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# **Protected Areas and Watershed Management**

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## Abstract

*About 28% of the Canadian flora are non-indigenous species (NIS). What is their impact on woodlands? While some spectacular introduced invasive plants in North America function as keystone species, altering ecosystem structure and function, most NIS simply increase the species richness of an area. We have found that some so-called invasive plant species are likely not having a major impact on plant communities, and that ecosystem and landscape-level disturbances are of much greater significance in determining plant community composition. Predicting which introduced species may become a problem remains a challenge, although, in keeping with the literature, we have found that one problem species, Japanese Barberry, was deliberately introduced as a garden plant and then escaped. Additionally, we also found that human-induced disturbance is associated with the spread of non-native plants.*

## Introduction

Concerns about “invasive” plants are very much rooted in the notion that the earth’s biota is experiencing its 6th episode of mass extinction (Myers, 1976; Wilson, 1985). Current extinction rates are estimated to be 10 – 100 times greater than in the past (Lawton and May 1995; Wilson, 2001 and 2002). Diamond (1989) attributed this biological diversity or “biodiversity” crisis (Wilson *et al.*, 1985) to five main human activities: 1) habitat destruction; 2) habitat fragmentation; 3) over-exploitation of species; 4) introduced species; and, 5) secondary effects or “chains of extinction”. All of these factors, along with pollution (Lande, 1999) and global climate change (Chapin *et al.*, 2000) may have the effect of reducing species richness, genetic variation or richness in ecosystem types.

The Carolinian or Deciduous Forest Ecozone of Canada is located in southwestern Ontario. This is the most densely populated, industrialized, and intensely farmed part of the country, with more Canadian species of rare flora and fauna occurring here than anywhere else. The remaining natural habitat (3 – 12% cover) is highly fragmented and disturbed by human activities. At Point Pelee National Park, and Rondeau and Pinery Provincial Parks, high deer populations, now controlled, have altered the forest structure significantly over the last 40 – 100 years. Ecological restoration efforts have addressed high deer populations, the reintroduction of appropriate disturbances such as fire, and the issue of introduced plants. The scientific challenges that we face in determining the ecological impacts of introduced plants in Canadian woodlands, specifically those in the Carolinian woodland ecozone include:

- determining the nature of competitive interactions between non-native and

native plants;

- understanding how disturbances may affect the spread of non-native species;
- predicting which non-native plant species may become invasive; and,
- providing sound ecological advice for habitat managers and restoration practitioners.

These challenges must be considered in the broader context of what we know about non-native plant species, such as their sources and patterns of introductions, and research that seeks to understand the factors that determine the likelihood of a habitat being "invaded".

## What is an Invader?

Every country's flora has its "stay at homes", native, indigenous or endemic species and its "come from aways" (Myers and Bazely, 2003). Terms used to describe the latter group include: "non-native, non-indigenous, exotic, imported, immigrant, introduced, naturalized, colonizers, and invaders". Some terms are neutral, but others imply a definite threat. In evaluating ecological impacts of non-native species, it is important to remember that all plants, including native species, have the potential of expanding their range (assisted or unassisted by people). Invaders, the species of concern, are colonizers considered to have significant impacts. Frequently, they are identified by their rates of rapid movement across a region or landscape. In other words, an invader is, by definition, invasive. This is not always helpful from a predictive viewpoint.

Approximately 900 of 3,200 plant species in Canada (28%) are non-native (Myers and Bazely, 2003). These numbers vary both within and across regions and sites. For example, at Point Pelee National Park, 37% of plants are non-indigenous (Dunster, 1989). Many are agricultural weeds and garden escapes, which is consistent with the farming and cottage history of the park. In contrast, in the globally rare oak savanna plant communities on the western shoreline of the park, only 11% of plant species are non-native (Tagliavia, 2002). What effect are these non indigenous species having in this park?

## Scale is Important when Considering Non-natives

Although Diamond (1989) stated that "*Introduced species cause species loss...*", there is, to our knowledge, no documented case of any introduced plant causing extinction of another species. In reviews, both Lonsdale (1999) and Levine and D'Antonio (1999) observed that most introduced plant species add to the overall species richness of an area. This is not the pattern predicted by Elton (1958) in his hypothesis that diversity enhances community resistance to biological invasions. Instead, it appears that those natural plant communities with a more diverse structure seem to allow higher levels of invasion. Levine (2000) sought to address the apparent contradiction between Elton's hypothesis and the commonly observed patterns in his study of *Carex nudata*, a tussock-forming sedge, micro-islands at South Fork Eel River, California. He observed that over a 7 km stretch non-native plant invaders occurred more frequently on tussocks with higher native species richness (Levine, 2000). His two main questions were:

1. What is the relationship between species diversity and community susceptibility to biological invasions?
2. How does dispersal and propagule supply drive patterns of diversity and patterns of invasion in natural systems?

