The Role of Native Plant and Seed Collectors and Growers in Protecting Floral Diversity

by
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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

The planting of native species is a common strategy for the conservation of biodiversity; it not only allows for the restoration of degraded habitat both within conservation reserves and the matrix lands between reserves, it supplements the populations of the floral species which are planted. These supplemental populations may play an important role in providing demographic security for rare species. However, the conservation of rare species depends on more than simply maintaining adequate numbers of the species: the diversity within the species must also be conserved. Although maintaining genetic diversity is increasingly a concern for formal species recovery efforts, there has been very little research done about the diversity within plantings by non-state actors. This research was undertaken to address this knowledge gap by studying the provenances of planted rare species and the activities of those who collect and grow these plants. This research was undertaken in the Carolinian zone of southern Ontario, a region with a large number of rare plant species and a large human population.

Part of this study utilized semi-structured interviews with commercial seed collectors, commercial native plant growers, and non-commercial, hobbyist growers. A variety of factors limited the diversity with the seeds collected by commercial collectors. Due to difficulty in accessing information about the natural occurrences of rare species, collectors typically collected from the same, limited number of source plants. Trespassing on private property or protected lands was common to access these seed sources, although their preference for easily accessible, reliably fecund source plants on flat, mowed sites also meant that horticultural specimens were also desired.

Many of these biases were passed on to commercial growers when the seed was sold by the commercial collectors. Commercial growers shared many collection practices with commercial collectors, creating similar restrictions on the diversity within their collections. However, further limitations in diversity were also created by the growers' establishment of small populations of seed plants and by the trading of seeds and plants between growers. One boutique grower was a dominant source of seeds and plants in these trades. The limitations in the diversity within these rare species were passed onto those who purchased and planted them.

This study also focused on enthusiastic native plant hobbyists and found that they not only purchased plants but collected and grew their own plants. They also traded with other hobbyists. Much of the information about where to collect seed or plants, as well as much of the seed or plants traded between hobbyists, originated with a key individual. Thus, this champion hobbyist plays a significant role in the character of planted examples of rare plant species and the genetics of the champion's plants are heavily represented with other planted occurrences.

The practices of commercial seed collectors, growers and native plant hobbyists create biases which limit the diversity within plantings of rare species. Although these plantings provide demographic security for these species, they do not represent the diversity within their remnant "wild" populations. Thus, important questions must be raised about the conservation value of these plantings.

Since many of the practices of seed collectors and growers are also used when growing more common species, the diversity within plantings of these species should also be suspect. Although the lack of diversity within common species may not threaten the regional survival of the species in the short term, it may impact the ultimate success of restoration projects.

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Finally, I dedicate this dissertation to my wife, Monica. Her patience, understanding and unwavering faith in my abilities were foundational to this research and all that I do.

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Chapter 1 – Introduction

Although it is inevitably intertwined with many other pressing environmental problems, the ongoing loss of the diversity of life on Earth has increasingly been recognized as a crisis in its own right. Concern over this crisis is undoubtedly motivated, at least in part, by a profound sense of loss and collective culpability for "… the folly our descendents are least likely to forgive us" (Wilson, 1984, p. 121). It is also increasingly apparent that this crisis has profound implications for human well-being: the loss of biological diversity will inevitably lead to the loss or transformation of many of the ecological goods and services upon which we all depend.

While many have argued that the scale of this crisis is still underappreciated by decision makers (see, for example, Loreau et al., 2006), there is evidence of increasing awareness of the problem. Legislation and policies have been widely implemented to protect "biodiversity" at all levels. Concern for the loss of biodiversity also pervades the disciplines of biology and ecology; the desire to understand other living systems is now intimately aligned with recognition of the need for their conservation. Popular support for conservation efforts also appears to be generally increasing, despite the inevitable distractions of other crises. Despite this increasing awareness, the global loss of biodiversity has not slowed (Secretariat of the Convention on Biological Diversity, 2010).

Despite the immensity of this crisis, it must compete for attention and resources with an apparent plethora of other crises. Thus, it is perhaps understandable that conservation efforts focus first and foremost on those elements of biodiversity which seem most in peril, particularly rare species and habitats. Since species have been the traditional measure of biodiversity, rare species have become the dominant focus of efforts to conserve biodiversity.

Not all rare species are treated with equal attention, though; large, charismatic animals often receive more attention than smaller animals or plants (Bowker, 2000).

While this large animal bias may be understandable, there are important arguments for increased focus on the conservation of plant species. For example, the planting of native flora is widely considered a key strategy in the conservation of biodiversity (see, for example, Van Andel & Aronson, 2006). However, such plantings do more than simply supply habitat or refuge for faunal species. These plantings may also supplement existing populations of the floral species. In doing so, these plantings should provide enhanced demographic security for the species against catastrophic losses resulting from environmental stochastic events (Reinartz, 2001).

It is not enough to simply provide demographic security for rare plant species. They must be protected from genetic stochasticity, such as the increased genetic drift or elevated inbreeding that often occurs in small, isolated populations (Trakhtenbrot, Nathan, Perry, & Richardson, 2005; Young, Boyle, & Brown, 1996). Indeed, as Falk (1992) notes, "… the distribution of genetic variation in rare plant species is a key consideration in conservation strategies" (p. 408). However, actively managing the genetic variation within rare plant species would be extremely expensive, perhaps prohibitively expensive, except for the rarest and most valuable species (Schemske et al., 1994).

A useful proxy for understanding the genetic variation within planted occurrences of rare plant species would seem to be a study of those who collect and grow these species. If demographic security for a rare plant species is to be achieved through the planting of more examples of the species, the genetic diversity within these plantings is largely determined by the practices of those propagating and growing the species (Hufford & Mazer, 2003; Rogers, 2004). However, these practices are poorly understood. Thus, by examining these practices, it may be possible to better understand the diversity within the plantings of rare plant species and the role that these collectors and growers play in conserving this diversity.

The Carolinian zone of southern Ontario provides a useful location for such a study. This region contains the highest concentration of rare species in Canada (Jalava, 2000). However, traditional conservation approaches have had limited success because the overwhelming majority of the land in this region is privately-owned, unprotected and extensively modified from the conditions before European settlement (Jalava, 2000). This presents significant challenges for the study not only of rare plant species in general, but also for the study of those who collect and grow these species. The genetic diversity within plantings of Carolinian plants has also been identified as an important issue by the Environmental Commissioner of Ontario (2005). Thus, despite the challenges, this region was selected as an appropriate case study.

1.1 Case Study Background: The Carolinian Zone

The Carolinian zone is a region that is best described by superlatives: it is simultaneously the smallest, the most southerly, the most biologically diverse, the most densely populated and the most endangered major ecosystem in Canada (Reid, 1985, 2002; Larson, Riley, Snell, & Godschalk, 1999; Jalava, 2000; Waldron, 2003). To some extent, limiting the Carolinian zone's special nature to a Canadian context is misleading. However, such a limitation on the zone's special nature is common because the Carolinian zone is generally classified as simply a northern extension of the massive and biologically rich eastern deciduous forest region (see figure 1) that covers much the eastern United States[1] (Merriam, 1898; Macoun & Malte, 1916; Adams, 1938; Fox & Soper, 1952, 1953, 1954). Thus, its distinctiveness might simply be considered to be a product of what might be considered an ecologically meaningless international boundary. Similarly, the Carolinian zone's proximity to an economically powerful region of the United States can account for its intensive settlement; it might simply be considered an extension of the American industrial heartland in Canada, sharing similar settlement patterns and densities, as well as their ecological impacts, as its American counterparts. From this perspective, the Carolinian zone's special nature is deceptive and must necessarily be limited to a Canadian context. However, this perspective is overly reductionistic: it overlooks the interdependence of the ecological and socio-cultural components of a socio-ecological system like the Carolinian zone, and does not appreciate the very real ecological consequences of differing socio-cultural contexts, like those created by an international border (Slocombe, 1990; Forbes, Fresco, Shvidenko, Danell, & Chapin, 2004). Thus, while the Carolinian zone is taxonomically linked to the eastern deciduous zone and the northeastern United States, it is an ecologically and socio-culturally distinctive and a uniquely special region.

By Canadian standards, the Carolinian zone is remarkably small. Located in extreme southern Ontario, this ecosystem is bounded on all but its northern edge by the Great Lakes and the Canada-U.S.A. border (see figure 1). Its northern boundary, defined by the range limits of plant species that are characteristic of the zone, constitutes a transition zone (Fox & Soper, 1952, 1953, 1954; Soper, 1956; Soper, 1962; Thaler, 1970; Thaler & Plowright, 1973).

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[1] Although the "Carolinian" name was originally used to describe the Eastern deciduous forest of the United States and only later applied to the extension of this region into southern Ontario, its use in the United States has largely been dropped (see Morris, 2005, for a more in-depth discussion). The term Carolinian zone is now generally reserved for the Canadian part of the region and this is how it will be used in this proposal.

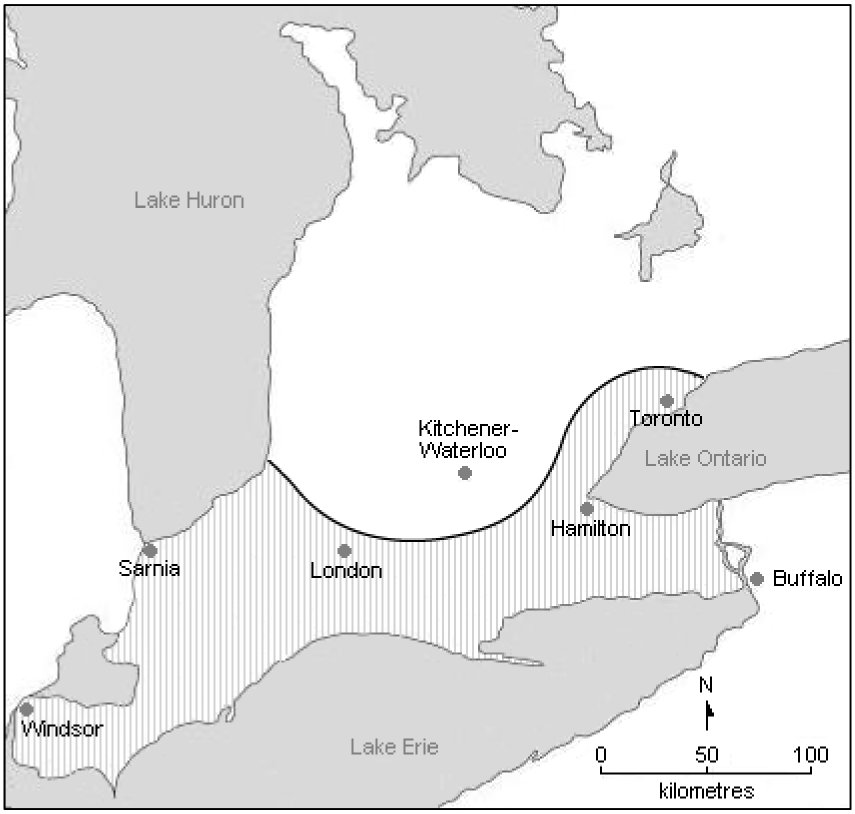

Figure 1 – Map of the Carolinian Zone (adapted from Waldron, 2003)

Within these boundaries, the region encompasses only about 22,000 ha, or just 0.25 % of the land area of Canada (Allen, Eagles, & Price, 1990; Jalava, 2000). Thus, the Carolinian zone represents a nationally rare type of ecosystem. Furthermore, since the Carolinian zone occurs at the northern margin of the eastern deciduous forest region and populations of species at the margins of their ranges are generally smaller and more fragmented than in the main part of their range (Hengeveld & Haeck, 1982), even widespread Carolinian species are often relatively rare within the Carolinian zone. Therefore, many Carolinian species and their habitats can be considered intrinsically rare in Canada.

Anthropogenic changes to the landscapes of the Carolinian zone have made this rarity more pronounced. The loss of Carolinian natural cover provides a relatively easily quantified yet telling measure of the impact of anthropogenic changes to the region. While natural cover was virtually continuous in the Carolinian zone a little more than 200 years ago at the beginning of intensive European settlement in the region, today only about 15% of the region is covered by what might be considered “natural” cover (Jalava, 2000). Similarly, two centuries ago, Carolinian forest covered approximately 80% of the region. Today, only about 11% of the zone is forested and a mere 0.07% of the zone is covered by old-growth conditions that approximate the pre-European conditions (Larson et al., 1999). This profound loss of natural cover in the Carolinian zone since the beginning of European settlement has made many Carolinian natural communities and Carolinian habitats increasingly rare.

Anthropogenic loss of habitat has also made many Carolinian species much rarer, demanding prioritized attention to the conservation of these species. Indeed, more than one third of all species at risk in Canada are Carolinian species and one of the most significant threats to these species is habitat loss (Carolinian Woodland Recovery Team, 2007). To some extent, though, it could be argued that this figure is misleading because most Carolinian species are much more widespread and many are more common elsewhere within the eastern deciduous forest zone. While this is true for many Carolinian species, this insight does not lessen the conservation priorities that arise when a species is considered rare, whether its rarity is at the global, national, or regional scale. For example, many of the human pressures that have made Carolinian species increasingly rare in Canada are duplicated in the United States. Therefore, failing to conserve rare species in the Carolinian zone in the hope that they will remain plentiful within their main range in the United States may eventually be disastrous for the species. Dismissing regionally rare species because they may be plentiful elsewhere also overestimates our understanding of the complex ecology of natural communities and our ability to manage ecosystem functioning. A regionally rare species may play an important functional role in its regional ecosystems, and its loss, whether through extinction or extirpation, could profoundly alter their ecosystems' functioning (Chapin et al., 1997). Finally, this view of biological diversity is too narrow and assumes species are more or less the same wherever they occur in their ranges. Conservation within species is also critically important. Since Carolinian species are generally at the northern limits of their ranges and such marginal populations typically contain a disproportionate level of the genetic diversity within the species (Millar & Libby, 1991), many Carolinian species should be considered genetically rare and distinct. Thus, their conservation must be a priority, particularly if they are regionally rare.

1.2 Reconciling Conservation with Human Activities

The challenge of conserving Carolinian species and their habitats in the face of ongoing anthropogenic pressures in southern Ontario is unquestionably daunting. Traditional conservation approaches based on the creation of conservation reserves will likely be inadequate in the long term. The overwhelming majority of the land in the Carolinian zone is privately-owned (Jalava, 2000) and the competition between humans and other species for space is intense. Indeed, it is likely to become more intense in the near future: the human population of the region is expected to grow by approximately a third by 2031 (Ontario Ministry of Finance, 2008). Conserving Carolinian species will ultimately require not only improving the conservation potential of existing and any future conservation reserves, but creating habitat for them in the midst of human-dominated landscapes activities.

Unlike traditional conservation methods that attempt to create or restore islands of wilderness as refuges for non-human species, these "reconciliation ecology" approaches attempt to diversify or modify human-dominated landscapes to provide habitat for native species (Rosenzweig, 2003a, 2003b). Such alternative approaches should not be considered either replacements for traditional conservation methods or a license for unrestricted destruction of remnant natural areas under the assumption that that we can simply reconcile the needs of native species later. Rather, reconciliation approaches must be considered as part of a comprehensive conservation strategy that includes the traditional conservation approaches based on the creation of reserves or the restoration of degraded habitat.

Reconciliation conservation approaches emphasize the creation of habitat that is useable by at least some species at least some of the time within the human-dominated matrix lands outside of conservation reserves (Lindenmayer & Franklin, 2002; Rosenzweig, 2003a, 2003b). Admittedly, this description would not, in itself, seem to inspire confidence in the ultimate utility of the reconciliation approach; it would seem to argue that a small, suboptimal habitat is an adequate replacement for a larger, high-quality one. Such a criticism, of course, ignores the small island effect (Lomolino, 2000, 2001). This effect suggests that, because of a variety of idiosyncratic features, some small patches of habitat may contain a greater diversity of species than would be predicted by their area alone. Furthermore, reconciliation efforts should never be considered as a "stand alone" solution to a conservation problem. As previously mentioned, they must be used in concert with the creation and maintenance of reserves and, wherever possible, the restoration of habitat. The effectiveness of individual reconciliation efforts will undoubtedly also often depend on the agglomeration of impacts with many other individual efforts spread throughout the matrix lands. This amalgam of reconciliation projects would do more than just create habitat. Such modifications to the matrix lands would also facilitate the dispersal of species between existing conservation reserve or patches of habitat, thus helping maintain connectivity between remnant species populations within a fragmented landscape (Lindenmayer & Franklin, 2002).

As in restoration ecology (see Van Andel & Aronson, 2006), the planting of native flora must be considered a key strategy in this matrix management approach to reconciliation ecology. Such planting would do more than simply supply habitat or refuge for faunal species. These plantings may also supplement existing populations of the floral species. In doing so, these plantings should provide enhanced demographic security for the species (Reinartz, 2001). This increased security against catastrophic losses resulting from environmental stochastic events would be particularly beneficial for rare species. As long as these matrix plantings constitute a representative sampling of the populations of the rare plant species, they may also provide important ex-situ collections that could provide some degree of increased security against the loss of genetic diversity.

1.3 Research Goal and Questions

The principle goal of this study was to better understand the activities of plant and seed collectors and growers and how these activities might impact efforts to conserve rare floral species. To achieve the goal of this study, a four primary research questions were formulated. These questions were:

1. What are the provenances of planted examples of rare Carolinian floral species?
2. What is the relationship of these planted examples to the remnant populations of the species?
3. How do seed and plant collectors and growers find, gain access to, and collect rare plants or their seeds (or other types of propagules)?

4. What are the relationships between those who collect, grow, and/or plant these species, and how do these relationships influence the character of the planted populations of rare species?

1.4 Motivations for Study

At its most base level, this study was motivated by a desire to preserve the distinctive plants of the Carolinian zone and the promise that this reconciliation approach to conservation offers in achieving this goal. This motivation was also the impetus for a previous study. It was the results of this earlier research that determined the focus for this study.

A previous study (see Morris, 2005) surveyed rural landowners in the rural areas of the city of Hamilton, Ontario, to see if landowners were planting Carolinian woody species (i.e. trees and shrubs) and which species were being planted. The results of this study suggested that there is already considerable planting of representative Carolinian woody species by landowners on non-conservation lands. It also found that there is considerable "untapped" interest in planting native species. The study also showed that many of the most commonly occurring species were, not surprisingly, the most commonly planted. Many rare Carolinian woody species, including endangered or threatened species with regulations covering their planting, were also planted although in very small numbers. The study suggested that this emphasis on common species did not reflect a lack of interest in the rare species. Indeed, there is substantial evidence to suggest that rarity *enhances* interest in a species (Courchamp et al., 2006). Instead, the study suggested that there were significant obstacles to the increased planting of rare Carolinian species, including seed collector's lack of access to seed sources on protected or private lands, legal restrictions on the collection from some species, and the demands from commercial growers for only large seed lots. Large seed collections are typically difficult to obtain from rare species because of their small and often dispersed populations and their often poor production of viable seeds (Morris, 2005).

However, despite the considerable obstacles to the growing of rare species and their apparent lack of commercial availability, this previous study showed that a wide variety of rare Carolinian species were being planted by landowners. This observation raised important questions for the conservation of rare Carolinian flora. Most importantly, where were these plants coming from? Were the plants of non-Carolinian provenance and grown from seeds imported by growers or collectors to satisfy the demand for Carolinian species? Since access to many of the seed sources is difficult or prohibited (Morris, 2005), do these planted occurrences represent the progeny of a few of the most accessible "wild" examples of the species or, perhaps, locally collected seeds from plants of non-Carolinian provenance? Since planted examples of rare species may interbreed with the remnant natural populations of these plants or may be presumed to constitute ex-situ collections of native Carolinian populations, the answers to these questions will likely have significant implications for the conservation of the genetically-distinctive biological diversity of the zone. This study was undertaken to examine these questions and recommend how its insights may be accommodated in policy and/or practice.

