly on the whole data set and secondly when the 20 quadrats from the two old exclosures had been omitted (ter Braak, 1987). Detrending by segments was used in both cases and rare species were not downweighted. Two outlying quadrats were omitted (they each had a very high percentage cover of one species).

Plant species names follow Morton & Venn (1990) for Canadian work and Clapham, Tutin & Moore (1987) for references to British flora.

Results

Site ordination of all quadrats using Detrended Correspondence Analysis showed that the plots within the two 14 year-old exclosures had compositions differing greatly from the grazed plots (Fig.2). The first two axes accounted for 7.0% and 5.5% of the total variance and had gradients of 4.28 and 3.65 SD units length respectively. Any possible differences in the composition of the ground flora in dry, wet and mesic sites were obscured by the overwhelming effect of grazing pressure. *Angelica atropurpurea* (angelica), *Uvularia perfoliata* (perfoliate bellwort) and *Anemone quinquefolia* (wood anemone) were only found within the exclosures. Other species with high scores on axis 1 and therefore characteristic of communities protected from heavy deer grazing, included: *Arisaema triphyllum* (Jack-in-the-pulpit), *Sanguinaria canadensis* (bloodroot), *Dicentra cucularia* (dutchman's breeches) *Maianthemum canadense* (Canada Mayflower) , *Trillium grandiflorum* (trillium) and *Viola* spp. (violets). Species with low scores on axis 1 (and therefore characteristic of the deer-grazed plots) included: *Berberis thunbergii* (Japanese barberry) and *Stellaria media* (common chickweed) which are weedy, invasive species. This axis also seems to be showing a corresponding nitrogen gradient with nitrophilous species having low scores: *S. media, Dentaria* spp. (toothworts) and *Urtica dioica* (stinging nettle) .

In a further analysis, the plots in the old exclosures were omitted (Fig 3). The first two axes accounted for 7.6% and 5.8% of the total variation and had gradients of 3.54 and 3.23 SD units in length respectively. There is considerable overlap between the 'dry', 'mesic' and 'wet' plots. However, there is a clear trend in that the 'dry' plots are found mainly at the bottom left of the graph. Species indicating relatively moist conditions (e.g. *Galium* spp. and *Impatiens capensis*) have high scores on axis 2 suggesting that it represents a moisture gradient.

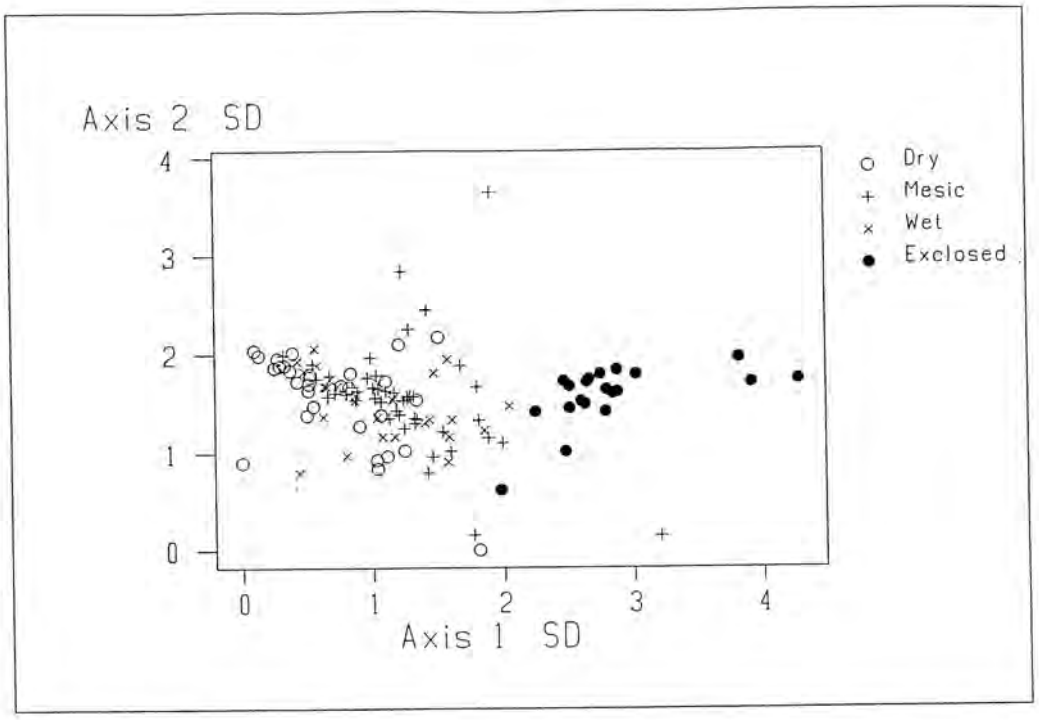

Fig. 2. Detrended Correspondence Analysis of all sample plots: distribution of the plots on axes 1 and 2.