In an experiment, Levine (2000) removed all plants from 65 tussocks at a single riffle in the river, and created tussocks with one of 5 plant species richnesses: 1, 3, 5, 7, or 9 native species excluding *C. nudata*. He added 200 seeds of each of three species considered to be invasive (*Cirsium arvense*, *Plantago major* and *Agrostis stolonifera*) and followed their establishment over the growing season. Levine (2000) found that in tussocks with higher native species richness, the size of the largest non-native plant was lower compared with that of individual non-native plants in low-richness tussocks, and that seed establishment also declined significantly for two of the three species as native species richness increased. This finding, that increasing diversity within a micro-neighbourhood enhances resistance to invasions both lends support to Elton's hypothesis and to a new hypothesis, that "the effects of diversity on invasions arise at the neighbourhood scale" (Levine, 2000: 853).

### Disturbance and Non-native Plants in Carolinian Woodlands

If not all introduced species pose a problem, and if, at a local scale, native species can resist invasion, then what is the evidence that introduced plants are interfering with native species? The impacts of introduced species will depend on three factors:

1. the range of suitable habitat;
2. the abundance of the species in the range; and,
3. the effect per individual or unit biomass of the colonizing species.

These factors require evaluation at multiple ecological scales varying from the individual to the population to the ecosystem. Diamond's (1989) fifth factor, of "chains of extinction" is of particular relevance for research into plant introductions and establishment, both of which are frequently associated with various human disturbances (Brothers and Springarn, 1992; Lozon and McIsaac, 1987). Thus, a critical challenge is the need to separate out whether non-native species are simply colonizing disturbed habitats where few other plants are growing and they are a symptom of inappropriate disturbances, or whether they are truly causing reduced growth of native species with the potential to invade and colonize undisturbed ecosystems. Three examples from Canadian Carolinian parks illustrate this and other challenges:

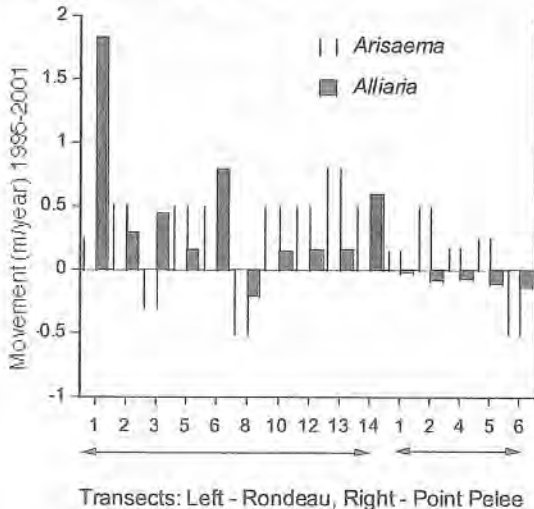
1. garlic mustard – invasive species or symptom of human disturbance?
2. garden escapes – can one predict the next problem plant invader?
3. ecosystem level approaches to introduced species – seed banks as Trojan horses and realistic time frames for recovery.

Garlic mustard (*Alliaria petiolata*) is highly visible throughout large portions of the woodland understorey plant community at Point Pelee National Park. In contrast, it is present



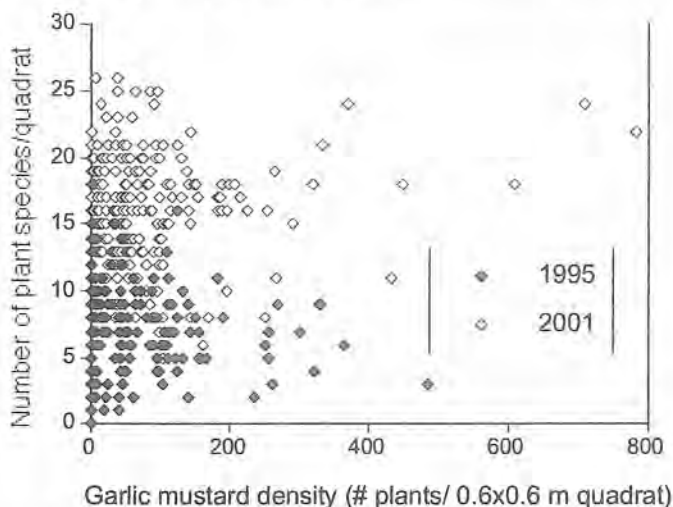
but not widespread at nearby Rondeau Provincial Park. Since 1994 we have asked if it is spreading and suppressing native plant species in either of the parks. Monitoring of its presence in permanent plots shows that garlic mustard is spreading at Rondeau (Firanski *et al.*, 2002). However, there was no difference between its movement rates to new plots both at Rondeau and nearby Point Pelee Park, and those for the native plant, Jack-in-the-pulpit (*Arisaema triphyllum*), from 1995 to 2001 (Figure 1). The density and presence of *A. triphyllum* was severely reduced at both parks by high deer herbivory during the 1970s and 1980s (Koh, 1995). Following herd reductions in both parks, its cover is expanding. Along 15 of 30 permanent transects where both species were recorded in 2001, the rate of movement (appearance or disappearance) between 20 permanent plots, 3 m apart, per transect, sampled since 1995 was not significantly different (paired t-test:  $t = 0.075$  n.s.  $df = 14$ ) (Firanski, 2003) (Figure 1). In addition, following 4 deer herd reductions, from 1994/95 to 2000/2001, the plant species richness in these permanent plots has more or less doubled in Rondeau. In 2001, species richness was significantly greater in all plots regardless of whether garlic mustard had been present or absent in 1995 (Mann-Whitney  $U = 5123$   $p < 0.0001$ ) (Figure 2).