Chapter 2 – Theoretical Justifications for Study

2.1 Introduction

The competition for space and resources has created profoundly complex conservation challenges. Indeed, there is a general consensus among ecologists and biologists that the earth is currently experiencing the sixth mass extinction event in its history (Chapin et al., 2000; Luck, et al., 2003; Wilson, 1992). Unlike earlier mass extinctions, though, this one is largely caused by humans. Although many contributing factors have been identified, most are simply the result of too many humans consuming too many resources and leaving too little space and too few suitable resources for non-human species (Palmer et al., 2004; Rosenzweig, 2003a, 2003b;). Faced with the sheer immensity of the problem, as well as the competition for attention and resources for other, seemingly equally important issues, it may be understandable if we assume a grudging acceptance of the loss of biodiversity. Indeed, the future may ultimately show that most non-human species are simply unable to tolerate the consequences of human activities in the long term. Yet, "to say that humans by definition degrade environmental quality is an overly simplistic and highly pessimistic conclusion, one that is depressingly fatalistic in its consequences" (Hull & Robertson, 2003, p. 403). It is both our ethical obligation and in our own self-interest to make every effort to conserve biodiversity. Since it is increasingly apparent that traditional approaches for the conservation of biodiversity have been inadequate, innovative approaches must be employed that try to reconcile human activities with conservation efforts. This does not mean dismissing traditional approaches. On the contrary, the maintenance of conservation reserves and the restoration of degraded habitat must be the cornerstone of conservation efforts. These largely state-run efforts, though, must be supplemented by strategies that incorporate the largely undervalued resources and expertise of non-state conservationists.

2.2 Defining Biodiversity Conservation

The conservation of biodiversity has become such a cornerstone of what might be broadly described as the environmental movement, that the meaning of the term is too often assumed to be self-evident. Indeed, the concepts of biodiversity and conservation have become so intertwined in common usage that the term “biodiversity” is often implicitly assumed to mean “conservation” (Reaka-Kudla et al., 1997). These seemingly inseparable terms, superficially denoting the protection of nature or at least the living components of nature, represent both a goal and an ethic with such popular appeal that it is almost universally embraced or seen to be embraced. However, despite being codified into laws, such as the Canadian Species at Risk Act (SARA), and international agreements, such as the Convention on Biological Diversity, there is considerable ambiguity in what is meant by biodiversity conservation. It is worthwhile, therefore, to examine the meanings of “conservation” and “biodiversity.”

The term “conservation” is often assumed to mean “preservation.” Indeed, the two terms are often used interchangeably (Norton, 1994; Redford & Richter, 1999). Although the equivalence between these two terms is undeniably consistent with most dictionary definitions of conservation,[2] there are important distinctions that have implications in their application to the protection of living organisms. Implicit in the term “preservation” is the maintenance of current conditions. Such a strict interpretation of preservation not only eliminates the

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[2] The Concise Oxford Dictionary (8th edition) defines conservation as “preservation, esp. of the natural environment” (Allen 1991: p.244).

possibility of either consumptive or non-consumptive uses (Redford & Richter, 1999), it implies a stability that would be almost unattainable naturally and would certainly eliminate the term's utility in describing living organisms. Frankel, Brown and Burden (1995) offer an interpretation of the term preservation that better illustrates its distinction from conservation. They suggest that preservation, as applied to living organisms, entails the maintenance of the current or desirable genetic state of the organism; virtually freezing the genetic line of the organism at its current level of evolution (Frankel, Brown & Burden, 1995). Preservation, therefore, might be important for maintaining the distinctive genetic lines of domesticated species, such as breeds of livestock or cultivars of plants. Conservation, on the other hand, does not require that conditions be "frozen" in an arbitrarily determined condition. A variety of uses are considered acceptable as long as that which is being conserved is not completely destroyed (Redford & Richter, 1999). For living organisms, this requirement not to destroy not only necessitates the maintenance of sufficiently large populations to procreate, but the protection of the ability to adapt to changing conditions (Frankel et al., 1995). Therefore, for living organisms, conservation requires the protection of the evolutionary potential within the organism that is determined by its genetic diversity.

The distinction between conservation and preservation is not merely semantic; they reflect quite different ecological perspectives with significant implications for the protection of the diversity of non-human life. The reason for the importance of the distinction between these two words is that they represent different ecological worldviews. Ecology has been undergoing a transition from a worldview in which ecosystems were viewed as essentially stable entities that developed along a linear path toward a predictable "climax" state, to a worldview in which ecosystems are complex, dynamic, uncertain, and historically contingent

(Folke et al., 2004; Levin, 1999; Lister, 1998; Wallington et al., 2005). Despite these insights, most current approaches to the protection of ecosystems and their biological components are based on the older static model and the creation of reserves to *preserve* the wildlife within them (Lister & Kay, 1999). Within the emerging ecological perspective, it is readily apparent that reserves ultimately cannot adequately protect the ecosystems that they were created to preserve (Folke, Holling, & Perrings, 1996; Folke et al., 2004; Klinkenberg, 2002; Loreau et al., 2006; Rosenzweig, 2003a, 2003b). In the face of substantial uncertainties, the *conservation* of the ability of organisms to adapt, determined by genetic diversity within the context of the environment, must be considered critically important. However, conservation measures must not abandon the important role of protecting sufficiently large populations of organisms, for "without a demographically, self-sustaining population, questions of genetic diversity are moot" (Guerrant, 1996, p. 172).

Like "conservation," the term "biodiversity" is widely used, yet lacks universal agreement on either its definition or application in practice (Fischer & Bliss, 2006). Etymologically, "biodiversity" is little more than a catchy contraction of "biological diversity." In its abbreviated form, the term has fairly recent origins: it traces its origins to Walter Rosen and the 1986 "National Forum on BioDiversity" in Washington, DC (Wilson, 1988). Conceptually, however, the scholarly recognition of the diversity within living entities dates back at least to the Aristotelian classification of species (Jefferies, 1997). There were undoubtedly also many earlier informal or folk classifications of organisms. In spite of, or, perhaps, because of its long conceptual history, biodiversity is a contested term that is laden with both scientific relevance and social values (Fischer & Bliss, 2006). This contestation has not hampered the utility of the term in advocating for the protection of living entities. Indeed, like the terms "sustainability" or "health," the ambiguity of "biodiversity," combined paradoxically with its seemingly self-evident meaning, has undoubtedly helped it to become "one of the most recognized environmental slogans" (Lister, 1998, p. 123). However, because the term has also been embraced within both academia and governments, its definition has become increasingly formalized.

At its simplest, biodiversity is "the variety and variability among living organisms and the ecological complexes within which they live" (Office of Technology Assessment, 1987). Although this definition is appealingly simple, it does not adequately reflect the complexity inherent within the concept (Lister, 1998). The *Global Biodiversity Strategy* offers a slightly more informative definition: "biodiversity is the totality of genes, species and ecosystems within a region" (WRI et al., 1992, p. 2). Within each of these components or levels of biodiversity (i.e. genes, species and ecosystems), though, are compositional, structural, and functional attributes (Noss, 1990; Redford & Richter, 1999). The compositional attribute describes the identity and variety within each component. Structure refers to the physical organization of the component. Finally, the function describes the ecological or evolutionary processes occurring at that level, such as gene flow, survivorship, and disturbance frequency or intensity. Given that the attributes of the species and ecosystem levels have traditionally been the focus of ecologists, Frankel et al. (1995) insightfully abbreviates this rather cumbersome description of biodiversity to define biodiversity as "the integration of ecology and genetics" (p. 5). This abbreviation exploits the popularity of the biodiversity "slogan" to focus much needed attention onto the "secret extinctions" (Ledig, 1991) resulting from the often unnoticed loss of genetic diversity.

With an understanding of the meanings of "conservation" and "biodiversity," it now becomes possible to formulate a definition of "conservation of biodiversity." The conservation of biodiversity requires the protection of the adaptive capacity or evolutionary potential within living systems at all scales. It excludes neither consumptive nor non-consumptive uses of these systems as long as there is neither complete destruction nor conversion of the systems nor its components, and the requirement to protect adaptive capacity is met.

2.3 Reasons for Conserving Biodiversity

To those who are committed to the conservation of biodiversity, the reasons to make the effort seem self-evident. Yet, in the contest of issues demanding attention, the problem of the loss of biodiversity faces significant challenges in gaining the public's attention. For example, cities not only threaten biodiversity through the direct conversion of habitat, they have a profound homogenizing effect on biodiversity (McKinney, 2006; Miller, 2005; Ricketts & Imhoff, 2003). Consequently, since most people now live in cities, most people only experience biological uniformity (Miller, 2005). Therefore, within the day-to-day life of most people, the world seems to function quite fine with low biological diversity. Even among people who are exposed to a wider variety of biodiversity than the typical urban dweller, the "shifting baseline syndrome" (Pauly, 1995) obscures the relentless loss of diversity. Within this phenomenon, each new generation of humans experiences less diversity and compares the further loss of diversity against this standard. Consequently, since most readily apparent biodiversity is outside most people's everyday experiences, the claims of a looming biodiversity "crisis" may seem unfounded. However, despite its apparent obscurity, there are critically important reasons for the conservation of biodiversity. The decisions about whether or how to act on these reasons will ultimately reflect socially-determined environmental values. They will also inevitably involve trade-offs because many of the actions that diminish biodiversity also provide important economic and social benefits (Robertson & Hull, 2001; Tilman, 2000).

Biodiversity is critical for the functioning of ecosystems and the provision of ecosystem services (Costanza et al., 1998; Chapin et al., 2000; James et al., 2001; Loreau et al., 2001; MEA, 2003, 2005). Changes in biodiversity, therefore, can have direct consequences on provisions of these services and, ultimately, on human economic and social activities. Although any categorization of these ecosystem services would undoubtedly be somewhat arbitrary and would have to recognize the inevitable overlap, the Millennium Ecosystem Assessment (2003, 2005) provides a useful taxonomy. The MEA divides these services into provisioning services (products provided by ecosystems, such as food, fuel and fibre), regulating services (benefits resulting from the regulation of ecosystem process, such as climate regulation and the maintenance of air quality), cultural services (benefits such as aesthetic appreciation, spiritual or religious meaning, recreational opportunities, and the definition of a distinctive sense of place) and supporting services (services that are necessary for the provision of the other services, such as nutrient cycling and soil formation). Since these biodiversity-dependent ecosystem services are crucial to the physical, cultural and spiritual well-being of all humans, calculating their monetary value would be virtually impossible and, perhaps, pointless; they are truly priceless. However, James et al. (2001) suggests the value of biodiversity simply for the provision of economic services is worth several trillion dollars annually. Boumans et al. (2002) places a relative value on ecological services by suggesting that globally they are worth approximately 4.5 times the gross world product. However their value is calculated, even if we consider only this rather narrow economic perspective, biodiversity *must* be conserved to maintain the reliable functioning of ecosystems and the continued flow of ecosystem services.

The alarming rate at which biodiversity is being lost raises the question of how much can be lost before ecosystem functioning is significantly impaired and critical ecosystem services are lost. To some extent, such a question is unnerving because it assumes that we have sufficient knowledge to understand the complexities within ecosystems such that we can determine which elements of the ecosystems are unnecessary or redundant. Given the value of ecosystem services, such an assumption seems to invite disaster. Still, the practice of conservation planning demands that such questions be asked. The answer, however, is uncertain. For example, Grime (1997) suggests that there is no evidence that higher levels of biodiversity are necessary for the maintenance of ecosystem functioning. He also suggests, however, that there appears to be thresholds beyond which, further loss of biodiversity will impair significantly ecosystem functioning and the provision of ecosystem services. If this is indeed true, how can we identify these thresholds so that they can be avoided?

Once again, there is uncertainty over how much biodiversity can be lost before ecosystem functions and services are significantly impaired. This uncertainty is partially because our understanding of the links between biodiversity and ecosystem function is poor (Holling et al., 1995) although improving (Symstad et al., 2003; Whitham et al., 2006). The uncertainty about the relationship between biodiversity and ecosystem function is also a result of the complexity of ecosystems (Levin, 1999). For example, if a group of species (and their associated genes) that perform a particular function in an ecosystem (a "functional group") is completely lost, ecosystem functioning can be dramatically altered (Chapin et al., 1997). Yet, as long as one species within the functional group is retained, the function should be preserved. Therefore, a particular function within an ecosystem may seem unthreatened despite a continual loss of species within the functional group. The loss of the last species within the functional group, though, may result in a sudden transformation of the functioning of the ecosystem, apparently without warning. Conversely, in an ecosystem that lacks a particular functional group, the introduction of even a single species may also significantly alter the ecosystem functioning (Chapin et al., 2000). Because of the uncertainty about how much biodiversity may be lost before ecosystem functioning is transformed and ecosystem services are lost, it is essential to conserve biodiversity whenever and wherever possible.

Strong ethical arguments can also be made for the conservation of biodiversity. However, some scientists, even some of those that are interested in conserving biodiversity, prefer to avoid the question of ethics (Gould, 1997a, 1997b; Van Houtan, 2006). This is unfortunate, though, because ethical arguments allow the problem of loss of biodiversity to be framed in ways that often have the most cultural resonance. The principle ethical argument for the conservation of biodiversity is that all life has intrinsic value (Callicott, 1986; Ehrenfeld, 1981; Nash, 1989; Nash & Carpenter, 1994; Wilson, 1992). Although this ethical argument is most commonly focused on the need to protect diversity at the species level, the interconnectedness of all levels of biodiversity means that this argument must necessarily apply to all of them.

Ethical arguments for the conservation of biodiversity can also be made based on social justice concerns and the need to allow equitable access to the services provided by biodiversity (MEA, 2003, 2005). As outlined by the Millennium Ecosystem Analysis (2003, 2005) and elsewhere (see, for example, Davies, 1996; Neffjes, 2000), maintaining biodiversity is vital for providing humans with resiliency in the face of changing conditions. This is particularly important for the rural poor who depend on biodiversity to supply food and other ecological resources during hard times. It does not simply require the complete loss of a component of biodiversity to deprive access to its services by the poor, though. As a component of biodiversity, particularly at the species level, becomes increasingly rare, its value and its price increases (Courchamp et al., 2006). This ultimately limits access to the resource for the poor. It also increases pressure on the resources as poachers and harvesters try to capitalize on the increased value. This increased pressure may accelerate the slide toward extinction for the species. Unfortunately, traditional state-based conservation efforts that are heavily reliant on the creation of reserves that restrict access to biodiversity are often at odds with the need to provide equitable access to biodiversity services (Adams et al., 2004; Brockington, 2002). Therefore, the conservation of biodiversity is not only necessary to provide ecological services for all humans, but must also be conserved in ways that provide equitable access to these services. To achieve this, it is necessary to conserve biodiversity not just within reserves but in places where people actually live and work.

Finally, a reoccurring theme among the other arguments for the conservation of biodiversity at all levels is that, even with the most skilled forecasting and the most accurate modeling, the future is uncertain. In his landmark paper on the conservation of genetic diversity, Otto Frankel (1974) argued that, since we cannot anticipate the conditions or needs of the world a century or two in the future, "it is our evolutionary responsibility to *keep our evolutionary options open*" (p. 63). However, it is not only important to preserve diversity at the genetic level. Biodiversity at all levels (genes, species, and ecosystems) provide insurance, flexibility and risk-spreading in dynamic landscapes and the capacity to adapt to surprise

(Folke, Colding & Berkes, 2002; Folke et al., 2004). This does not suggest that the conservation of genetic diversity is any less important. Genes are essential for remembering past adaptations and facilitating evolution to adapt to future conditions (Lister, 1998). If this were sufficient, though, all that would be necessary would be to *preserve* a representative sample of the genes in a gene or seed bank. Diversity at the higher levels (species and ecosystems), however, provides the context in which the genes are expressed and adaptation occurs (Lister, 1998).

It is cannot be too heavily stressed about the high degree of uncertainty that faces biodiversity and the socio-ecological systems of which they are part. This uncertainty presents one of the most daunting challenges for ecology and the formation of plans to conserve it (Chapin et al., 2000; Chapin, Sala, & Huber-Sannwald, 2001; Mora et al., 2007; Myers, 1995; Sala et al., 2000). This does not diminish the accomplishments of researchers that are attempting to identify the threats, trends and likely outcomes of the loss of biodiversity. It is increasingly apparent, though, that even identified threats to biodiversity may combine synergistically or through feedback loops to increase the threat to biodiversity in unexpected ways (Chapin et al., 2000; Mora et al., 2007). For example, in a simulation of the effects of combining identified threats to biodiversity, Mora et al., (2007) found that the combined effect of habitat fragmentation and harvesting on species population sizes was merely the total of their individual impacts. When combined with the effects of climate change, however, decrease in population sizes were as much as 50 times faster than anticipated. Such unexpected results would almost certainly threaten or undermine formal efforts to protect biodiversity.

Despite the strong arguments for the conservation of biodiversity, it continues to be undervalued by decision and policy makers (Loreau et al., 2006; Rosenzweig, 2003a, 2003b). Unfortunately, these arguments for the conservation of biodiversity offer little insight into how it should be done. It is important, however, that the inherent complexity and uncertainty in understanding the problem does not discourage conservation efforts. Instead, it is necessary to understand the problem, at least as well as possible, and to recognize the limitations and vulnerabilities in the current approaches. Rather than despairing over the uncertainty, it must be accounted for by incorporating multiple levels of insurance or redundancy in the approach, maintaining flexibility, and, as much as possible, spreading the risk so that localized failure does not become catastrophic.

2.4 What Biodiversity should be Conserved

The reasons to make every effort to conserve all biodiversity are undoubtedly compelling. Why, then, does biodiversity continue to be lost at an alarming rate? There have been a myriad of attempts to explain our inability to adequately address this looming crisis. Identifying individual threats to biodiversity so that efforts can be made to mitigate them is unquestionably helpful yet the continuing loss of biodiversity suggests that this approach may be tactically appropriate yet strategically inadequate. Loreau et al., (2006) suggest that part of our inability to conserve biodiversity is explained by the inherent complexity of the problem; the loss of biodiversity is simply more complex than other environmental problems. In the "tournament of values" that defines conservation decision-making (Robertson & Hull, 2001), this complexity must certainly make advocacy for biodiversity conservation much more difficult. Given the competing agendas and the continuing loss of biodiversity, perhaps it is simply best to conserve those elements of biodiversity that can be saved. But how do we decide which elements of biodiversity should be conserved?

With limited resources and competing issues, many conservationists favour a triage strategy: decide which elements of biodiversity (principally species) are likely to go extinct no matter what actions are taken and concentrate efforts only on the biodiversity that is likely to survive (Noss, 1990). There is undeniable, if callous, logic in abandoning efforts to protect "zombie species" (Rosenzweig, 2003a, p. 134) whose slide towards extinction appears irreversible. Certainly, given current expenditures on conservation and the number of species in dire need of protection, a triage approach seems necessary: providing the increasing number of at-risk species with special attention and possibly legal protection will ultimately prove cost prohibitive and too inflexible to protect them all (James et al., 2001; Meir et al., 2004; Rosenzweig, 2003b). For example, Wilcove and Chen (1998) found that the cost of protecting the 681 listed species-at-risk that were threatened by either fire suppression efforts or alien species exceeded the U.S. Fish and Wildlife Service's total annual budget for endangered species. Most of this budget, however, went to cover court costs and administrative expenses. Worse still, alien species and fire suppression are not even the principle threats to species-at-risk in the United States; habitat loss is the greatest threat to the species-at-risk (Rosenzweig, 2003a). Therefore, a triage approach would seem to be a practical and financial necessity, even if legislation and policy requires the protection of all species-at-risk (Noss, 1996).

A triage approach to conservation is problematic, though, because it ignores many of the previously discussed reasons for conserving biodiversity. Most importantly, it presumes that we know more than we do about the functions played by biodiversity. For example, a rare species may be the last member within a functional group of species that performs a critical function within an ecosystem (Chapin et al., 1997). However, since the species are rare, it is even more difficult than usual to determine the function that it plays (Gaston, 1994). Even if the role of a rare species is, in itself, rather insignificant, the collective impact of several rare species interacting in unforeseen ways with each other could be significant (Lyons et al., 2005; Theodose et al., 1996). Therefore, a triage approach that dismisses a rare species simply because it seems destined for extinction or because its protection would be prohibitively costly may be unknowingly causing significant changes in the ecosystems in which they occur.

Recognizing that a triage approach to the conservation of biodiversity is ethically questionable and ecologically unsound, and that all biodiversity should be conserved, does not mean that all types of biodiversity are being treated equally. Both research and conservation tends to focus on the biodiversity at the species level, on biodiversity with direct utilitarian value to humans, and on charismatic mega-vertebrates (Bowker, 2000; MEA, 2005; Robertson & Hull, 2003; Walker, 1992). As Bowker (2000) notes, "when entities have the misfortune to be small and generally disliked, then they will certainly not get the attention that others do" (p. 658). Although it is easy to criticize this bias as unenlightened and misguided, it is, perhaps, understandable. Such biases can also be useful for facilitating conservation of other types of biodiversity. For example, focusing conservation planning on large, wide-ranging species, such as large carnivores, that have both broad public appeal and require territories that cross several eco-regions can simultaneously encompass a great deal of biodiversity (Carroll et al., 2001). Of course, the need to preserve large areas limits the usefulness of this approach in areas that are dominated by human activities and, therefore, where biodiversity is most threatened.