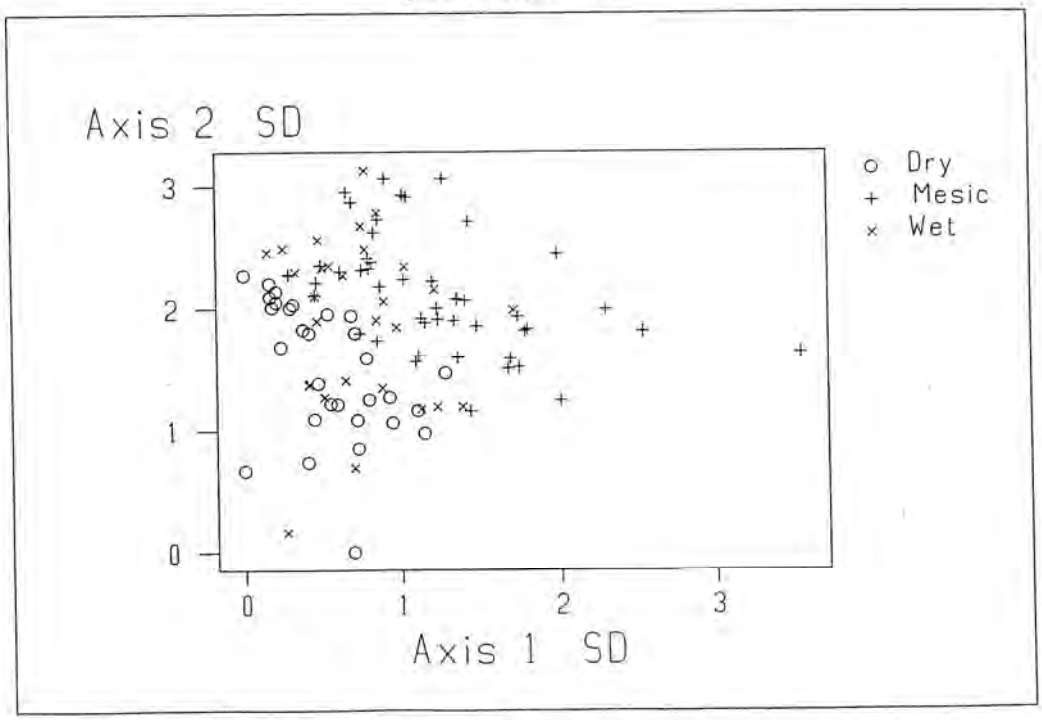

Fig. 3. Detrended Correspondence Analysis of sample plots excluding those in the old exclosures: distribution of the plots on axes 1 and 2.

Discussion

Herd reductions (culls) of deer took place regularly in Rondeau Provincial Park between 1912 and 1972. In 1972 the hunts were stopped because of objections from the public. Deer numbers steadily increased and clear differences between the vegetation within the 1978 exclosures and the rest of the Park became apparent. Some of the characteristic species were only seen flowering within these exclosures. In particular *Trillium grandiflorum* has been found to have a minimum age for flowering of about 15 years (Koh, 1995; Koh, Bazely & Voigt, in press). This work parallels that on changes in abundance and size of *Mercurialis perennis* (Dog's mercury) a characteristic species of ancient woodland in England. Studies in nine woods in Cambridgeshire and Northamptonshire showed that the height of *M. perennis* plants was negatively related to a score for muntjac abundance and damage (Cooke, Farrell, Kirby & Thomas, 1995) and a herd reduction is being considered in the heavily-grazed Monks Wood . The possibility of using heights of indicator species plants as management tools to indicate when a herd reduction is required is being explored in both countries.

Recent studies in remnants of native vegetation left after clearing for agriculture in the south-west of Western Australia have found that the number of species of native shrubs and perennial herbs was significantly reduced in grazed plots and numbers of exotic annual grasses and herbs were significantly higher (Pettit, Froend & Ladd, 1995). After three years of exclosure they found good regeneration of many native perennial species. Annual recordings of the ground flora in Rondeau Provincial Park have continued since 1992. In 1993, a herd reduction finally took place. By 1995 recovery in many ground flora species was apparent and re-recording of the plots has taken place and will be reported elsewhere. However, the structure of the woody species has not returned because even the reduced deer numbers have resulted in the browsing of almost all of the new growth. Thus another herd reduction will soon be required.

In Britain populations of all five species of deer (red deer *Cervus elaphus*, sika *C. nippon*, roe *Capreolus capreolus*, muntjac *Muntiacus reevesi* and fallow *Dama dama*) are increasing (Gill, 1992a: Chapman, Harris & Stanford, 1994) and the question of whether damage to ground flora or trees necessitates a herd reduction is one which is increasingly likely to be posed. The New Forest in southern England is an area which has sustained heavy pressure from fallow, roe, red and sika deer, cattle and ponies for 900 years. This has resulted in a reduction in the diversity and species composition of the ground flora and the elimination of many shrub species as well as the lack of tree species regeneration (Peterken & Tubbs 1965). The effects of maintaining fallow deer grazing or of excluding large herbivores were studied there for many years (Putman et al., 1989). Many graze-sensitive or palatable species (e.g. *Brachypodium sylvaticum*, *Poa nemoralis* and *Conopodium majus*) became re-established in the ungrazed area, but by 22 years after inclosure the regenerating tree species were excluding the shrubs and herbs. Thus a low level of grazing by large herbivores in woodland provides a greater diversity in vegetation structure and species composition than either overgrazing or the absence of grazing (Mitchell & Kirby, 1990). Grazing management in woodlands should be directed towards specific objectives and be planned over long periods (10-50 years) (Kirby, Mitchell & Hester, 1994).

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