Figure 1. Movement (appearance and disappearance) of the native, *Arisaema* and the introduced species, *Alliaria*, in permanent plots along transects in Rondeau (left arrow) and Point Pelee (right arrow) parks, 1995–2001.



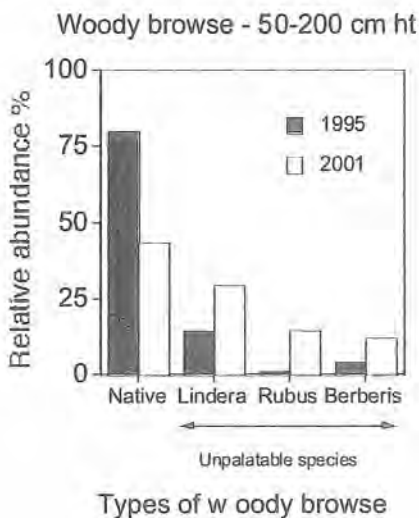
Japanese Barberry (*Berberis thunbergii*) is, in contrast to garlic mustard, a plant with low visibility, unless one sits on it. It is an ornamental shrub that has escaped from cottage lots on the east side of Rondeau sandspit, and during the early 1990s to the present has moved rapidly westwards. It now comprises over 12% of the woody browse stems in the 50-200 cm height range, and is a major component of the significantly increased proportion of unpalatable woody stems since 1995 (Chi-square = 82,  $p < 0.0001$ ), during the period of deer control. It is not a preferred deer browse species, but the deer will nibble the fruit and spread them. Its expansion was not anticipated. *B. thunbergii* is filling a gap in the shrub understorey more rapidly than other native species, and is significantly altering forest shrub composition.

Figure 2. Plant species richness per quadrat (permanent plot) versus garlic mustard (*Alliaria*) density per quadrat in 1995 and 2001.



*B. thunbergii* is also present at low levels in Pinery Provincial Park. Park staff have been spraying and removing bushes for the last four years (Purdy, 2002). Mapped GPS sites of located and removed bushes clearly show how the fruit are most likely being dispersed down river from local subdivision gardens outside of the northeast end of the park (T. Purdy, pers. com.).

Figure 3. The relative abundance (% of stems sampled at 50–200 cm ht,  $n = 247$  (1995),  $n = 400$  (2001)) of stems bearing current annual growth, of three “unpalatable” woody species, sampled in winters, including the introduced species, *Berberis thunbergii*, at Rondeau Park (D. R. Bazely and S. Chopra, unpubl. data). The native species are those considered to be palatable.



While the next problem non-native species may be just around the corner in a garden, habitat fragmentation and human caused disturbances may be creating a less visible source of non-native problem species. The usefulness of the plant functional group concept—where plants are considered by common life-history traits—is becoming increasingly accepted (Gitay and Noble, 1997). We have recently shown how different functional groups (e.g., early spring ephemerals versus ruderals) respond differently to habitat disturbances such as deer overgrazing, forest fragmentation and other human disturbances (McLachlan and Bazely 2001 and 2003; Koh, 2002). While woodland ground cover in long-term deer exclosures at Rondeau and in some small forest fragments (<1ha) is predominantly spring-flowering ephemerals and other later-flowering native woodland species, the viable seed banks, sampled in 1995 at Rondeau and other Carolinian forest sites are dominated by ruderals, many of them non-native (Koh, 2002). The exception was larger (>1 ha), undisturbed forest blocks, where frequencies of all seeds, including ruderals was low (Koh, 2002).

## Conclusions

The ruderal functional group (weedy species) has life history traits (seed dispersal and tolerance to herbivory) that makes it more tolerant to disturbance. These species are more successful in overgrazed and fragmented forest patches and have higher input to the seed bank. Further disturbance at seemingly intact forest sites may result in the emergence of plant communities dominated by non-native species. What does this bode for the future? The time-frame is key. McLachlan (1997) showed that cottage removal and cottage lot restoration at Point Pelee resulted in a significant decline in non-native plants at a site—but over 35 years. Similarly, increased native plant cover at Rondeau and Pinery Provincial Parks, following deer control, has taken from 5-10 years and is continuing. Successional pathways are not always predictable and unexpected events may alter their course (Klotzli and Grootjans, 2001), as in the case with *B. thunbergii*. Nevertheless, with appropriate management of disturbance regimes, many native plant species do appear able to recolonize habitat, at least at local scales.

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