A similar approach to the emphasis on the conservation of focal species would be to emphasize the conservation of "keystone species," or species whose influence on an ecosystem is disproportionate to their numbers (Groves et al., 2002; Power et al., 1996). Although the influence of these keystone species can be quite profound (Kotliar, 2000; Smith, 2006; Whitham et al., 2006) relatively few of them have yet been identified. Furthermore, keystone species do not necessarily correspond to the previously mentioned conservation biases and, therefore, may be less likely to receive the attention that they deserve.

Since focusing on specific species for conservation will almost inevitably omit a great deal of biodiversity, many scientists support conserving representative examples of different ecosystems or ecological communities (Hunter, 1991; Noss, 1987). This "course filter" approach would certainly seem to be an efficient way to protect a large number of species, both charismatic and those that seem less likeable, as well as the interactions between those that create a distinctive community. However, some species, particularly many species that are commonly exploited by humans and some rare species, do not occur in predictable fashions within ecosystems and, therefore, would not be captured by such a course filter approach (Groves, 2003; Groves et al., 2002; Klinkenberg, 2002). To compliment the course filter, therefore, it is recommended that a "fine filter" is necessary to capture these species, particularly in the "matrix lands" (*sensu* Lindenmayer & Franklin, 2002) outside of reserves. Since these two filters will still potentially omit some biodiversity, Hunter (2005) suggests that an intermediate or "meso-scale" filter is also necessary. Such a multi-scaled approach certainly goes a long way toward the implementation of a comprehensive strategy for the conservation of biodiversity (Lindenmayer & Franklin, 2002) yet still raises some important concerns. First, the effectiveness of this approach is ultimately dependent on the quality and extent of the information that is available to conservation planners (Margules & Pressey, 2000). In densely settled, human-dominated landscapes and where most of land is owned privately, as in the Carolinian life zone of southern Ontario (see Morris, 2005), it is also questionable whether publicly-run conservation programs could adequately protect the fine-scale or meso-scale features or create enough course-scale reserves to provide a representative sample of the ecosystem or community types. Even if a representative number of sites could be protected, there are concerns that significant genetic differences between similar communities may be lost. The importance of preserving this important genetic component will be discussed more fully later. Finally, this patchwork of conserved areas within a landscape potentially overlooks the dispersal limitations of some types of biodiversity, such as plants (see, for example, Cain, Milligan, & Strand, 2000; Ehrlen & Eriksson, 2003; Murphy & Lovett-Doust, 2004). Therefore, this ecosystem-focused approach to the conservation of biodiversity is ultimately inadequate.

If ecosystem and species focused approaches to deciding which elements of biodiversity to protect are inadequate, perhaps the decision of what to conserve should be determined by the genetic level of biodiversity. Since the goal of conservation is the protection of the adaptive capacity or evolutionary potential of biodiversity and this adaptive capacity is determined by genetic diversity (Frankel et al., 1995), this would seem to be where conservation efforts should be focused. But is this single-level approach to conservation any more adequate than approaches that focus on protecting the products of evolution (i.e. species and ecosystems)? If the conservation of genetic diversity were, in itself, adequate, all that would be necessary would be to preserve it in gene or seed banks. The adaptive capacity of genes, however, is highly dependent on context (Lister, 1998). Genes that may appear neutral within one context, and, therefore, apparently unworthy of conservation, may become non-neutral in another context (Hamilton, 2001). Furthermore, the adaptive changes typically result from a combination of genes interacting with the environment (Allendorf & Luikart, 2007). Consequently, unless we are able to preserve the entire spectrum of genetic diversity, we have no way of knowing which genes to conserve. Even if all the genetic diversity could somehow be preserved outside its evolutionary environments, the effect of (re-)introducing these genes, or at least their phenotypic expressions, into a future environment with perhaps significantly different conditions would be uncertain.

Asking which elements of biodiversity to conserve is ultimately inappropriate. Given the reasons for preserving biodiversity, it is quite obvious that we should try to preserve all of it (except, perhaps, virulent hazards that significantly threaten human health). Asking how to decide, however, makes it apparent that no one approach is adequate. Instead, many ways to conserve biodiversity must be undertaken simultaneously. Since, as previously discussed, formal, state-run conservation efforts do not have the resources to adequately conserve biodiversity, the role of non-state and informal efforts must be recognized and facilitated. Just as biodiversity adds insurance, flexibility and risk-spreading within dynamic landscapes and in the face of uncertainty (Folke et al., 2004), so non-state actors provide insurance, flexibility and risk-spreading to the attempts to conserve biodiversity at all levels.

2.5 Where to Conserve Biodiversity

Although the arguments to conserve biodiversity are convincing, the answer to the practical problem of where this biodiversity should be conserved is not so readily apparent. Hindering the conservation of biodiversity is what Rosenzweig (2003a) describes as "the tyranny of space" (p.101). This rather ominous phrase describes the predicament resulting from the continuing growth of human populations and the resulting displacement of non-human elements of biodiversity. The growth of human populations is widely regarded as the root cause of the current loss of biodiversity and ecosystem function (Ehrlich & Ehrlich, 2004; Forester & Machlis, 1996; Kerr & Currie ,1995; McKee et al., 2003; Olden et al., 2006). Although there are certainly many mechanisms through which biodiversity is lost, Rosenzweig (1995, 2003a, 2003b, 2005) argues that the rate of loss is best predicted by the species-area relationship, arguably one of the oldest and the most fundamental rule in ecology (Lawton, 1999). At its simplest, this relationship states that the larger the area, the more species there will be in that area (Rosenzweig, 1995). Therefore, as humans occupy an increasing proportion of the world with their settlements and activities, there is progressively less area for non-human species. Estimates of the area appropriated by humans vary and often reflect differences in opinion in what constitutes conversion from a natural condition. Huston (1993) suggested that, at that time, 95 percent of the area of the world had been taken for human use. Noss and Carpenter (1994) suggested that more than 97 percent of the United States was now dominated by humans. In the Carolinian life zone of southern Ontario, about 15 percent of the region remains in what might be described as natural conditions although only 0.07 percent of the zone remains in old-growth conditions that are similar to the original (i.e. pre-European arrival) conditions (Jalava, 2000). As human populations grow by almost 1 percent a year

(UN, 2006), the area available for conservation will be able to accommodate progressively less biodiversity. However, “abating human population growth is a *necessary, if not sufficient*, step in the epic attempt to conserve biodiversity” (emphasis added, McKee et al., 2003: 161).

Since human activities are generally viewed as the greatest threat to conservation, the traditional approach to conserving biodiversity has been to create reserves, generally large ones, typically in places where people are absent or have been evicted (Lindenmayer & Franklin, 2002). There is little doubt that this approach is critical for the conservation of biodiversity. As previously discussed, large reserves are important because they may encompass examples of different ecosystems or ecological communities (Hunter, 1991 ;Noss, 1987). Conservation reserves are irreplaceable in otherwise human-dominated regions for species that require large territories or are intolerant of even low-levels of disturbance by humans (Lindenmayer & Franklin, 2002; Rosenzweig, 2003a). Reserves are also important for those species that are relatively tolerant of some disturbance by humans yet may be sensitive to the cumulative effect of repeated disturbances (Lindenmayer, 1995; Riffell et al., 1996). Reserves also provide reference conditions that allow us to judge the impacts of human activities on non-reserve areas (Christensen et al., 1999; Lindenmayer et al., 2000; Norton, 1999). They also provide opportunities for humans to learn about and appreciate biodiversity within its “natural” context (McNeely, 1994). Since this last benefit of reserves is potentially at odds with some, if not all, of the other benefits (Grumbine, 1991), it quickly becomes apparent that there are some critical shortcomings in the over-reliance of reserves to conserve biodiversity.

Although reserves constitute an essential component of a comprehensive conservation strategy, it is increasingly evident that a reserve-only approach is not adequate for the conservation of biodiversity (Folke et al., 2004; James et al., 2001; Li et al., 2006; Lindenmayer & Franklin, 2002; Loreau et al., 2006; Rosenzweig, 2003a, 2003b; Soulé & Sanjayan, 1998; Wallington et al., 2005). The inadequacy of a reserve-only approach reflects the inherent limitations of reserves. Perhaps most important of these limitations, as suggested in the species-area discussion, is that both the existing network of reserves and area available for reserves is simply too small (James et al., 2001; Lindenmayer & Franklin, 2002; Rosenzweig, 2003a, 2003b; Scott et al., 2001; Soulé & Sanjayan, 1998). Establishing minimum necessary areas for networks of protected areas is difficult because it overlooks the importance of criteria such as representativeness and comprehensiveness (Armesto et al., 1998). The World Conservation Union has suggested that at least ten percent of the land area of any country or ecosystem should be set aside as conservation reserves (IUCN, 1993). Ultimately, though, such arbitrary targets are founded more on political goals than an understanding of the area needed to conserve biodiversity. Soulé and Sanjayan (1998) suggest that as much as 50 percent of all lands must be set aside to adequately conserve biodiversity. Noss and Carpenter (1994) suggest that in some cases, as much as 100 percent of an ecosystem should be protected. However, in most countries, reserves are unlikely to protect more than 10 to15 percent of the land area (Lindenmayer & Franklin, 2002). Usually, much less land is protected. Across 26 countries in Europe, only about 1.7 percent of the total forest area is protected (Parviainen et al., 2000). In the Carolinian zone of southern Ontario, less than 2 percent of the land area is protected in any kind of reserve (both state and non-state) (Jalava, 2000). It is clear, therefore, that in these places, as elsewhere, most biodiversity will exist outside of reserves.

It is not only the limited total area of land available for reserves that hinders the ability of reserves to adequately conserve biodiversity. Because of the limited area available for reserves, the size of individual reserves is also often too small to support viable populations of many species in the long term (Brent et al., 2001; Grumbine, 1990; Miller & Hobbs, 2002; McNeely et al., 1994;), too small to accommodate natural disturbance regimes (e.g. fires) without the loss of all or most of the elements for which the reserve was created (Baker, 1992), and/or too small to accommodate species with large ranges and that require resources that differ substantially in their spatial and temporal availability (Law & Dickman, 1998). This does not mean that small or even intermediate-sized reserves do not have value as part of an overall conservation program (Lomolino, 2000; Zuidema et al., 1996). Certainly, through what has become known as the "small island effect" (Lomolino, 2000), idiosyncratic features of a particular location may allow that place to possess higher levels of biodiversity than would be predicted by the species-area relationship. The protection of these areas is important for both their habitat value and the improvements that they make to matrix lands between larger reserves (thus aiding dispersal between reserves). Without truly large reserves, though, the ecological benefits that reserves were designed to offer cannot be fully realized.

A particularly vexing problem in relying on reserves for the conservation of biodiversity is that they are, as a group, not adequately representative of the biodiversity of the regions in which they occur (Gaston, Smith, Thompson, & Warren, 2006; Khan et al., 1997; Rodrigues et al., 1999). This is because, in most countries, reserves are generally in areas that are steep, at high elevation or latitude, and/or in areas of low productivity (Norton, 1999; Rouget et al., 2003; Scott et al., 2001). Since diversity at the species level is generally, although not always, positively correlated with productivity (Luck, 2007; Srivastava &

Lawton, 1998) as well as steepness and elevation (Hunter & Yonzon, 1993; Noss & Carpenter, 1994), the location of such reserves is less likely to reflect regional diversity than a more representative sample that included more productive areas. Existing reserves are also often less representative of regional biodiversity because they were generally created for other reasons, particularly for their scenic or recreational value (Pressey, 1994). Rugged beauty and opportunities for recreation, while important for attracting human visitors to reserves, are not necessarily compatible with the conservation of biodiversity.

Finally, an important flaw in the over-reliance on reserves for conservation is that ecosystems and the biodiversity that they contain are dynamic (see, for example, Margules et al., 1994) while the boundaries of reserves are static. Therefore, even with conscientious management, biodiversity within reserves is likely to be lost. Species will disappear (Rodrigues et al., 2000; Witting & Loeschcke, 1995). Since small, isolated populations of species tend to lose genetic variation by generic drift more quickly than larger, more connected populations, biodiversity at the genetic level will also be lost (Frankham et al., 2002; Young et al., 1996). As species and genetic diversity is changed, ecosystem processes and functioning will also become altered (see, for example, Whitham et al., 2006). These changes in biodiversity within reserves will also likely be accelerated and exacerbated by climate change (Lemeiux & Scott, 2005). Therefore, in a dynamic landscape, reserves cannot be expected to conserve the biodiversity within them.

Since reserves are inadequate for the conservation of biodiversity, the critical conservation challenge becomes finding the extra space to accommodate the habitat needs of non-human organisms. Some of these habitat needs might be accommodated by the restoration of habitat that has been degraded by human uses. The role that ecological restoration *sensu* *stricto* (i.e. the replication of previous conditions), can play in conserving biological diversity is uncertain, however. For example, given the increasing demands of the growing human populations, the areas available for restoration are likely to be relatively small or relegated to more remote areas where the anthropogenic threats to biodiversity are not as great. Even if restoration were truly possible (the feasibility of restoration is not assured, as will be discussed), it would seem to differ little from the reserve approach to conservation except in the starting conditions. Like conservation approaches based on the creation of reserves, restoration approaches to conservation assume that static conditions will ultimately be attainable (Rosenzweig, 2003a, 2003b). Unlike reserves, though, the biodiversity that restoration efforts try to conserve exists at some future reference point, not at the start as in the creation of a reserve. However, ecological processes, such as compositional succession within a community, are extremely sensitive to their initial conditions and, therefore, quite likely chaotic (Green & Sadedin, 2005; Hastings, Hom, Ellner, Turchin, & Godfray, 1993; Huisman & Weissing, 1999, 2001a, 2001b, 2002; Roelke et al., 2003)[3]. Therefore, despite even the most skillful efforts of restorationists to introduce the desired biodiversity by planting locally appropriate species and genetic lines, the ultimate composition of the restored community will quite likely be different from the target or reference conditions. This does not mean that restoration projects should not be attempted. On the contrary, the motivation to restore degraded ecosystems should be encouraged. However, despite the ambitious goals implied by the term "restoration," it should be acknowledged that restoration is merely an attempt to reconcile the best available knowledge about biodiversity and ecosystem function with inherent

[3] Although likely, chaotic behaviour in biological or ecological systems is very difficult to prove (Ferriere & Fox, 1995; Green & Sadedin, 2005, Theiler, 1994).

uncertainty. This realization should motivate us to explore other ways to reconcile the conservation of biodiversity with human activities.

2.6 Conservation of Biodiversity within Human-dominated Landscapes

The inadequacies of the traditional approaches to the conservation of biodiversity suggest that these efforts will, in the long term, be unable to protect all but the most human-tolerant components of biodiversity. The inability of traditional conservation approaches should not be taken to mean that all hope is lost, though. Instead, it should provide the motivation to try to extend conservation efforts beyond traditional, state-run, science-based and highly professionalized traditional approaches. Enabling such supplemental conservation strategies requires not only recognizing the importance of non-experts in conservation planning but finding novel places in which to undertake conservation efforts.

Extending conservation efforts beyond traditional science-based conservation approaches demands, in part, a re-conceptualization of who is responsible for conservation. This requires a transition from conservation approaches based primarily on the insights provided by traditional or “normal” science to one that also accommodates the flexibility of “post-normal science” (Funtowicz & Ravetz, 1991, 1994; Ravetz, 1999). Unlike the Kuhnian (Kuhn, 1962) normal science, which is characterized by “routine problem-solving by experts” (Ravetz, 1999, p. 648), post-normal science recognizes the potentially important and active role that non-experts may play in understanding and resolving problems in a complex, dynamic and uncertain world.

Although the sciences of biology and ecology have provided irreplaceable tools for the understanding of the human and non-human elements of nature, they are ultimately inadequate to the practical requirements for effective conservation efforts (Noss, 1996). This does not, however, require the abandonment of accepted theoretical frameworks provided by science. On the contrary, biological and ecological principles provide the essential ontological and epistemological foundations of conservation efforts (Robertson & Hull, 2001). As Robertson and Hull (2001) observe, though, conservation goals must ultimately be negotiated within a "tournament" (p. 973) of values within which the expert biologist or ecologist is but one stakeholder among many. Such a tournament is an "… inherently political and shamelessly unscientific" (Robertson & Hull, 2001, p. 976) contest between competing and often passionately held positions. A wholly scientific approach to reconciling these diverse agendas, therefore, must be considered anathema to the goals of conservation. Therefore, in principle and in practice, conservation ecology must be practiced as a post-normal science with an inherent acceptance of uncertainty and complexity, a multiplicity of legitimate perspectives, and extended peer groups (Funtowicz & Ravetz, 1994). Such a post-normal approach to conservation should not be seen as denial of the relevance of conservation experts. Instead, it should be seen as an approach that provides critical assistance to accredited professionals in the face of daunting conservation challenges (Ravetz, 1999).

Since traditional conservation efforts based on the protection of conservation reserves or the restoration of degraded habitat are inadequate, conservation efforts must increasingly focus on conserving biodiversity "in places where people live, work, or play" (Rosenzweig, 2003a, p. 7). Although Rosenzweig (2003a, 2003b) calls this supplemental conservation strategy "reconciliation ecology," essentially similar concepts have been described using other names (Lindenmayer & Franklin, 2002; Miller & Hobbs, 2002; Redford & Richter, 1999; Robertson & Hull, 2001). All, however, are based on the assumption that human activities are not necessarily incompatible with conservation of non-human biodiversity. If this assumption is true, it may allow us to overcome the dire implications of the species-area relationship and Rosenzweig's (2003a) "tyranny of space."

Perhaps the most important quality of a reconciliation approach to the conservation of biodiversity is the critical role played by non-state actors. To some extent, recognizing the role of non-state actors in conservation is anathema to professional conservation practitioners and decision-makers. After all, it is destructive actions of non-conservationists that seem to most threaten biodiversity. Traditionally, it has been the mission of professional ecologists and conservation biologists to use their scientific knowledge and expertise to protect biodiversity from these threats. Yet, as previously discussed, their traditional conservation approaches are inadequate to protect biodiversity. Therefore, including non-state actors and the resources and knowledge that they offer is little more than recognition that the resources and expertise that governments are willing to direct toward conservation efforts are insufficient to the task. It is also recognition that, given the uncertainty and complexity inherent in ecosystems and their components, the scientific foundations upon which professional conservationists depend are also inadequate (Robertson & Hull, 2001). Indeed, as Robertson and Hull (2001) note, "the world and how it works is so complex, chaotic, and changing that, relative to what might be known about it, we now know very little, and we are not likely to know that much" (p.972). Therefore, although there are undeniable risks that the uncoordinated or uniformed actions of non-professionals, however well-meaning, may be counter-productive, there is much to gain by acknowledging the role of non-state actors in conservation efforts. At the very least, it is important to understand their activities so that they may be accommodated.

Perhaps the most fundamental reason for including non-state actors in conservation is that they own much of the land where biodiversity is most imperiled. For example, in the United States, where most of the land is privately owned, almost all (more than 90 percent) of threatened or endangered species have at least part of their distribution on private lands, and about two-thirds of these species have at least 60 percent of the areas in which they occur on private lands (Groves et al., 2000; Knight, 1999; Scott et al., 2001). In Canada, where a higher percentage of the country is owned by the government (Crown lands), the situation might be expected to be different. Of course, Crown lands are not necessarily protected lands. Furthermore, the Crown lands are concentrated towards the north while biodiversity is generally higher towards the south of Canada. In one of the most biologically diverse ecological regions in Canada, the Carolinian life zone (ECO, 2004; Waldron, 2003), almost all of the land is privately owned (Jalava, 2000). Although Klinkenberg (2002) found that rare Carolinian plants were disproportionately likely to be found in reserves and other identified significant natural areas, about 80% of their occurrences were on private lands outside of these areas. Clearly, to protect the remaining biodiversity in the Carolinian zone, in the Eastern Deciduous forest, and elsewhere, the owners of privately-owned, matrix lands outside of reserve must be involved for, in many areas, these are the only lands available.

Perhaps the most fundamental role of these human-dominated matrix lands is to provide habitat, although possibly sub-optimal habitat, for broadly distributed populations of species (de Maynadier & Hunter, 1995; Daily et al., 2003; Fischer et al., 2005; Miller & Hobbs, 2002; Murphy & Lovett-Doust, 2004). Despite the dichotomy between habitat and human-occupied lands that are inherent in the assumptions of the species-area relationship, research is increasingly demonstrating that many species are able to live in human-dominated landscapes at least part of the time. Much of this research has focused on the habitats available within primarily agricultural matrix lands, such as small remnant patches of forest or woodlots (Bellamy et al., 2000; McCollin, 1993; Smith et al 1996;), in hedgerows (Hinsley & Bellamy, 2000; McCollin et al., 2000), along roadsides (Bennett 1991; Forman & Alexander, 1998; Shochat et al., 2005), on cropped fields (Butler et al., 2007) and along streams (Martin et al., 2006). This research suggests that in rural agricultural areas, the creation and maintenance of even small patches of vegetation by rural landowners can be important for providing habitat for a wide variety of species.

In contrast, most research on the role of urban lands has emphasized the negative effects of urbanization, such as the loss of habitat and the homogenization of the biodiversity within them (see, for example, McKinney, 2002, 2006). There is certainly strong evidence that green areas within urban areas, such as publicly owned parks, that become isolated from the surrounding non-urban environments tend to lose biodiversity and their associated ecosystem services (Barthel, Colding, Elmqvist, & Folke, 2005). However, such criticisms of the conservation value of habitats within urban areas often fail to recognize the critical role that urban private lands play in creating habitat for species (Head & Muir, 2006). For example, private homeowners can play an important role in maintaining bird diversity within urban areas by creating suitable backyard habitats (Sandstrom et al., 2006; Savard, Clergeau, & Mennechez, 2000). Thompson et al. (2003) also noted that because of the active management of urban and suburban gardens, plants are able to persist in remarkably low populations. These backyard plant communities are also much more heterogeneous than semi-natural habitats (Thompson et al., 2003). Since many gardens incorporate native plant species, such gardens not only provide habitat for wildlife, they supplement existing populations of native plant species (Gaston, Smith, Thompson, & Warren, 2005; Head & Muir, 2006).

Managing the matrix for the conservation of biodiversity does not simply create habitat for some species outside of reserves; it can also improve the effectiveness of reserves in human-dominated landscapes. This is possible because the planting of vegetation within the matrix lands surrounding reserves can decrease the edge effects resulting from a high structural contrast between the reserve and the surround areas. When reserves are located within an otherwise human-dominated landscape, the stark contrast between the often quite open conditions in the matrix and the reserve can create significant edge effects (Murcia, 1995). In general, the greater the contrast between the matrix and the reserve, the more intense will be the edge effects. Although these edge effects were once considered to be beneficial for conservation because they appeared to be areas of enhanced biodiversity, it is now evident that they may have quite negative effects on biodiversity, particularly on habitat-interior species (Lidicker, 1999; Sisk, Haddad, & Ehrlich, 1997). These are quite often the species that are most in need of conservation within the reserve. Therefore, decreasing the contrast between the reserve and non-reserve lands through appropriate matrix management (e.g. planting vegetation) can lessen the edge effects and, at least for the habitat-interior species within the reserve, make the reserve seem functionally larger (Lindenmayer & Franklin, 2002). Although the managers of the reserves (typically the state) have a strong interest in enhancing the matrix conditions surrounding the reserves and may play an important role in promoting these modifications, in areas, such as southern Ontario, where most of the surrounding lands are privately-owned, the extent and nature of these modifications are ultimately the decisions of the landowners.

The management of matrix lands for the conservation of biodiversity does not simply mean providing habitats for species or buffering patches of existing habitat. The matrix also plays a critical role in determining the connectivity or linkages between patches of habitat (Lindenmayer & Franklin, 2002). Conditions in the matrix may either facilitate or hinder the movement of organisms and genes between populations that are either in reserves or within the matrix (Burkey, 1989; Taylor, Fahrig, Henien, & Merriam, 1993). Maintaining connectivity or linkages between populations is critical to the preservation of biodiversity. Isolation resulting from a lack of connectivity is often associated with declining populations resulting from reduced gene flow between populations, increased genetic drift and elevated inbreeding (Young et al., 1996). Inbreeding in small, isolated populations may lead to lower fecundity and reduced viablility among individuals in the population (Allendorf & Luikart, 2007) and is considered to be the main genetic factor that influences the short-term survival of populations (Booy et al., 2000). On the other hand, genetic drift resulting from the random loss of genetic diversity and increasing homogeneity within small, isolated populations, may reduce the survival of the population in the long term by diminishing the population's adaptability to changing conditions (Booy et al., 2000; McKay, Christian, Harrison & Rice, 2005; Ouborg, Vergeer, & Mix., 2006). Connectivity through the matrix facilitates the movement of species and their genes between otherwise isolated populations and can help prevent both genetic drift and inbreeding. Ultimately, therefore, facilitating connectivity through the matrix lands can allow populations to maintain or even increase both their demographic sizes and genetic diversity (Sacchari et al., 1998).

The modifications to the matrix to facilitate dispersal should be as widespread as possible but do not necessarily have to be large to be effective. Certainly, long but relatively narrow wildlife corridors are commonly advocated for facilitating dispersal (Donald & Evans, 2006; Hilty et al., 2006). Although some studies have questioned the benefits and effectiveness of corridors (Beier & Noss, 1998; Wiens, 1995), the establishment of all but the shortest corridors in settled landscapes would seem to be problematic. For example, finding agreement among a series of neighbouring private landowners, each with different sets of values and interests, would seem to require considerable bureaucratic effort and/or expensive incentives. However, facilitating dispersal need not require centralized, typically state-run co-ordination to be effective. Even small corridors, such as hedgerows, have been shown to aid dispersal (Bright, 1998; Kremen & Ricketts, 2000). Unconnected small patches of habitat, some as small as single trees (Fischer & Lindenmayer, 2002), have also been found to be effective as "stepping stones" for some species (Baum et al., 2004; Murphy & Lovett-Doust, 2004). Rudd (2002) has shown that private backyards are extremely important "stepping stones" for dispersal in urban environments. It is increasingly apparent, therefore, that even small modifications by private landowners, working separately but having an effect through agglomeration with each other, can help to facilitate dispersal through the lands between larger patches of habitat.

This discussion of the importance of connectivity raises an important question, however. Given plants' sessile nature, how can improvements to conditions in the matrix maintain connectivity between plant populations and, ultimately, the viability of the habitats that they create? Most plants, however, live at two spatial scales: the relatively broad dispersal scale of the pollen and seeds, and the typically much finer scale at which the sessile plants live most of their lives (Murphy & Lovett-Doust, 2004; Petit, 2004). Connectivity between individuals and/or populations can generally only be maintained through the dispersal of seeds (thus potentially maintaining gene flow through the introduction of new individuals) or pollen. Since gene flow resulting from pollen dispersal requires a receptive stigma, though, pollen dispersal can only be to existing populations of the species (Petit, 2004). In comparison, seeds can either be dispersed to an area with an existing population or to new, unoccupied areas. The distance over which seeds may disperse, however, is generally very short. Although distance varies with species and environments, seed dispersal is rarely more than a few hundred metres (Cain et al., 2000). Long-distance dispersal is extremely rare and governed by extreme stochasticity (Cain et al., 2000). In fragmented landscapes that have experienced high levels of habitat loss, like many human-dominated landscapes, seed dispersal may be even shorter and successful migration substantially reduced (Cain et al., 2000; Higgins et al., 2003; Trakhtenbrot et al., 2005). Successful long distance dispersal of seeds is, ultimately, so rare that areas in which populations of plants have become extinct are unlikely to be recolonized (Ehrlén & Eriksson, 2003).

In general, pollen can disperse over much longer distances than seeds (Ghazoul, 2005). It would seem, therefore, that maintaining genetic connectivity between seemingly isolated plant populations would be best accomplished by interbreeding through pollen dispersal. However, successful pollen dispersal is often much more limited than one might expect. For example, among wind-pollinated plants, pollen dispersal is rather haphazard and the likelihood of successful pollination often decreases rapidly with distance (Fenner & Thompson, 2005). Because of this, wind-pollinated plants tend to be quite sensitive to declining population densities and increasing isolation (Ghazoul, 2005). But many plants do not rely on the wind and mere chance for pollination. It would seem that those plants that go to the expense in resources of attracting mutualistic faunal dispersers of their pollen would receive important reproductive benefits. Certainly, the purposeful or directed nature of animal-pollinated plants would seem to make these plants less sensitive to population densities or isolation. After all, even the tiniest of pollinating wasps can travel incredible distances in search of suitable plants (see Nason et al., 1998). Pollinators, however, tend to forage over a much shorter distance than they are capable of traveling, particularly in areas with abundant floral food sources. For example, Sowig (1989) found that bumblebees tended to forage over an area of only a few square metres despite being able to travel over much longer distances. In an interesting example of a feedback loop in improving connectivity in a landscape, Kremen and Ricketts (2000) also found that improving dispersal corridors for animals in fragmented landscapes, such as the planting of hedgerows along field edges, improved the pollen dispersal abilities of pollinators in both agricultural and natural systems. Ultimately, though, in both animal-pollinated and wind-pollinated plants, pollen dispersal and reproductive success are negatively correlated with distance between individuals or populations.

This discussion of the seed and pollen dispersal limitations of plants is important for understanding the role of the matrix lands between reserves in conserving plant biodiversity. Quite simply, by planting floral species of appropriate provenance (discussed below) within the matrix, the maintenance of gene flow and the spread of populations may be possible with only short distance dispersal events (Trakhtenbrot et al., 2005). To be effective, though, these plantings should encompass a broad spectrum of the regional plant biodiversity as widely within the region as possible. The requirement to plant a wide spectrum of plant biodiversity means that as many regional species as possible must be planted from a wide variety of regional provenances. The requirement to plant widely throughout the region[4], although at odds with the mantra of many restorationists to use only local provenances (McKay et al., 2005), is consistent with the principles of reconciliation ecology of creating habitat wherever possible. The condition that these plantings should be limited only to the region of their provenance is to maintain interactions with the remnant populations (such as those in reserves) and to keep the species and genes within the context within which they evolved (Lister, 1998). As long as this condition is satisfied, it can be argued that, at least within the perspective of matrix management (Lindemayer & Franklin, 2002), even backyard plantings of species could be considered desirable examples of *in situ* conservation.

Because successful long distance dispersal of plants is so rare, it cannot be relied upon to create these plantings within the matrix lands. Such plantings must be done by the humans that already dominate the matrix. Dispersing plants across the landscape is certainly not a new role for humans. As Hodkinson and Thompson (1997) note, "in considering the likely future spread of [plant] species across the landscape, man (*sic*) must be included, not just as a modifier of the landscape itself, but as a major (perhaps *the* major) dispersal vector" (p.1492). Quite often, though, the dispersal abilities of humans have worked toward the loss or homogenization of plant diversity (Bailey, 2007; MEA, 2005). The planting of regionally appropriate species throughout the matrix lands simply exploits humans' proven dispersal abilities for the conservation of biodiversity.

But who should be responsible for these plantings? If ecological knowledge was complete, the authority of the state unlimited, and the resources available for conservation dependent only on the extent and severity of the problem, ecologically appropriate plantings

[4] The criteria that define a region are subjective and may or may not be defined entirely in ecological terms. In general, though, ecological factors, such as the natural range of the species, should be a consideration in reconciliation efforts.

could be imposed on those areas where they would be most effective. However, ecological knowledge is not complete, conservation efforts must compete for resources with other socially-valued programs (Robertson & Hull 2001), and in many, if not most, human-dominated landscapes, most of the lands are privately-owned and managed. Therefore, whether or not such plantings are made will principally be the decision of non-state actors. Even when the state facilitates or participates in these plantings, Morris (2005) notes that lack of resources and competing goals often limits the species (and likely genetic) diversity used.

2.7 Modifying the Matrix: Choosing the Appropriate Species and Provenances

While matrix plantings of whatever plants were most readily available, least expensive or most easily grown would likely be able provide many of the benefits outlined above (i.e. support species, buffer existing reserves and facilitate dispersal), it would not necessarily be compatible with the goals of biodiversity conservation. Certainly, the planting of non-native plant species would not help the conservation of local floral diversity. Therefore, the use of native species in matrix plantings, as in restoration efforts, would seem to be preferable unless non-natives plants would be helpful in establishing the native species (such as providing shelter, improving soil fertility or stabilizing soil) (Davy, 2002). The challenge to emphasizing the planting of native plants, of course, is having adequate knowledge of what is native to the area being planted. Although this would seem to be easily obtained simply by inventorying the area, such inventories may be incomplete because of lack of co-operation from private landowners (Hamilton Naturalists Club, 2003). Even in the densely-settled landscape of southern Ontario, new native Carolinian tree species continue to be discovered (Waldron, 2003).

Determining which species are native is also difficult because the meaning of the term "native" is subjective. For example, native plants are commonly defined as those that occur within a particular region without the aid of either direct or indirect human actions (Morse et al., 2000). Such a definition is, of course, problematic, not only because it assumes a strict dichotomy between nature and humans but because it assumes that the dispersal vector responsible for a plant's arrival can be easily determined. For example, *Asimina triloba* (pawpaw) is generally recognized to be a native species to southern Ontario, yet may have been brought into the region by First Nations people (Ambrose & Kevan, 1990; Keener & Kuhns, 1997). Some have offered a partial solution to this dilemma by suggesting that the term "native" should only apply to species that arrived within a region (at least in the Americas) prior to the arrival of Europeans (Leopold, 2005). Such a definition is useful in that it provides a baseline. It is still problematic, though, in that it still assumes that human and non-human processes in a complex socio-ecological system can be easily distinguished (although it now seems to reclassify the actions of aboriginal peoples as "natural"). It also seems to assume that speciation and "natural" dispersal into a region ended with the arrival of Europeans in the Americas. These definitions also fail to recognize that the term "native" is scale-dependent; a list of native species at the national or regional scale will differ substantially from a site-specific list of native species. It seems, therefore, the term "native" eludes a simple, widely-applicable definition. Ultimately, it should be recognized that the term "native" is socially-defined and must be defined within the context of the goals of biodiversity conservation.

Choosing which plant species to use in reconciliation efforts within the matrix is not as simple as planting "native" species. Whether such plantings are undertaken by the state or private landowners, resources are limited. Since more common species are more widely available, they are also more likely to be planted (Morris, 2005). As long as appropriate precautions are taken to preserve the genetic diversity within these common species, the planting of common species should be considered to be compatible with the goals of biodiversity conservation. However, the widespread planting of common species seems to have high opportunity costs. The risk of extinction and the associated loss of biodiversity is greater for rare species (Gaston, 1994; Lyons et al., 2005). Planting rare species must, therefore, be given paramount importance. This does not mean that rare species should be planted to the exclusion of common species. As noted in Morris (2005), rare plant species are often more difficult to grow commercially and, therefore, are generally unlikely to be grown to the exclusion of more common and less challenging plants. However, non-state actors, particularly committed native gardeners, are more likely to go to the effort to grow and distribute these rare native plants (Head & Muir, 2006; Morris, 2005). This is yet another reason why the involvement of non-state actors is critical to the effective conservation of biodiversity.

It is not merely important to select the appropriate species for planting. The species must also be genetically appropriate. This means that, to meet the goals of biodiversity conservation, these plants must not only be of regional provenance, they must, as a group, represent as complete a sampling of the genetic diversity within the species as possible (Bischoff et al., 2006; Bussell et al., 2006; Hamilton, 2001; Hufford & Mazer, 2003; McKay et al., 2005; Rogers, 2004). Much has been written about the importance of using only plants of local provenance in revegetation efforts. One of the main reasons is that plants of local or regional provenance are adapted to the local conditions; their genes contain the remembered fitness that is the result of evolution within the context of the local environment (Joshi et al., 2001; Potts, Barbour, Hingston, & Vaillancourt, 2003). The use of plants of non-local provenance may also cause outbreeding depression, a reduction in fitness within local populations resulting from the introduction of genes for populations that are adapted to other environments (Hufford & Mazer, 2003; Keller, Kollmann, & Edwards 2000; Lynch, 1991; McKay et al., 2005). Introduction of new genetic lines may also result in the replacement of distinct genetic lines through genetic swamping (Hufford & Mazer, 2003; Lenormand, 2002; Potts et al., 2003). Unfortunately, the “cryptic invasion” of non-local genetic diversity and the associated loss of the locally adapted genes may go undetected until the diversity is irrecoverably lost (Hufford & Mazer, 2003). Therefore, if local or regional provenances are not used for the plantings within the matrix, or even in restoration efforts to rehabilitate degraded habitat, the plantings may ultimately be counterproductive to the goals for the conservation of biodiversity.

Supporting the conservation of biodiversity through the planting of regionally appropriate vegetation does not simply require that native species of local provenance be used. It also requires that the plantings represent as complete a sample of the genetic diversity contained within the local or regional populations as possible. If the plants were grown from seeds or other propagules (e.g. cuttings) from a biased sample of just a few individuals in a limited number of populations, it is likely that much of the genetic diversity within the regional populations of the species will not be represented (McKay et al., 2005). This research was motivated by the need to understand the extent to which the plantings used for reconciliation efforts in the matrix lands reflect a representative sampling of regional populations and to understand how this sampling is done.

Chapter 3 - Methodology

This study used a variety of complementary research approaches, including semi-structured interviews, a survey, and provenance tracing (see Table 1). A variety of approaches were used for several reasons. One of these reasons was that there was no established model or precedent for this type of study so a variety of approaches was deemed worthwhile. This study also dealt with sensitive information which may be considered proprietary by some potential participants; since these individuals were likely to be reluctant to share this information, a variety of means was useful in accumulating sufficient information. Similarly, this study dealt with activities which may be considered illegal under some circumstances. Thus, it was also expected that some potential participants would be reluctant to share information about these

Seed Collector Course	**Semi-Structured Interviews**	**Survey**	**Provenance Study of Planted *Magnolia acuminata***
Representatives of the Forest Gene Conservation of Ontario and the Ontario Tree Seed Plant	Commercial seed collectors	Hobbyist growers of native plants	Various – landowners, conservation professionals, tree/native plant enthusiasts
	Commercial native plant growers		
	Hobbyist growers of native plants		
	Various others, including conservation professionals, landowners, and employees of arboreta		

Table 1 - Participants in Different Parts of Study

activities. Therefore, a variety of complementary approaches was used in case one or more of the approaches proved to be inappropriate or impractical, and to accumulate enough meaningful information to draw useful conclusions.

3.1 Seed Collector Certification Course

The Forest Gene Conservation Association of Ontario, in association with the Ontario Tree Seed Plant, offers a course on tree seed collecting to individuals who are interested in becoming certified tree seed collectors. This course was useful for providing me with an introduction to commercial seed collecting as well as the expectations of the purchasers of tree seeds in Ontario. This course also allowed me to cultivate relationships with those who could help me find commercial collectors in the Carolinian zone.

3.2 Semi-structured Interviews

One of the approaches used in this study was the use of semi-structured interviews with commercial seed collectors and commercial native plant growers. Although formally structured interviews may have provided more standardized data, this style of interview was deemed to be inappropriate for this study. There were several reasons for this preference for a semi-structured interview style. For example, commercial collecting activities, whether by professional collectors or growers, were not well understood before this study. Thus, a semi-structured interview style allowed the investigation of previously unidentified activities as they were revealed by participants. Also, since these interviews were about potentially proprietary and/or illegal activities, it was felt that a relatively informal interview style would be less intimidating and more successful in soliciting information. Finally, it was expected that formal interviews might be logistically difficult to undertake, given the dispersed locations of potential participants and the need to conduct interviews in very informal places. In retrospect, the choice to use semi-structured interviews was appropriate. Given the secretive nature of some of the activities and participants in this study, the use of structured interviews may have resulted in misleading responses and inaccurate findings.

Semi-structured interviews were also conducted with a variety of other individuals, either to provide context for the other parts of this study or to verify or clarify information obtained through other means. These interviews were typically very brief. Participants in these interviews included conservation professionals, employees of arboreta, landowners, and gardeners not participating in the survey parts of this study.

3.2.1 Commercial Seed Collectors

Since commercial seed collectors are an important determinant of the provenance of Carolinian tree species grown by commercial growers, this study included semi-structured interviews with individual seed collectors. These interviews initially attempted to determine whether the collectors collected seed, or other types of propagules, from rare Carolinian species. If the collectors did collect from rare species, they were then asked a variety of questions to determine which species were collected, where such collections were made, how they found these collection sites, and how they accessed these collection sites. In several cases, I was able to accompany the collectors to observe them as they went seed collecting.

Since there are very few commercial seed collectors that collect within the Carolinian zone (Boysen, 2004), it took considerable investigative effort to find a useful sample. Finding commercial collectors began with taking the seed collector certification course. Finding commercial seed collectors also required talking to their customers: tree nurseries and conservation organizations. Finally, I spent a great deal of time simply driving around to areas where seed collectors had been reported during tree seed collecting season. Finding out this kind of information would have been very difficult without my existing connections to the native plant community in the Carolinian zone.

The difficulty in finding commercial seed collectors was complicated by the secretive nature of the profession; commercial seed collectors often go to considerable effort to protect their sources and individual collecting practices are generally considered proprietary (Boysen, 2004, 2006). Assurances that I had no commercial interest in seed collecting and would not divulge detailed information about their seed sources during this study or in any printed articles was essential to gaining the trust of these collectors. Establishing trust with the seed collectors also required patience; many visits were often necessary before enough trust was established so that collectors felt comfortable with sharing their experiences and practices.

Interviews with seed collectors were typically carried out over several days spread out over several weeks. Formal, probing questions were generally counterproductive. Instead, informal discussions were more useful for obtaining useful information. However, no deception was ever used and all seed collectors were informed about the nature of the research.

3.2.2 Commercial Growers

Semi-structured interviews were also undertaken with commercial growers of rare native plant species. Locating these growers was fairly straightforward, and was based on personal knowledge, the results of the surveys, supplier lists provided by conservation organizations, and advertisements. Growers were located throughout the Carolinian zone.

Since these growers often collect their own seed, these interviews involved similar questions to those asked of commercial seed collectors. Since growers also sometimes relied on commercial seed collectors for propagules, questions were also asked about these relationships. Although this study did not focus on production methods or methods of propagation of rare species, some interviews did examine these methods

Like commercial seed collectors, many of the commercial growers had concerns about secrecy. Some of their concerns were about the disclosure of practices which might be considered illegal, such as trespassing or collecting from protected species. Some were also concerned about the disclosure of proprietary information, such as seed sources. As with seed collectors, assurances of complete anonymity were necessary. The development of trust also sometimes took considerable time to develop. However, unlike the interviews with commercial seed collectors, pointed, probing questions were generally acceptable with commercial growers.

3.3 Provenance Survey

This study also included the distribution of surveys to members of various naturalist clubs and other organizations with a focused interest in native plants. The distribution of these surveys was principally at club meetings or other social events, although casual distribution to self-identified native plant enthusiasts and/or gardens was also common. This was not intended to be a truly random sample of hobbyist native plant growers. However, it did represent hobbyists from throughout the Carolinian zone.

Participants in the survey part of this study were asked to provide basic provenance information about 20 rare Carolinian species: 10 species of trees and shrubs and 10 herbaceous species. For each species that they had planted, participants were asked to provide the source of the plants as well as the approximate age of the planting. Finally the survey asked the participant if they are interested participating in a short interview or discussion about their plant collections and seed collecting methods.

Semi-structured interviews were also conducted with participants in the survey part of this study who had indicated a willingness to be interviewed. This interviews focused on many of the same questions as those asked of commercial collectors and growers and allowed a comparison between the activities of commercial and non-commercial collectors.

3.4 Provence Study of Planted Examples of *Magnolia acuminata*

This study included a bio-geographic examination of the provenance and distribution of planted examples of an endangered tree species, *Magnolia acuminata*, in the Carolinian zone. The goal was to collect location and provenance information about planted occurrences of *M. acuminata* from throughout the Carolinian zone in order to get a comprehensive inventory of the planted examples of this species and its relationship to its remnant populations. A website was established seeking reports of planted cucumber trees. This website was useful not only for attracting information from those who had planted or owned specimens of this species, it also attracted enthusiasts who actively sought out and reported planted examples of *M. acuminata* in their regions of southern Ontario. Short overviews about this part of the study were also presented at naturalist and horticultural clubs throughout the Carolinian zone. Flyers were also widely distributed.

This provenance study sought to identify the location where the specimen(s) was planted and where if it was obtained. Generally, the location information was an address. For the purposes of this study, this information was generally sufficient. However, site visits were sometimes necessary to obtain a more accurate location when the original report was too vague. When site visits were made, location information was recorded as street addresses on small properties, or as UTM co-ordinates taken on a handheld GPS receiver for large, rural properties.

This study did not employ a molecular (DNA) approach to the determination of genetic diversity. Although molecular approaches are undoubtedly useful in studying provenance, they do not adequately identify potentially important adaptive variability within a species (Ouborg, Piquot & Van Groenendael, 1999). The information provided by molecular approaches also offers little insight into practices of conservation by non-state actors. For example, understanding the genetic variation within remnant natural populations of a species is of little practical value if most new plantings of the species are by non-professional private landowners using seeds from a biased sample of the population. Such technological techniques are unquestionably important as scientific measures of the effectiveness of conservation efforts. Ultimately, though, decisions about the practice of conservation "are decisions about socially valued environmental conditions" (Robertson & Hull, 2001, p. 974).

3.5 Secrecy and Privacy Concerns

There were significant concerns about secrecy and privacy with this study. Some participants, such as most of the seed collectors and many of the commercial growers, were concerned about the identification of any activities which might be considered illegal, or the disclosure of proprietary information which might provide competitors with an unfair advantage. Some participants, however, particularly among the non-commercial, hobbyist growers, appeared to have few, if any concerns about privacy. Whether participants had overt concerns about privacy or not, given the legal implications of some of the activities studied in this research, significant precautions were necessary to protect the identity of all participants. These precautions were above and beyond those typically used in studies like this.

Because of these privacy concerns, and the relatively small size of the communities studied in this research, no names or identifying locations have been used in this study; even pseudonyms have been avoided. Furthermore, pronouns that would identify the gender of the participant have been avoided; instead, “he/she” has been used. These precautions have been maintained during the research and throughout this document.

The significant challenges created by some of the participants’ concerns about secrecy and privacy cannot be overcome quickly. During this study, these concerns could only be eased with ongoing reassurances of anonymity and progressive relationship building. These efforts were undoubtedly helped by the perception that I was a member of the community of growers and collectors in the Carolinian zone. Had I been viewed simply as a researcher from outside of the networks of growers and collectors, this research may have been much more difficult.

Chapter 4 - Rare Plant Species and the Law

4.1 Introduction

Many of the participants in this study had concerns about the legality of collecting and growing rare species. Despite their concerns, those involved in this study choose to collect and grow rare plant species, included some protected species at risk. Thus, whether these activities are illegal or not, they are worthy of study. However, the legality of these activities is also relevant to this study and has implications for its findings. Accordingly, a determination of the legality of growing rare plant species is necessary. There are also a number of aligned concerns about the legality of growing rare species. For example, does legislation prohibit the collecting of seeds from protected plant species? Is it legal to sell protected species? Does simply owning a protected plant species contravene such legislation? Although the answers to these questions would seem straightforward, even some species-at-risk officials in Ontario are uncertain as to the answers (key informant #36, 2009).

Legislation has been enacted by many jurisdictions to protect those species, including some plant species, deemed most at risk. Although these laws, such as the United States' Endangered Species Act (1973), generally have strong public support and have had a few notable successes, they have also been criticized for being unduly heavy handed, costly, and generally ineffectual (Bean & Rowland, 1997; Tear, Scott, Hayward & Griffith, 1995; Yaffee, 1982). Rosenzweig (2003a) argues that the United States' Endangered Species Act (1973) generally prohibits many forms of reconciliation ecology, such as the collection of seeds from listed plant species. This, he argues, presents significant obstacles to the conservation of rare plant species, particularly in settled landscapes. However, Rosenzweig (2003a) also suggests that such restrictions on the collecting of seeds from protected species are widely ignored.

However, this claim was unsupported. It is important, therefore, to determine if such laws are a deterrent to the conservation of plant species at risk and whether or not they are actually ignored.

4.2 Endangered Species Legislation and the Collection and Planting Rare Plant Species

Both the 2002 Canadian Species at Risk Act (SARA) and the 2007 Ontario Endangered Species Act (ESA) regulate the collection and/or planting of certain listed rare plant species or their propagules. Indeed, the general prohibitions provided by the Canadian Species at Risk Act (2002) appear to unequivocally forbid any unauthorized collection or planting of listed species:

> 32. (1) No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species.
>
> 32.(2) No person shall possess, collect, buy, sell or trade an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species, or any part or derivative of such an individual.

The Ontario Endangered Species Act (2007) provides very similar general prohibitions:

> **9.** (1) No person shall,
> - a) kill, harm, harass, capture or take a living member of a species that is listed on the Species at Risk in Ontario List as an extirpated, endangered or threatened species;
> - b) possess, transport, collect, buy, sell, lease, trade or offer to buy, sell, lease or trade,
>   - i) a living or dead member of a species that is listed on the Species at Risk in Ontario List as an extirpated, endangered or threatened species,
>   - ii) any part of a living or dead member of a species referred to in subclause (i),
>   - iii) anything derived from a living or dead member of a species referred to in subclause (i); or
> - c) sell, lease, trade or offer to sell, lease or trade anything that the person represents to be a thing described in subclause (b) (i), (ii) or (iii). 2007, c. 6, s. 9 (1).

Despite the apparent explicitness of these general prohibitions, neither Act completely outlaws unauthorized growing of protected plant species or the collection of their propagules. Although the general prohibitions of SARA apply to all listed plant species on federal land, they do not generally apply to occurrences of listed planted species on private land unless special orders have been implemented to protect particularly vulnerable occurrences on private land (Environment Canada, 2007). Since the overwhelming majority of rare Carolinian plant species occur on privately-owned land (Klinkenberg, 2002), this apparent inadequacy in SARA would seem to leave many federally-listed Carolinian species at risk vulnerable to exploitation, including the harvesting of seeds and other propagules. However, SARA "may not have considered seed collection for restoration or other purposes when [it] was written" (Risley, 2006).

To address the inadequacies in SARA and the earlier version of the Ontario Endangered Species Act for protecting plant species at risk on private lands, the 2007 update of the ESA provided explicit controls on the growing of listed plant species by private and commercial growers. However, the ESA was also intended to seek a balance between protecting species at risk and promoting economic activity (Endangered Species Act, 2007). Therefore, these controls are far less onerous than is implied by ESA's general prohibitions. The ESA states that growers are permitted to possess, grow and sell provincially protected plant species as long as their possession is reported to the Ontario Ministry of Natural Resources within three months of the species being listed, the plants (or their propagules) were not taken from the "wild" after the species was listed, and they are not planted in the "wild" or in a way that could "compromise the genetic integrity of wild populations" (Endangered Species Act – Ontario Regulation 242/08, 2007).

Although these controls introduce some regulation over the exploitation of remnant populations of protect species on private lands, they present considerable, perhaps even insurmountable, challenges in practice. For example, the term "wild" is not defined. Since "wild" areas are typically defined in opposition to "tamed" areas that have been exploited for private interests (Cronon, 1996; Higgs, 2003), they may simply be seen as being synonymous with conservation reserves or public lands. Thus, in practice, ESA would seem to provide little more regulation over the collection, growing and planting of protected plants for plant species at risk on private lands than SARA. This would be particularly relevant in the Carolinian zone, where most land is privately-owned and most rare plant species and plant species at risk occur on private land (Klinkenberg, 2002).

To overcome this uncertainty in the law, the Ontario Ministry of Natural Resources uses a more precise but potentially problematic interpretation of "wild": wild species are those that are "self-reproducing and not under intensive management" (Stuart, 2008). Although this interpretation would undoubtedly seem to satisfy the apparent intent of the law, it also potentially extends protection where none was presumably intended and may not provide protection where it may be needed. Under this interpretation, a fecund example of a listed species that was planted in a now-neglected garden could be interpreted as "wild." Conversely, a non-reproducing, naturally-occurring example of the same species growing on what is now a lawn might not satisfy the "wild" requirement of the law. This concern over the meaning of "wild" is not merely semantic: ambiguity in the meaning of the term can allow commercial collectors, growers and buyers of protected species, as well as conservation enforcement authorities, to have differing interpretations of what is allowable in practice.

The ability of the ESA to regulate the collecting, growing and planting of plant species at risk is not simply limited by the vagueness of critical parts of its wording. The legislation is also hampered by the necessity to limit access to detailed information about the locations of occurrences of species at risk. This is necessary not only to avoid exploitation of protected species but to protect the privacy of landowners where the species occur (Natural Heritage Information Centre, 2006). Despite this necessity, the legislation assumes that collectors, growers and buyers of listed plant species will have adequate knowledge to ensure that their plantings will not compromise the integrity of wild populations. Thus, by allowing listed plant species to be grown under certain conditions yet restricting access to the information that would allow these conditions to be met, the legislation would seem to be ambiguous about the legality of growing these species.

Even if collectors, growers and buyers of listed plant species at risk had access to the information required to satisfy the restrictions under ESA, their legally-grown plants may not satisfy the intent of the law to protect at-risk plant diversity. For example, if the restrictions on collecting from “wild” examples of a species were followed and commercial growers only propagated protected plant species from “captive” populations or “wild” populations where collection was legal, the number of grown plants might ultimately outnumber the wild examples of the species. As a result, the genetic pool of the “wild” population of the species may be underrepresented in the landscape, increasing the risk of interbreeding between wild and grown populations and potentially compromising the integrity of the wild populations. Thus, even if the conditions of the legislation were met, the intent of the ESA might ultimately be circumvented.

Because of limitations of the Canadian SARA and the inconsistencies and competing goals of Ontario's ESA, there would seem to be few legal restrictions on the collection, growing and sale of listed plant species at risk occurring on privately-owned lands. However, there appears to be considerable confusion about the legality of growing listed plant species. For example, Issacs (2005) highlighted the supposed illegality of planting threatened or endangered tree species in Canada, despite the apparent need to increase the number of individuals of these species. Because of the uncertainty over the legality of planting species at risk, many potential participants in this study either declined to participate or spoke about their collections and practices with great reservation. After the receipt of a letter sent to all commercial growers by the Ministry of Natural Resources in September, 2008, about the implications of the ESA on growers, it became significantly more difficult to enlist participation in this study. Two conservation officials with responsibility for species at risk suggested that this concern and confusion about the legality of collecting and growing listed plant species was helpful in their efforts to protect listed plant species (key informant 1, 2007; key informant 2, 2008). Although there was no evidence to suggest that regulatory agencies encourage confusion about the planting of species at risk, the fear of inadvertently breaking the law seemed to be viewed by some officials as a remedy for perceived inadequacies in the legislation.

4.3 Collecting and Growing Listed Species by Conservation Professionals

Conservation professionals interviewed for this study had differing opinions about the appropriateness of collecting and growing listed plant species at risk. Many within this group, which included employees or contractors of federal and provincial ministries with responsibilities for species at risk, suggested that listed plant species at-risk should generally not be grown unless they are grown in accordance with established recovery plans for the species. Some also expressed reservations about the appropriateness of concerns about the planting of any rare plant species, not just listed species at risk, unless it is done in accordance with a recovery plan. The reasons for this concern varied. Of the 11 professionals with direct and officially-defined responsibility for the conservation of listed species at risk that were asked specifically about the appropriateness of planting these species, all but one generally opposed the unauthorized planting of listed species at risk (see Table 2). Only two of those interviewed expressed concerns that such plantings were inconsistent with either the content or intent of species at risk laws. The most common concerns were that such plantings might introduce non-local provenances and potentially "contaminate" the distinct genetic lines of remnant populations of the species, or that such plantings might be poorly documented and create confusion for future conservation efforts. Several of those interviewed expressed multiple concerns about the planting of plant species at risk.

Concern	Responses	Percentage of Respondents (n=11)
Mixing of distinct genetic lines	4	36%
Concerned about lack of record keeping/confusion for future conservation efforts	4	36%
Waste of money/effort/resources	3	27%
Inconsistent with content/intent of species at risk laws	2	18%
Not generally concerned	1	9%

Table 2 – Concerns of conservation professionals about unauthorized planting of list SAR

Despite the concerns about the planting of listed species at risk expressed by the majority of conservation professionals interviewed for this study, some conservation professionals are, or have been, actively involved in the unauthorized collecting, growing and selling of these species. For example, in other parts of this study, I spoke to five individuals (other than the 11 conservation professionals who were interviewed for their opinions about planting SAR) who worked for, or were under contract to, various conservation agencies and had responsibilities related to the conservation of plant species at risk yet were involved in the sale or distribution of listed planted species for unauthorized plantings. Three commercial tree seed collectors who have had contracts with conservation agencies suggested that they had collected seed from listed species for sale to commercial growers. One of these collectors had previously been contracted by a government agency to collect seed from species at risk for authorized recovery efforts and research. A number of other individuals with direct connections to recognized conservation organizations simply grew listed plant species for their own enjoyment. However, almost all of these individuals were very reluctant to discuss the potential conflict between the official duties and their unregulated activities. Some were openly hostile to discussing it. The one person who was willing to comment simply said, “I guess I should stop selling them” (key informant #7, 2008). Therefore, it was impossible to determine whether those conservation professionals actively involved in the distribution of listed plant species at risk shared some of their colleagues concerns about the activity.

Chapter 5 – Accessing Seed Sources: Comparing the Practices of Commercial Seed Collectors, Commercial Growers, and Non-commercial Collectors

5.1 Introduction

The provenance of a planted specimen is determined by the provenance of the source of seeds (or other types of propagules) from which the plant was grown. However, gaining access to reliably productive seed sources is often a significant challenge for collectors and growers of native species (Allison, 2005). It is even more challenging in the Carolinian zone because most of the land in the region is privately-owned. Although some of the most significant natural areas and richest seed sources in the Carolinian zone are on publicly-owned lands (Jalava, 2000; Kettle, 1999; Larson et al., 1999; Waldron, 2003), the collection of any plant materials, including seeds, from these parks and conservation areas is generally forbidden (Morris, 2005; Ontario Parks, 2006). Consequently, unless seed collectors are willing and able to grow their own seed, they must either obtain permission from either the landowner or area manager to collect seed, find seed sources in public areas where seed collecting is not strictly forbidden, or trespass.

The collectors and growers interviewed for this study used all of these methods to overcome the problems of accessing seed sources. However, not all methods were used by everyone and nobody relied on just one method. There were, however, important differences between different groups of collectors in their preferred methods of overcoming access limitations.

In this chapter, I will detail the results of interviews with commercial seed collectors, commercial growers and non-commercial collectors and growers to compare how each group accesses seed sources. I will begin with an examination of the guidelines provided to commercial collectors of seed in Ontario to determine the implications of these guidelines and to establish a standard with which to compare collecting practices.

5.2 Tree Seed Collecting in Ontario

It is seemingly self-evident that the growing of trees is heavily dependent on the collection of seed. Indeed, despite the widespread application of vegetative propagation techniques for the production of trees in horticulture, the overwhelming majority of trees grown for planting out each year in Ontario are still grown from seed (Noland et al., 2001). However, maintaining an adequate supply of tree seeds to meet the demand in Ontario has become increasingly problematic. A variety of factors, ranging from the global to the very local scale, have combined to threaten this supply.

The global economic recession of the early to mid-1990s created socio-economic conditions that threatened the Ontario tree seed supply. As part of an economic rationalization program in response to this recession, the Ontario government privatized or closed all of its tree seedling nurseries between 1995 and 1998 (Draper et al., 2003; Environmental Commissioner of Ontario, 2003). Despite the loss of these nurseries, the Ontario Tree Seed Plant, the processing, storage and distribution centre for most of the tree seeds collected in Ontario, was retained. However, the sudden loss of most of its market prompted significant reorganization and layoffs within the Seed Plant (key informant #35, 2006). With a much reduced market for tree seed and reduced capacity at the Ontario Tree Seed Plant, many seed collectors were unable to acquire contracts for seed and moved on to different pursuits (Boysen, 2006). Once the privatized nurseries began to increase production and demand for tree seed increased, fewer tree seed collectors were available to provide the seed for the Ontario Tree Seed Plant.

Although the shortage of tree seed collectors would seem to be an easily solved problem, the distinctive culture among seed collectors made this problem quite intractable. Commercial tree seed collectors earn very little money for their efforts: even the most skilled tree seed collectors rarely earn more than $10,000 (CDN) per year from seed collecting (Boysen, 2004). For many seed collectors, the money from seed collecting may represent as much as half of their annual income (Boysen, 2006). Despite the relatively low income typically made through seed collecting, many tree seed collectors are attracted to the occupation by the possibility of earning an income while working seasonally and independently (Boysen, 2006). However, this characteristic independence of seed collectors, combined with the short seed-collecting season and the irregular seed production of most tree species, create significant rivalries between seed collectors and competition for the most productive and reliable seed sources. Many seed collectors go to great efforts to maintain the secrecy of the most reliable seed sources, sometimes even leading potential competitors toward decoy seed sources, only to double-back toward their “secret” sources. Often, even the collectors’ closest relatives do not know these secret locations (Boysen, 2006). Consequently, once a tree seed collector is no longer collecting seed, the knowledge of the most productive and reliable seed sources is effectively lost. Without this knowledge, new seed collectors must often work much harder and travel much further distances in order to earn an adequate income (Boysen, 2006). Often, they simply become discouraged and stop collecting (Boysen, 2006). Thus, in the wake of the disruptions in the Ontario tree nursery industry, the loss of experienced tree seed collectors created a significant reduction in collected seed supply that was very difficult to replace.

Foreign demand for Ontario tree seed further reduced the tree seed supply available for provincial tree production. For example, in 2002, the government of China began a massive reforestation program as part of an effort in western and northern China ("World; in Brief," 2002). Since China was unable to satisfy the demand for trees seeds for this project domestically, they looked to foreign suppliers. Many tree seed collectors in Ontario were approached by agents for the Chinese government and were offered significantly higher prices for their seed than was being paid in Ontario (Boysen, 2004). This ultimately further reduced the supply of seed for tree growers in Ontario, particularly for the recalcitrant seed of many hardwood species.

The rising price of fuel in recent years has also impacted the supply of tree seeds in Ontario and likely changed the provenances from which it was collected. Despite the increased prices for Ontario tree seed being paid by foreign tree growers, the income of most tree seed collectors remained very low. Consequently, tree seed collectors are very sensitive to rising fuel prices (Boysen, 2004). Since the monitoring and collection of tree seed also requires considerable travel, the rising price of fuel since 2000 has forced many seed collectors to travel less widely in search of seeds and often reduced the size of the collections. In speaking to seed collectors for this study, it was apparent that seed collectors had also changed their collecting practices to save fuel, collecting fewer species and from fewer individual trees (key informant #15, 2006; key informant #16, 2007; key informant #17, 2007, 2008; key informant #18, 2007, 2008; key informant #19, 2008). Thus, the increasing price of fuel not only diminished the tree seed supply in Ontario, it potentially reduced both the diversity of species collected and the size and diversity of the genetic pool from the seeds obtained.

5.2.1 Ontario Certified Seed Collector Program

Concerns about maintaining an adequate supply of tree seed in Ontario and the provenances of the collected seed led the Forest Gene Conservation Association of Ontario, in association with the Ontario Ministry of Natural Resources' Tree Seed Plant to introduce a certification program for tree seed collectors in 2002 (Forest Gene Conservation Association, 2002). The program, named "Ontario's Natural Selections," was intended to not only increase the number of seed collectors in Ontario, particularly southern Ontario, but to influence the practices of seed collectors to ensure a higher quality and better documented supply of tree seeds in Ontario. The program's motto, "Seed Source Matters" (Forest Gene Conservation Association, 2006) highlights the program's emphasis on seed provenance and genetic diversity within Ontario's tree seed supply. Since it was expected that most people who took the course were unlikely to become professional seed collectors (Boysen, 2006), the course has been directed to an increasingly large and more diverse audience in the hopes that some day there would be enough seed collectors to meet the industry's need. Although it was originally only offered to those individuals willing to pay the full cost of the course and travel to the Ontario Tree Seed Plant in Angus, Ontario, for up to two days of onsite training, the course is now offered throughout Ontario through sponsored collaborations with a wide variety of naturalist, stewardship and woodlot associations. Although the program has undoubtedly increased the number of trained tree seed collectors in Ontario, it is unclear how much it has increased the collected tree seed supply in Ontario.

As part of this study, I took the tree seed collector's certification course. The purpose for taking this course was to learn how the program's goals were promoted and the ways in which potential seed collectors were taught to collect, as well as to evaluate how these practices might influence the collection and growing of rare tree species.

This course presented conflicting messages about the appropriateness of collecting seed from rare species. On several occasions, participants were told to never collect from rare tree species, although no reasons were offered for why such a prohibition is important. Despite this warning, detailed seed collection information for several rare species was provided in the course materials. One of the course materials supplied to each participant, the Ontario Ministry of Natural Resource's (1996) book "Guidelines for Tree Seed Crop Forecasting and Collecting," included detailed seed collection information for cucumber tree (*Magnolia acuminata* L.), an endangered species then listed under SARA and Ontario's ESA, and hop tree (*Ptelea trifoliata* L.), then listed as a threatened species under SARA. Seed forecasting and collection information was also provided in the field for cucumber tree while examining a planted example of the species. One of the instructors even suggested to the seed collectors that it is sometimes helpful to include seed from some rare trees as an extra bonus for their contractor when they have been contracted directly by a commercial grower. The mixed messages about the appropriateness of collecting seed from rare species ultimately suggested that while provincial authorities would prefer that such seed be left alone, it is a wise business or career move to collect it.

Although the course provided conflicting messages about the appropriateness of collecting seed from rare species, its guidelines for trying "to ensure genetic diversity and a high level of fitness" (Forest Gene Conservation Association et al., 2006) were emphatically and consistently presented. The guidelines for collecting tree seed that were repeatedly emphasized during the course were:

1. Record the location (with as much precision as possible) where the seed was collected and keep the information with the seed lot.
2. Collect seed only from healthy, vigorous trees that have good form
3. Collect only from large stands of the desired species of tree (at least 100 trees of seed-bearing age)
4. Collect from a variety of trees within a stand
5. Collect seed only in good seed years

These guidelines, while consistent with the demands of tree growers for high quality seeds and predictable quality seedlings, would potentially have implications for tree growers, the customers, and the populations of planted trees.

5.2.2 Potential Implications of Tree Seed Collecting Guidelines

Although simplified explanations of biological/genetic and commercial justifications for each of these guidelines were presented during the course, the potential implications of these practices were not examined. While this omission would seem to be quite understandable in such a narrowly focused course, it is useful to examine the potential implications of these guidelines, particularly on the genetic diversity within tree species.

The imperative to record the precise location where the seed was collected is consistent with the need to make informed decisions about matching seed provenance with planting site conditions (see, for example, Hamilton, 2001; McKay et al., 2005). Interestingly, the justification given by the course instructors for requiring provenance information was not based on the widely accepted idea that local seed provenances are best adapted to a range of conditions at the planting site (see, for example, Hamilton, 2001) but on the desire simply to match climatic conditions of the seed source and planting sites. Although the guidelines may be well-intended and justifiable, they may be so problematic in practice that they are of little use or even counterproductive. Indeed, because tree seed collectors in Ontario are generally extremely secretive about their seed sources, many are not only unwillingly to identify their seed sources, they may intentionally mislead the purchaser of the seed. For example, when asked about the source of the seeds that he/she had collected, collectors sometimes responded with an ambiguous answer, such as "where do you want it to be from?" (Boysen, 2004). In order to make the collections appear more varied, seed collectors will also sometimes divide seed collected from a particularly fecund source or area and identify it as being from several different provenances (key informant #15, 2006; key informant #17, 2007; key informant #18, 2007). In order to avoid revealing secret sources or acts of trespass to collect the seed, collectors will also often simply misrepresent the provenances of the seed, often by a significant distance. While one should probably not dismiss a policy or guidelines simply because some people try to wilfully circumvent the guidelines, the labelling requirement of the seed collection guidelines seem to be so widely disregarded that they may actually be counterproductive.

The impact of misidentified seed provenances for the grower or in the final plantings would likely vary widely. Certainly, a large discrepancy between the expected provenance and actual provenance could potentially lead to sub-optimal growth or planting failure (Bussell et al., 2006). This potential impact, particularly for sub-optimal growth, was a concern for several growers interviewed for this study (key informant #6, 2008; key informant #8, 2008; key informant #10, 2008). However, none of the growers interviewed for this study experienced significant failure (defined by winter kill or heat-related mortality) that could be confidently attributed to improperly identified provenance for common tree species native to Ontario grown from seed collected by Ontario seed collectors. Although all of these growers found the mortality of rare species with narrow ecological or climatic niches tended to be higher than for more common species (sometimes much higher), they generally suggested that this was an acceptable risk when growing rare species (key informant #6, 2008; key informant #8, 2008; key informant #10, 2008). Therefore, although improperly identified seed provenances was a concern for growers, acquiring sufficient quantities of good-quality seed was a much greater concern. Thus, there is generally little market pressure for properly source-identified seed.

The genetic implications of growing trees from seed with improperly identified provenances may be much more worrisome than the practical, commercial implications. The greatest genetic concerns would be "cryptic invasions" of non-local genotypes, potentially resulting in outbreeding depression and/or genetic swamping of local genotypes. This concern would be greatest among rare species or genetically distinct populations (Hamilton, 2001). However, such cryptic invasions are potentially worrisome even in the absence of readily apparent influences on the local populations if they are able to lead to a loss of genetic diversity.

The other guidelines may also have important implications for the planted populations of both rare and common species. For example, the guideline to collect seed only from healthy, vigorous trees that have good form, while understandable from a forestry or horticultural perspective, may impose selectivity on seed collection that may not be consistent with the goals of conserving genetic diversity. Certainly the guideline to collect seed only from healthy, vigorous trees would seem to be in the best interest of conservation; the propagation of genetic lines with apparent susceptibility to diseases, pests or environmental stresses would seem to pose potential problems for broader conservation goals. However, determining the health of a potential seed source or the nature of any apparent health problems may be a challenge for many seed collectors. For example, literacy is a problem for many seed collectors (Boysen, 2006). Thus, comparing tree health to written standards is often difficult for these collectors. To avoid this problem, collectors often use their own highly subjective and imprecise criteria to determine tree health. Most of the seed collectors interviewed for this study simply preferred to use seed production as a surrogate measure of the health of a tree; they assumed that unhealthy trees would not produce enough fruit or seed to make it worth their while to collect from them.

The directive to collect only from trees with good form may be more problematic, though. Although the seed collectors' certification course went into considerable detail about what constitutes good form, for trees, good form mostly emphasized straightness and balance. To some extent, this guideline mirrors the traditional (and problematic) practice of "high grading" in resource exploitation industries, such as fishing or forestry, in which the resources with the most desirable characteristics are preferentially harvested, leaving a population or resource pool dominated by individuals with less desirable characteristics. In forestry, this practice of "cutting the best and leaving the rest," often leaves a population of trees with undesirable form to reproduce. However, in seed collection, the guideline to collect from trees with good form is qualitatively different: it allows preferential propagation of the trees with narrowly defined characteristics, effectively "collecting the best and leaving the rest." Thus, trees with other desirable characteristics, those that may be less readily observed as form, may be excluded. This bias for trees with aesthetically pleasing form may be reducing the genetic diversity of species in ways that will have important consequences for the adaptability of the species.

This requirement to collect seed from the trees with good form was embraced by all of the commercial seed collectors interviewed for this study. However, all of them suggested that good form was less important than convenience of collection. The reasons for following this guideline are more complex than simple adherence to its requirements. Indeed, not all seed collectors could recall this guideline. Instead, many of them simply wanted to satisfy their contractors, which for collectors of hardwood tree seeds are generally tree nurseries (Boysen, 2006), by providing seeds that produced attractively shaped seedlings (key informant #15, 2006; key informant #16, 2007; key informant #18, 2007). Some collectors suggested that they collect from the "best trees" (key informant #16, 2007) and felt better about their work when they collected from trees with more aesthetically pleasing forms (key informant #16, 2006; key informant #18, 2007). This desire for trees with good form was also used as a justification for collecting from planted horticultural specimens since these specimens were often already selections with good form and/or in locations in which good form could be most easily assessed (key informant #15, 2006; key informant #16, 2007; key informant #18, 2007). One seed collector, while suggesting that he/she did not "consciously think about the shape of the tree" from which he/she was collecting seed, suggested that his/her preference to collect seed from trees growing from lawns, parks and roadsides "pretty much guaranteed that they were some of the best trees" (key informant #17, 2007). Thus, the emphasis on collecting seed from trees with good form may not only fail to include important provenances, it likely creates a positive feedback loop in which genetic lines may became increasingly narrow because seed collectors preferentially collect from trees that have already been selected for good form.

The guideline to collect only from large stands of trees and to collect from a variety of trees within a stand, although intended to ensure good seed set and, as much as possible, increase the genetic diversity with the collection (Boysen, 2006), was generally not a conscious consideration of the collectors that were interviewed for this study. Indeed, two of the collectors stated that they generally preferred to avoid collecting from large stands because they often found it more difficult to obtain seed from trees with high canopies than from open-grown specimens with relatively low branches (key informant #17, 2007; key informant #18, 2007). However, three of the commercial seed collectors (key informant #15, 2006; key informant #16, 2007; key informant #18, 2007), as well as one of the commercial growers who also collected seed for sale to other growers (key informant #5, 2006), sometimes preferred to collect the seeds of some rare tree species from relatively large stands because these stands often had more reliable seed set than isolated specimens. It is doubtful, though, that these stands were generally as large as the minimum population of 100 trees mentioned in the guideline. This failure to collect from large stands may create a further restriction on the genetic diversity of planted trees.

The final guideline for collecting seed was to collect seed only in good seed years. This guideline's intent was to ensure good quality seed (assuming that years with low productivity will have lower seed quality) and well-filled fruit/cones (Boysen, 2006). Many commercial seed collectors suggested that it was often not worth their time to try and collect from trees with few seeds. However, two seed collectors noted that it was sometimes worth their effort to collect seed from trees with poor seed because this seed would be more valuable to their customers (key informant #16, 2007; key informant #17, 2007). They also stated that some rare species frequently had poor seed set and that waiting for a good year was impractical.

5.3 Commercial Seed Collectors

Among those seed collectors interviewed for this study, there were five commercial seed collectors who were not also commercial growers or nursery owners. All of these seed collectors collected only seeds from woody plants (mostly trees). They all also relied heavily on both trespassing on private property or collecting on public lands, such as provincial or national parks or protected areas managed by regional conservation authorities, where seed collecting is not allowed or strictly regulated. Two of the seed collectors collected seed from their own property, although only for common species (examples given: sugar maple, white pine, northern cedar).

All of the collectors said that they had collected seed from provincial or national parks or conservation areas in the Carolinian zone. Although all of the collectors also admitted that they either knew or suspected that seed collection was not allowed in provincial and national parks, only two stated that they believed that conservation authorities also forbade unauthorized seed collecting on their lands. Two collectors suggested that they “frequently” collected from provincial or national parks and both suggested that their preferred park was Pinery Provincial Park (particularly for *Quercus velutina*, *Quecus prinoides* and *Celtis tenufolia*). Although all of the collectors were noticeably uncomfortable about speaking about their collecting activities in conservation reserves, they all suggested that the most important reasons for collecting from these areas was the ability to find relatively productive seed sources and the ability to access seed from species that were uncommon or rare outside of the reserve. All of the collectors also suggested that collecting in protected areas, particularly provincial or national parks, was a relatively risky and, given the admission fees and the distance to the parks, costly endeavour. Consequently, since productive seed sources for many common species could be found outside of parks, they all suggested that the primary motivation was to access seed from uncommon or rare species. For these "special" species, the cost and the risk of collecting in protected areas were considered worth the reward.

Given the risk of being caught and possibly legally charged for collecting seed in protected areas, it would seem that the reward for collecting seeds from rare species must be relatively substantial. However, although none of the collectors were willing to talk about the prices that they were paid for their seeds, they suggested that they were generally not paid significantly more for the seeds of rare species than for the seeds of more common ones. Indeed, two collectors suggested that the pay for such seeds was not really sufficient to make their collection profitable. They all seemed to suggest, though, that although the monetary rewards of collecting seeds for rare species from protected areas were generally not commensurate with the risks, they found it rewarding in other, often less tangible ways.

Despite the apparent self-serving motivations for collecting in prohibited areas, these seed collectors also appreciated their foundational role within the ecological restoration system and the importance of their activities in facilitating the perceived greater good of planting more trees. Indeed, despite their reservations about speaking about their collecting activities in protected areas, one collector defended their collecting activities by emphasizing the importance of their seed to tree growers and, ultimately, to restoration efforts. This collector also argued that their collections were miniscule relative to the overall number of seeds in the park and that the prohibition on collecting seeds on protected lands was short-sighted. This collector stated:

> The rule [restricting seed collection in the park] is nuts. I'm not doing anything. Even if I take buckets full I'm not making a dent in all the seeds there. Everyone wants to have trees but where they going to get the seed? (key informant #5, 2007).

All of the commercial seed collectors interviewed for this study also admitted to trespassing on private property to collect seeds. Indeed, all but one of these collectors suggested that their collecting activities frequently involved some kind of trespass on private property. However, these collectors generally avoided the use of the term “trespass” to describe these activities. Instead, they used phrases with less legal connotations, such as “onto someone’s land, “back in the bush” or “a little ways off the road,” to describe their collecting activities on private lands that they did not own. Even when later questions about these activities included the term “trespass,” all of them continued to use euphemisms for trespass. Although the reasons underlying their avoidance of this term may simply be to avoid admitting law-breaking, it appeared that most, if not all of them, felt there were significant differences between their activities and criminal trespass. For example, three of the collectors mirrored one of the justifications for collecting in protected areas by suggesting that their collecting activities were serving a greater environmental good and that the seeds would go to “waste” if not collected. Four of the collectors emphasized the speed with which they collected the seeds, seemingly suggesting either that trespass was less problematic if it was brief or that they were simply less likely to get caught if they were expeditious. As one seed collector stated, “I get in there, gather up only what I need, and I’m outta there in no time ... and no problem” (key informant #15, 2007).

Despite their justification for trespassing to collect seeds, these seed collectors generally seemed to go to some effort to avoid being caught by the landowners or their employees. Most of them said that they preferred to collect on weekdays during the working day, when landowners were less likely to be home. If the land where the desirable seed source was located was a working farm, this time was also preferred because it was supposedly easy to determine the landowners location at this time of day (i.e. highly visible farm activities during this time). However, seed collecting is not always best undertaken during workdays: the commercial collectors preferred to collect seed from some types of private property during the evenings or on the weekends. For example, most of the commercial collectors often preferred to collect from commercial or industrial properties during the evening or on weekends. Three of the collectors had also collected seed from the grounds of the Royal Botanical Gardens (RBG) in Hamilton (see Figure 2). When asked what time they preferred to collect seed from the RBG, all said that weekday evenings were best, after most of the Gardens' employees had left. Weekends were also undesirable because of the intensive public use of the area. Even though these seed collectors felt justified in sometimes trespassing to collect seed, all of them seemed to take some precautions against getting caught.

Figure 2 - Seed Collector at RBG (identity obscured)

It is important to note that not all commercial collecting of seed on private property involved trespass. Indeed, even the Royal Botanical Gardens grants permission to some commercial growers to collect seed from their grounds (key informant #9, 2008). Although it has been suggested elsewhere that obtaining permission to collect seed on private lands is both advisable and commonly done by seed collectors (Allison, 2005; FGCA et al., 2006), the commercial collectors interviewed for this study suggested that they generally did not proactively seek permission to collect seed on private property. However, two of the collectors suggested that they believed at least some of the landowners knew that the collectors were collecting seed from plants on their property. One of the collectors also suggested that the lack of censure from the landowner for this activity effectively gave them tacit permission to be on the property. At least one landowner with a productive population of a protected species on their property admitted that he/she knew some collectors were trespassing on their property and suggested that he/she did not mind the trespassing as long as “no damage is done” (key informant #3, 2007). Not all landowners were initially so accepting of seed collectors’ trespassing, though: two collectors stated that they had occasionally been confronted by angry landowners while trespassing. Ultimately, though, the collectors stated that they usually were granted permission to collect seed, although they typically were also required to offer some assurance that no damage would be done to the property or the plants. Several of the commercial seed collectors also stated that they had rarely been asked for remuneration from landowners to collect seed and said that they had never paid to collect seed (key informant #15, 2006; key informant #16, 2007; key informant #18, 2007).

All of the commercial seed collectors stated that, whenever possible, they preferred collection sites which were on public lands other than protected areas where seed collecting was rarely strictly prohibited or where such prohibitions are laxly enforced, such as along roadsides, in municipal cemeteries and in public parks (key informant #5, 2007; key informant #15, 2006; key informant #16, 2007; key informant #17, 2007; key informant #18, 2007). Although it is possible that this preference is the result of the reduced likelihood of being legally charged for collecting seed in these unprotected public areas, none of the collectors offered this as a reason for preferring these areas. Instead, they all stated that they preferred these areas for their convenience of collecting. Both cemeteries and urban/suburban parks generally maintain mowed lawns, allowing easy and efficient collecting of fallen seeds. These areas also frequently have planted examples of rare tree species and, thus, offer convenient access to seed that is otherwise often difficult to access. Roadside seed sources, while not necessarily always offering conveniently mowed grass, are highly favoured because they are easily accessible by vehicle. This ease of access is important not only for collecting the seeds. It is also necessary for scouting for seed sources and for making repeated visits to assess the seeds' readiness for collection. However, field observations of two of these collectors suggested that they may be using a liberal interpretation of a public road allowance. Indeed, their collections along roadsides were often made on the private lands bordering the roadways and, thus, would be more appropriately considered trespassing. One of these collectors justified this blurring of the distinction between public and private property by highlighting the difficulty in collecting from ditch areas along the roadside because of the uneven ground (key informant #17, 2007).

5.4 Commercial Growers and Nursery Owners

Commercial growers and nursery owners share many of the problems of accessing reliable and productive seed sources that commercial seed collectors face. Not surprisingly, therefore, growers often hire commercial seed collectors to satisfy at least part of their seed needs. Large tree nurseries are particularly reliant on commercial seed collectors, whether independent contractors or hired staff (key informant #30, 2006; key informant #31, 2006; key informant #10, 2008).

Smaller scale, specialized "boutique" growers also purchased seed from commercial seed collectors, although much of these smaller growers' seed was obtained through other means. Five of the seven boutique growers interviewed for this study stated that they occasionally purchased seed from collectors. These five growers said that they generally only bought seed from collectors for difficult to access or rare species, for species that were too distant or cost ineffective to collect for themselves, and/or for species for which they did not know any occurrences. Four of these growers also said that they generally only purchased seed from one or two collectors. Interestingly, three of the growers named the same collector as one of their primary sources for seed of several rare species. In general, though, smaller boutique growers appear to overcome the challenges in obtaining the necessary seed by collecting their own seed.

Like commercial seed collectors, some of the boutique growers suggested that they occasionally collected seed from protected areas where seed collecting was prohibited. However, all of the growers were very reluctant to discuss this activity. Two growers did admit to collecting some seed in protected areas: one had collected seed in Point Pelee National Park and another had collected seed from a variety of protected areas, including Point Pelee National Park, Pinery Provincial Park, and several conservation areas (not named). These two growers' motivations for collecting in protected areas were very similar to the motivation of commercial seed collectors for collecting in these areas: to obtain the seeds of rare or hard-to-find plants. Another grower, while extremely reticent about talking about their collecting activities in protected areas, did state that one of the rare species that they grew, *Morus rubra*, was grown from seed that is collected in a protected area and that they had been led to the seed source by a local conservation official. Ultimately, though, given the reluctance of this group to discuss their collecting activities in protected areas, it was impossible to determine the extent to which boutique growers collected seed and other propagules from protected areas.

Like commercial collectors, boutique growers also trespass on private property to collect seed. Indeed, six of the seven growers interviewed stated that they had knowingly trespassed on private land to collect seed and five of them suggested that they continually did this to access important and reliable seed sources. Unlike the commercial collectors, though, none of these growers tried to justify their trespassing with arguments about the importance of their collecting activities. Instead, five of the growers emphasized the small quantity of seed that they collected from any one site and the "ecological insignificance" (key informant #34, 2006) of their collections on the local populations. Like the commercial collectors, the boutique growers preferred to collect from private lands stealthfully: one of these growers described in detail how he/she would quickly approach a seed source, strip a few branches or stalks of seed, "stuff" them in his/her pockets, and leave the site "in under a minute" (key informant #34, 2006). This kind of stealthy and quick form of trespass collecting would seem to be particularly suited to boutique growers because of the relatively small quantities of seed required.

Unlike commercial seed collectors, boutique growers often avoid some of the challenges of accessing reliable seed sources by growing some of their own seed. Indeed, all of the boutique growers in this study harvested at least some of their own seed from their own planted examples of the desired species. Although these growers grew a wide variety of plant species for seed, they all preferentially grew uncommon or rare species or common species for which fecund occurrences were too distant (a subjective term) to easily visit. All of the boutique growers stated that most of their grown seed sources were perennial herbaceous plants. The reason for this preference seemed to be that the growing of perennials for seed made the most efficient use of labour and space: seed sources could be grown relatively easily in a fairly small area, brought to seed bearing age relatively quickly, and would usually continue to produce seed for a number of years. Many perennial species will also increase vegetatively, thereby either increasing the number of seed plants and, thus, the available seeds; maintaining the size of the grower's seed source yet allowing replacement of the original plants; or providing large, higher-value, saleable plants through division. However, the growers did not concentrate solely on the growing of herbaceous perennial plants for seed: four of these growers also grew woody species for seed. This is noteworthy because many woody species, including some of the species grown by these growers for seed, take a considerably longer time to reach seed-bearing age than perennial species. Allocating growing space for some species would appear to be inefficient for a small grower where space is sometimes limited, and business life spans relatively short (key informant #32, 2008). The explanation for this apparent inefficiency is that these boutique growers are not simply business owners; all of them could also be described as native plant enthusiasts or "committed native gardeners" (*sensu* Head & Muir, 2006). Thus, the growers frequently made little distinction between plants grown strictly as seed sources and "garden" plants from their private collections from which seed was sometimes collected. As one grower noted, "As long as it's close and easy [to collect the seeds] … [my plants] couldn't be closer" (key informant #4, 2007).

The boutique growers also purchase seed or seed plants from each other. Two of the growers stated that they often purchased seed of several rare species from one of the other growers. When this was verified, the grower who supplied the seed stated he/she collected this seed both from his/her own plants and from "wild" examples (key informant #5, 2007). Often, however, growers simply purchased plants from other growers and use them as seed sources for more plants. Four of the growers stated that they had obtained at least some of their less common species from other small growers within or near the Carolinian zone. Although such purchases of seed plants appear to be most common early in the business' development, one grower who had been in business for several years suggested that he/she continues to build his/her seed plant collection by purchasing from other regional growers (key informant #7, 2008).

Boutique growers also obtain seed and seed plants in other ways although none of the growers interviewed for this study identified these alternative sources. However, interviews with non-commercial committed native gardeners (see below) suggest that they sometimes supply seed, seed plants, and/or plants to boutique growers. It also appears that boutique growers obtain plants from larger commercial growers. Although none of the boutique growers interviewed in this study stated that they had ever obtained seed or seed plants from large commercial growers, an employee from one large commercial grower stated that their company had sold seedlings of a listed SAR to several small regional growers (key informant #6, 2008). However, it is unknown whether these seedlings were later sold or retained as seed plants.

5.5 Non-commercial Collectors

Not all dedicated growers and distributors of native plant species are attempting to make a profit through their growing activities, yet, as a group, they may have a similar influence on the nature of planted native plant populations. Indeed, many non-commercial, hobbyist native plant gardeners grow their own plants from seed or other propagules (see, for example, Head & Muir 2004, 2006; Zagorski, 2007). However, Head and Muir (2006) identified a particularly dedicated sub-group among native plant gardeners, which they identified as “committed native gardeners,” who were not only more likely to grow their own plants from seed but were also more likely to distribute native plants to their friends and neighbours. Since these committed native gardeners may have a similar influence on the character of planted native plant populations, they were one of the focuses of this study.

Distinguishing committed native gardeners from other enthusiastic native plant gardeners required multiple approaches. Certainly, as a long time native plant enthusiast, and having undertaken previous research on the growing of native plants in this region, I had a list of potential candidates for this part of the study. The survey portion of this study also provided other potential names as did informal discussions with native plant groups and naturalist club members. Not all of the potential candidates could legitimately be described as committed native gardeners. Although many native plant gardeners occasionally grow some of their plants from seed or other forms of propagules, the distribution (“giving away”) of native plants seemed to be a relatively infrequent occurrence. Interestingly, though, many native gardeners suggest that they often or frequently give away propagations (seeds, cuttings or divisions) of their plants, when asked in more detail about the frequency of these distributions, they suggested that they are fairly rare (typically once every year or two and often with periods of several years between distributions). The committed native gardeners selected for this study not only stated that they often or frequently gave away plants, but it could be verified (through some of their recipients) that they had indeed distributed native plants on many occasions and over a number of years.

During this study, six committed native gardeners (perhaps more accurately described as committed hobbyist native plant collectors and growers) who frequently collected their own propagules and grew their own native plants were interviewed using semi-structured interviews to understand where they obtained the seeds and plants for their collections. None of these hobbyist growers generally sold seeds or plants, although at least three of them had unsuccessfully tried to turn their hobbies into businesses and occasionally sold seeds and plants. However, these sales seem to be exceptional and all of these hobbyists stated that they generally gave away plants to those who expressed an interest. Indeed, I was proffered plants, including listed species-at-risk from several of these hobbyists. This practice of giving away seeds and plants even extended to commercial growers: three of these committed collectors stated that they had supplied seed to friends who operated boutique nurseries. These seeds provided to friends were generally considered gifts, rather than sales, although one of these hobbyists stated that he/she accepted money or trade when it was offered in return.

There are some similarities between the practices of this group of non-commercial hobbyists and the commercial collectors and growers. For example, like many commercial growers and seed collectors, these hobbyists face challenges in finding and gaining access to rare species. Like some commercial growers and collectors, these amateur collectors occasionally bought plants and seeds from commercial operations. All of them admitted that that had, at times, trespassed on private and public property to obtain seeds or other propagules. Like boutique growers, they also relied on exchanges with other collectors and growers. Indeed, such exchanges between non-commercial growers seem to be more common than between commercial growers: all of these hobbyist growers suggested that they frequently or occasionally exchanged plants and seeds with other collectors and growers. Since both commercial and non-commercial collectors and growers are interested in a similar “product” from a similar “supply,” it is, perhaps, not surprising that there are similarities in their practices.

There is at least one important qualitative difference between commercial and non-commercial collectors and growers, though: information about where to find and collect plant propagules seems to be much more freely shared between non-commercial growers. Even though several of the non-commercial collectors aspired to earn money from their collections, all of them stated that they often shared detailed information with other interested individuals about where and when to collect plants, seeds and other propagules. Indeed, although seed and plant collecting is generally a solitary activity, all of the committed non-commercial collectors stated that they occasionally took other collectors (both commercial and non-commercial) on informal field trips to share the locations of difficult-to-find and rare species. This willingness to share information that commercial collectors consider proprietary or privileged knowledge seems to be an important characteristic of non-commercial collectors

Given the extensive sharing of information about where to find and collect seeds and other plant propagules among these committed collectors, it was important to determine to what extent new information about potential sources was being established or if the same information was being perpetually reused. For relatively common species, all of the committed hobbyist collectors stated that they generally, but not always, found their own sources. However, two of the committed hobbyist collectors suggested that they would occasionally seek out information from another collector when they had difficulty finding a less common species of interest when they did not know of any occurrences (key informant #20, 2007; key informant #21, 2007). One of the collectors also stated that he/she would also solicit information from another collector when that collector either owned or suggested that he/she had seen a common species with unusual features. However, sharing of information, as well as seeds and plants, seemed to be much more common for rare species. Indeed, only one hobbyist collector stated that most of his/her rare species were from occurrences that he/she had found him/herself (key informant #22, 2007). This collector stated that he/she was particularly proud that he/she had grown almost all of his/her plants from seed or other propagules. The other committed hobbyist collectors stated that most of their rare species were either purchased, given to them by other collectors, or were grown from seed collected from occurrences told to them by other collectors. Furthermore, all but one of these five collectors identified one of the other hobbyist collectors (i.e. key informant #22) as a frequent source for information about source locations. It appears, therefore, that although new seed sources are sometimes identified for rare species, committed collectors seem to be dependent on a fairly narrow base of knowledge about sources.

The sharing of knowledge about seed sources between hobbyist collectors seemed to be much more important for rare species, not simply because their rarity made them more difficult to find but also because their rarity made them more desirable to possess. As one collector stated,

> When I began growing [native plants], all I could really get were the usual ones. I mean, they were all new to me. Then I wanted the specialer (*sic*) ones. I've only got so much room, eh. Anyway, why grow the stuff that everyone else has? Not that I don't like the usual stuff – it's just your tastes change, ya (sic) know, and you want more than the same old. (key informant #20, 2007)

This desire for something special is a common motivation for collectors to seek out information about occurrences of rare species. However, it does not explain why hobbyist collectors are so willing to provide information to other collectors. Indeed, the desire to have something special, distinct from the collections of others, would seem to discourage the sharing of such information: if others have what you have, its distinctiveness may be somewhat diminished. Although the motivations for sharing valuable information with other collectors are undoubtedly complex and vary between individuals, they are likely rooted in the desire to build a form of social capital by engaging in mutually beneficial reciprocity (see Ostrom, 2000; Portes, 1998). Indeed, the apparent expectation of reciprocal benefits was suggested in the determination of who these committed hobbyist collectors would share the most privileged information with: the most valuable information was often only shared with those collectors with a demonstrable level of interest and capacity to provide reciprocal benefits in kind (i.e. of similar interest or rarity). For example, one of the collectors stated that while he/she will gladly share information about where to find most plants with almost anyone who expressed an interest in native species, he/she was unwilling to share some of his/her most propriety information with "dilettantes" (key informant #22, 2007, 2008). For this collector, the determination of who was a dilettante and who was truly a committed collector was not merely a product of the size of the collection of the person seeking information. Rather, it was based more on the collector's determination of the person's knowledge about native plants in general and specifically about regionally native species, such as their proper use of botanical Linnaean binomials (key informant #22, 2008). However, the expectation of reciprocal benefits in kind was never directly enunciated by any of the committed hobbyist collectors. Rather, it was couched in euphemisms, such as whether or not the person seeking information was "going to be friends" (key informant #22, 2008) or whether the collector "was ever going to see them again" (key informant #23, 2007). Thus, although these non-commercial collectors are willing to share information freely to a point, there is an expectation that the sharing of information that is considered valuable (i.e. a rare or hard to find species) is a favour that will be returned in kind some day.

It is likely that the sharing of information, as well as the sharing of plants and propagules, between committed hobbyists may restrict the genetic diversity within their collections. As previously stated, all but one of these committed hobbyist collectors stated that their rare species were either purchased, given to them by other collectors, or grown from seed collected from occurrences told to them by other collectors. From the interviews, there was little apparent commonality in where these committed collectors purchased rare species although they generally emphasized convenience/close proximity and chance in selecting purchases: when they purchased rare species, it was generally from a nearby seller and/or a fortuitous finding rather than an intended purchase of a species that was sought after.

Some of committed hobbyists’ plants were also acquired from propagules or plants given to them by other collectors. However, the networks of committed collectors through which each collector obtained seeds or plants were very small: one collector listed three other collectors from whom he/she had received seeds or plants; three listed two other collectors; one provided the name of only one other collector (see Figure 3). There was no correlation between the number of trades between individuals within the network and the physical distance between them. Thus, it appears that commit hobbyists will travel considerable distance to trade with other committed hobbyists.

One committed hobbyist plays a key role within the network. Indeed, four of the six hobbyists identified one of the other two (key informant #22) as a source of propagules and plants. This common source of seeds and plants was also the committed collector who was the

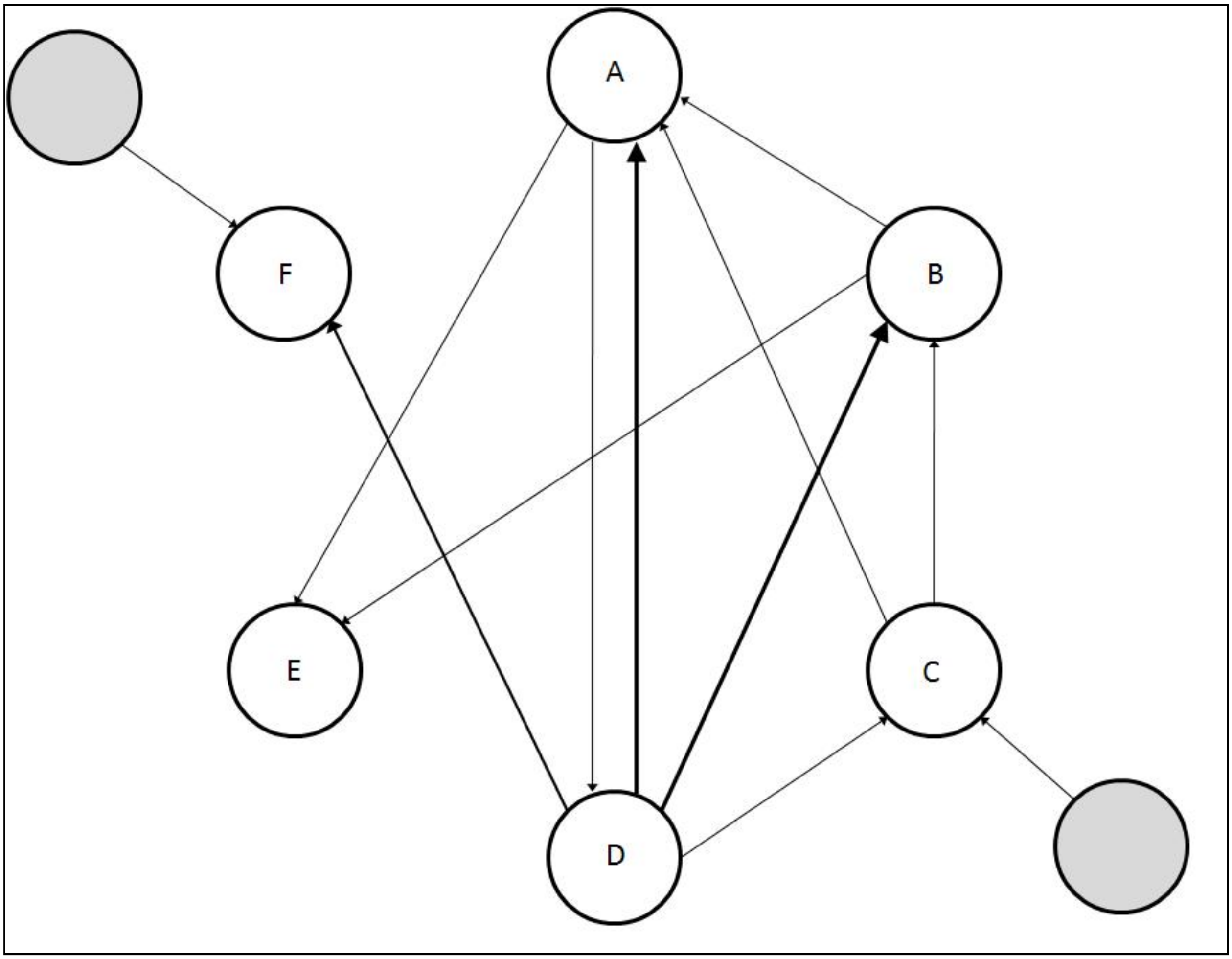

Figure 3 - Trading Between Committed Hobbyist Growers

This figure illustrates trades between committed hobbyist growers who participated in the survey part of this study. Each lettered circle represents a different committed hobbyist grower. The dark circles on the periphery of this figure represent individuals who qualify as committed hobbyists but chose not participate in the survey. The direction of the arrow indicates the direction of trade, from supplier to recipient and the thickness of the arrow indicates the relative number of trades.

most common source of information about where to find seed sources. Consequently, the provenances known by one, very knowledgeable committed hobbyist or the plants collected by him/her are likely disproportionately represented within collections of committed hobbyist growers. Since the planted populations of some rare plant species may rival or occasionally exceed the remnant "natural" populations of some rare species, and since the genetic lines of the native plant “champion’s”[5] plants and seed sources may be disproportionately represented within planted populations, this “champion’s” actions, however generous, may be contributing to loss of genetic diversity within some rare species within the Carolinian zone. At the very least, the apparent disproportionate representation of this champion’s plants and seed sources in the planted population may mean the genetic lines of some rare species may be disproportionately underrepresented in the total population of those species within the Carolinian zone.

5.6 The Native Plant “Champion”

Given the apparent importance of the native plant “champion” in shaping the planted populations of some rare Carolinian plant species, it is useful to examine how he/she determines which plants to collect, how he/she finds these plants, how many plants he/she distributes, and to whom he/she distributes plants. It is also useful to compare the champion to the other committed hobbyist growers.

The champion hobbyist grower (hobbyist “D” in Figure 2) was similar in many ways to the other committed hobbyist growers. All of the hobbyists, including the champion, could be considered amateur native plant growers; neither the committed growers nor the champion were employed in the horticulture or conservation sectors. Like the other growers, the champion had an extensive collection of native species yet grew his/her plants on a relatively modest-sized property, no larger than 0.4 hectare (1 acre). Like the other growers, the champion identified his/herself as both a naturalist and a native plant gardener. They all also

[5] The term “champion” is not used to denote one who has won something but one who distinguishes themselves through the passionate and skilful promotion of a cause.

stated that they "often" or "frequently" gave away plants, including rare species. Thus, the champion was similar in many ways to the other committed growers.

There were also important distinctions between the champion and the other committed growers. For example, the champion had been a grower of native plants the longest: he/she stated that he/she had been an "enthusiastic" grower of native plants for many decades (key informant #22, 2008). Since he/she considered him/herself a pioneering native plant grower, at least in southern Ontario, he/she suggested that he/she felt a responsibility to help promote the use of native plants and the help other enthusiasts acquire satisfying collections: he/she estimates that through his/her lifetime he/she has helped "hundreds or probably thousands" of native plant growers. Many, the champion claims, "got started by me [in growing native plants]" (key informant #22, 2008). When asked how all of these people had learned about him/her, the champion responded, "I guess like you did – through friends, news stories, magazines. I've been at this a long time – people find me. Like that one article said, everyone interested in this eventually makes it to me[6]" (key informant #22, 2008). Therefore, in many ways, this champion considered himself/herself, and was considered by members of the native plant hobbyist community, to be a knowledgeable and respected elder.

The champion also demonstrated a more extensive knowledge of the occurrences of many rare species in southern Ontario than the other committed growers. Indeed, there were only one or two rare species for which the champion could not describe in detail where to find an occurrence. In verifying one of the provenances described by the champion, I found an occurrence that was not even listed by the Natural Heritage Information Centre, the central database for rare species occurrences in Ontario. While other committed native plant growers were generally able to identify occurrences of many rare species, there were many more that

[6] This "article" is an article about searching for a rare *Quercus* species in an Ontario naturalist club newsletter.

they could not identify and many that they could identify by general region. Sometimes the only occurrences that could be identified were horticultural specimens. Indeed, two of the committed hobbyists identified the champion's garden as the only occurrence that they knew of a species. The champion suggested that this detailed knowledge was not only a product of his/her many years of interest in native plants but in his/her intense interest in finding occurrences of rare or "interesting species" (key informant #22, 2008). So focused was this interest that, for many years, family outings and vacations were often centred on looking for these plants. Therefore, through substantial effort and focused attention, he/she gained considerable experience in indentifying occurrences of rare species.

Through his/her extensive experience and knowledge, the champion distinguishes his/herself from other committed hobbyist growers. These less knowledgeable growers seek out the champion in order to locate potential seed sources or, as three of them suggested, in the hope that they would be proffered propagules or plants from the champion's collection. In turn, these committed growers proffer propagules and plants to other native plant growers. Thus the provenance of the champion's collection and the nature of the occurrence (seed source) information the champion gives to other growers is likely an important determinant of the nature of the planted population of some plant species, particularly rare species.

Although the champion is extremely generous in proffering information, plants and propagules to those who sought out his/her assistance, there were restrictions on his/her largesse. For example, the champion states that he/she will often proffer seeds of relatively common yet aesthetically appealing native species to those who visit him/her yet appear to be either beginners or "dilettantes." The champion suggested that if these visitors show sufficient interest to ask where they might find a specimen of a less common species from which they can collect seeds or cuttings to grow, they will be usually be directed toward an easily accessible horticultural specimen. If the visitor shows some knowledge about native species, such as knowing some Linnaean binomials, and state an interest in rare species that have less recognized horticultural attributes, the champion suggested that he/she may offer the seeds of some particularly fecund rare species in his/her collection, such as *Celtis tenuifolia* (status in Canada: threatened) or *Asimina triloba* (status in Ontario: S3). He/she may also offer these individuals directions to remnant examples of rare species, although he/she states that these directions are often intentionally complex, to provide a test of the recipient's interest, determination and skill: "if they can get there, they deserve it" (key informant #22, 2008). However, the most committed native plant enthusiasts, those who have demonstrated extensive knowledge of native species, are granted privileged access to information about the occurrences of very rare species and are often proffered examples of these plants propagated from the champions own collection. Indeed, the champion maintains a small nursery with propagations of his/her most rare species to offer these committed growers; casual visitors are generally not even shown the plants in this small nursery. Although monetary compensation for access to this privileged information and rare plants was generally not expected, the champion stated that there was an expectation of a continuing relationship. Thus, although the champion dispenses his/her knowledge widely and relatively freely, he/she limits his/her generosity.

Since the champion appears to be an important source of rare native plants and information about where to find reliable seed sources of these plants, it is important to understand the nature of this information and the provenances of the plants. As previously noted, the champion appears to have accumulated extensive knowledge of the occurrences of many rare species. He/she does not maintain a database or a written record of occurrences yet is able to recall several occurrences for most species with apparently little effort. However, when asked about which occurrences were told to other growers and collectors, the champion stated that he/she generally offered the same, *relatively* easy-to-find occurrences. Interestingly, the champion had stated that he/she had not previously considered that he/she generally recommended the same occurrences or specimens. When asked why he/she usually suggested the same occurrences, the champion suggested that there is usually just one that is "top of mind" (key informant #22, 2008): one that is so easy to find that he/she knows how to describe how to find it easily. It is also noteworthy that champion stated that conservation efforts to monitor remnant populations through the use of marking devices (such as paint marks or marking tape) made it easy to describe where to find some specimens[7]. The champion also suggested that the proximity to easily described landmarks also made it easier to describe the location of an occurrence. If collectors consistently used the information provided by the champion to collect their own propagules, the continuing use of the same sources would likely lead to the overrepresentation of that provenance in the planted population and, if the remnant "natural" population is very small, in the overall population of that species in the Carolinian zone.

Since the champion distributed propagules (seeds and cuttings) of rare species as well as whole plants, it is important to also understand the provenances of the specimens in his/her collection. The champion stated that the provenance of his/her native Carolinian plant species were an eclectic mix of provenances from throughout the region, although his/her municipality was disproportionately represented, followed by provenances from the neighbouring

[7] One other collector also stated that he/she used conservation marks left on *Morus rubra* (endangered) as a guide to reliably locate a known female as a source of scionwood for grafting onto *Morus alba* or hybrid mulberry rootstock, even though such actions are prohibited under Canada's SARA and Ontario's ESA.

municipalities. When the champion possessed multiple specimens of a species, they were almost always from the same provenance and were collected in the same year. A few native species were purposely grown from seed collected in the United States. American provenances were preferred for species which tend to grow vigorously: the southern provenances were planted preferentially to increase winter dieback and reduce vigour. The champion also possessed an extensive collection of plants that were not considered native in the Carolinian zone. However, the champion strongly believed that some of these species may have been native to the Carolinian zone before European settlement and should be considered native. Therefore, he/she often supplied seed plants from those non-native species that were able to set viable seed in his/her garden to other committed growers, potentially promoting range expansion of these species. Ultimately, though, although the champion possessed a wide variety of species, both native and non-native, collected from many locations, the provenances of most species were limited to just one occurrence and usually just one specimen.

5.6.1 Incorporating Local Knowledge into the Conservation of Rare Species

This study highlighted the knowledge of some non-state actors, such as the champion hobbyist, about the occurrences of rare species. The importance of this kind of local knowledge to the conservation of species at risk has increasingly been recognized. Indeed, both the Canadian Species at Risk Act (2002) and Ontario's Endangered Species Act (2007) require that community and aboriginal knowledge be considered when formulating a conservation or recovery plan for a listed species at risk. Such mandates are undoubtedly driven, at least in part, by recognition of the inadequacies of dominant conservation approaches which rely almost exclusively on scientific and bureaucratic expertise. It is also likely driven by postmodernist beliefs in the plurality of truth and a desire to recognize the interests of traditionally marginalized groups and ways-of-knowing (see, for example, Nazarea, 2006; Robertson & Hull, 2001). The value of such a "post-normal science" approach (Funtowicz & Ravetz, 1991, 1994; Ravetz, 1999) has been previously discussed. However, despite the potential benefits and the legal requirements of a post-normal scientific approach, incorporating it into the formal institutions which are responsible for conservation in Ontario, and which are still largely dominated by science-based, command-and-control cultures, remains problematic. Given the tension created between the mandate to protect species at risk using "the best available scientific knowledge" (Endangered Species Act, 2007, i) and the mandate to incorporate sometimes quite unscientific "community knowledge and aboriginal traditional knowledge" (Endangered Species Act, 2007, p.i), it is, perhaps, understandable that problems would arise.

Although legislation requires that a diversity of types of knowledge must be recognized in conservation efforts for species at risk in Ontario and Canada, not all knowledge appears to be treated equally. In practice, "community" and "indigenous" are often taken to be synonymous, and appear to be currently granted a relatively "privileged position" (Agrawal, 2002, 287) over other contributors of non-expert knowledge about species at risk. In contrast, claims by individuals from non-indigenous groups appear to require a standard of evidence which is little different from the scientific standard; there appears to be an assumption that claims by many individuals must be suspect until validated by an "expert." Although such caution in accepting individual claims is defensible from a scientific perspective, it may be problematic within a post-normal scientific perspective.

Examples of the reluctance to recognize individual claims were noted during this study. For example, the individual described as the "champion" hobbyist in this study has often repeated a claim that *Cercis canadensis* is native to the Niagara Region. The champion hobbyist claims to have seen a stand of very mature examples of *C. canadensis* growing in a woodlot in this region in the 1950s. Although this species, known commonly as Eastern redbud, is very widely planted within the Carolinian zone, its status as a native species has long been considered tenuous. There is only one recognized "natural" occurrence of the species in Canada: a report by a well-known botanist, John Macoun in 1892 of a single, half-dead specimen growing on the southern shore of Pelee Island (Waldron, 2003). A more substantial occurrence on the mainland of southern Ontario could potentially strengthen the case that this species is native, at least in the Niagara Region. However, although the champion's claim appears to be widely known, at least within the native plant community, it has been neither officially recognized nor recorded. Since there is no evidence to support the champion hobbyist's claim, it has been dismissed by conservation professionals.

There is reason to believe that the claim that *Cercis canadensis* occurred naturally within the Niagara Region is plausible. Certainly, the champion hobbyist has proven to be a reliable source of provenance information, although he/she lacks formal credentials to attest to his/her expertise. Furthermore, it is not inconceivable that this species could have occurred naturally in the Niagara region: although this species is not known to occur naturally within the adjacent state of New York, there are disjunct populations of the species across Lake Erie in northeastern Ohio. The presence of *C. canadensis* on Pelee Island certainly suggests that long distance dispersal across larges bodies of water is possible for this species. If Ohio were the source of the reported Niagara occurrence, it may suggest a different provenance for reintroduction efforts than the Michigan or northwestern Ohio provenances often recommended (see Waldron, 2003). Thus, the champion's claim is not only plausible, it may have practical implications.

This is not an argument to dismiss the standards of accepted scientific practice; a plausible claim should almost certainly not be given the same weight as one supported by empirical evidence. Post-normal science is not intended to replace science. However, it is a humble approach which recognizes that many problems are too complex, too pressing and so contentious that the methodical and measured approaches of traditional science are inadequate (Funtowicz & Ravetz, 1991).

A debate over the presence, or not, of an extirpated population of *C. canadensis* in the eastern Carolinian zone would not initially seem to demand the use of a post-normal science approach: it does not seem to be a particularly complex debate and the issue does not seem to be particularly pressing. However, since the use of native species in restoration projects and even urban plantings is increasingly mandated, questions about the historic presence of a species gain increasing importance. Furthermore, since, as suggested by this study, extirpated populations may have planted legacies, the potential that such a population may have existed also becomes increasingly important. Ultimately, it may be possible to scientifically determine if such a population may have existed and whether any legacies remain. Of course, by then, the legacies may have been lost. Thus, the importance of the issue and the need to take actions expeditiously would seem to favour a post-normal approach.

The incorporation of post-normal science into conservation efforts for species at risk also appears to be problematic because of bureaucratic reporting barriers. Ontario's Natural Heritage Information Centre has an on-line reporting form which is available to everyone; submissions may be made by either conservation professionals or non-professionals. However, the reporting forms require that the person making the submission provide their name and contact information. As suggested in this study, this requirement may be problematic if the occurrence was identified while trespassing. Furthermore, information about known occurrences is restricted. Such restrictions are undoubtedly necessary, but they appear to create a disincentive for reporting. The lack of reciprocity in the sharing of information would seem to be one potential disincentive. The inability of those making reports to verify if the occurrence that they have identified is already known would also seem to be a disincentive for reporting; it is possible that someone might not go to the bother of reporting an occurrence if they suspected that the occurrence was already known.

5.7 Collecting from Marked Specimens of Rare Species

Two hobbyist collectors mentioned that their searches for propagules of rare species were sometimes aided by the presence of flashes of paint or florescent marking tape on specimens. The marking of these specimens appears to be intended to aide conservation managers in monitoring them. For example, almost all of the individuals within a dispersed population of *Morus rubra*, commonly known as red mulberry, in Hamilton, Ontario, were marked with florescent marking tape (see Figure 4), although only one easily accessible specimen was mentioned by a collector as a source for propagation materials. Indeed, during the course of this study, the marking tape on several of the specimens, including the collector's source tree, appears to have been replaced. Although this marking of specimens undoubtedly helped conservation managers, it also helped collectors to initially find these potential sources, return to them in subsequent visits, and, if desired, share easily-understood locating instructions to others. The presence of such markings, particularly fluorescent marking tape on a tree that is not off of an established trail, would undoubtedly draw the attention of even inexperienced collectors. Thus, if the goal of this practice is to aide in the protection and effective management of a species at risk, it may be counterproductive. For collectors, it appears to be unexpected help.

Figure 4 - Marked *Morus rubra*

It is generally fairly simple to find course-scale occurrence information about many rare species. For example, information about the general location of the *Morus rubra* population in Hamilton was available from a local naturalist club's natural areas inventory, available at the local library or through the club. It is also available online in the unrestricted files of Ontario's Natural Heritage Information Centre. However, without expert help, finding specific examples of a rare species in a fairly large natural area can be much more challenging. The use of marking tape makes finding specimens much less difficult.

The specimen of *M. rubra* mentioned by a committed hobbyist collector was easily visible from the Bruce Trail along the escarpment in Hamilton. Although the committed hobbyist that stated that this was the source of one of the two examples of *M. rubra* in his/her garden, he/she did not appear to collect from there anymore; although he/she still propagates red mulberries to give away, they are grown from seed or propagated by grafting using materials from his/her specimens. However, it does appear that this original source is still being used by others. In late winter, 2008, I noted that the only low hanging branch from this tree had recently been trimmed. The trimmed branch was found nearby on the snow. Much of the previous year's growth had been removed. Since one year old growth is collected in the late winter for scions used in grafting or, sometimes, for hardwood cuttings, it is likely that this tree had once again been used to propagate this protected species. Since a government SAR biologist associated with the conservation of this species confirmed that no authorized collecting had been undertaken at this time, it is quite likely that it was either a commercial or hobbyist collector or grower (key informant #28, 2008).

A hobbyist collector from southwestern Ontario also stated that he/she was aided by the use of marking tape when looking for *Celtis tenufolia* (key informant #29, 2008). In this instance, though, the tape helped identify examples of this species-at-risk to a group of individuals during a naturalist club outing.

Since marked examples of species at risk near trails may be accessed by collectors more often than unmarked examples or less accessible marked examples, the practice of marking trees may be inadvertently narrowing the genetic diversity within planted populations of species-at-risk in the Carolinian zone and elsewhere.

Chapter 6 - A Study of the Provenances of Planted Examples of *Magnolia acuminata*

Magnolia acuminata, commonly called the cucumber tree, is perhaps one of the most high profile rare Carolinian plants. This renown is undoubtedly partly the result of its novelty as the only member of this genus that is native to Canada (Ambrose & Kirk, 2007; Farrar, 1995). However, this species has also had a long status as an endangered species in Canada: it has been listed nationally as an endangered since 1984 (Ambrose & Kirk, 2007). Because of the southern associations and exotic connotations of magnolias and this species' recognized rarity in Canada, *M. acuminata* has been widely viewed as symbolic of the special nature of the Carolinian zone (see, for example, Beresford-Kroeger, 2003; Reid, 1985; Waldron, 2003). While it would be unseemly to refute the deservedness of *M. acuminata*'s notoriety, its high profile is, perhaps, unexpected. For example, it is not an intrinsically rare species: although its distribution is extremely restricted within Canada, like many Carolinian plants, it is a widespread species in the United States that is relatively common throughout much of its range. Furthermore, although it belongs to a genus that is renowned for its handsome flowers, the flowers of *M. acuminata* are neither conspicuous nor precocious (Ambrose & Kirk, 2007). Also, since this species can become quite tall, the flowers are not easily appreciated. Similarly, its foliage, while tropical in appearance, is best described as "coarse" textured (Dirr, 1998). Thus, while *M. acuminata* is unquestionably a high profile rare Carolinian species, its fame among growers of Carolinian plants may seem somewhat surprising.

Given the high profile of *M. acuminata*, its apparent lack of horticultural appeal (large size, large but inconspicuous flowers, and coarse foliage), and the relatively few native occurrences in Canada[8], this species seemed to offer a manageable opportunity to undertake a comprehensive study of the provenances and distribution of planted examples of a rare

[8] 283 trees and saplings (Ambrose & Kirk, 2007)

Carolinian species. However, it quickly became apparent during this study that given the limitations in resources for this study, planted examples of *M. acuminata* are far too common in southern Ontario to undertake such a comprehensive study. Although most of the planted examples of *M. acuminata* that are growing in southern Ontario appear to have been planted since the species was listed as a SAR in 1984 (i.e. less than 25 years old), there are many planted examples that are quite large and apparently older than 25 years. One very large specimen in Dundas, Ontario, was reportedly planted sometime in the 1850s (key informant #9, 2008) and had been a source of seed for a number of mature specimens, including at least 5 examples in a large public arboretum (key informant #9, 2008). Unfortunately, the provenance of this tree and the majority of the planted *M. acuminata* was very difficult to determine and would likely require molecular studies. Despite the difficulties in undertaking a detailed study of planted examples of *M. acuminata* in the Carolinian zone, some useful information was gathered.

For example, the number of planted examples of *M. acuminata* in the Carolinian zone may exceed the native population of the species in the region. Before ending the preliminary stage of the *M. acuminata* study, 184 horticultural (i.e. not naturally occurring) examples of this species were identified. This limited sample, taken from a relatively small area within the Carolinian zone, is equivalent to approximately 65% of the known population of native *M. acuminata* in Canada identified by Ambrose and Kirk (2007). Therefore, it is quite possible that a more comprehensive study will find that the planted population exceeds the presumed naturally occurring population.

Although it was very difficult to determine the provenance of many of the 184 cucumber trees in this study, there are strong reasons to believe that they represent a limited number of provenances. From those horticultural specimens of *M. acuminata* for which relatively precise provenance was known (n= 39) and from the seed sources of the principle suppliers of cucumber trees in or near the Carolinian zone, it is possible to get an indication of the dominant provenances within the planted population of this species in this region. For example, eight planted examples were known to come from a single commercial grower who does not typically publicize their sale of this species. Unfortunately, this grower would not reveal their seed source. However, it was reported from three unrelated sources that this grower collects all or almost all of their cucumber tree seed from a single, well known and easily accessible tree (key informant #18, 2008; key informant #27, 2008; key informant #28, 2008). Furthermore, two of the other seven confirmed commercial vendors of cucumber trees in or near the Carolinian zone reported that they purchased their supply of cucumber trees from this grower (key informant #7, 2008; key informant #8, 2008). The seed tree used by this grower is also the source for seed used by an avid hobbyist who focuses almost exclusively on growing *M. acuminata*. This hobbyist collects seed only from this tree and distributes his/her trees widely through both sales and gifts (key informant #11, 2007). Although this hobbyist grows dozens of seedlings at any one time, production appears to be sporadic. This grower estimates that he/she has given away or sold "hundreds" of cucumber trees (key informant #11). However, of the 184 *M. acuminata* identified in this study, only three were identified as being grown by this hobbyist. It is evident, though, that this single, fecund tree is the seed source for many planted examples of this species in the Carolinian zone.

Other seed sources appear to be heavily represented among planted cucumber trees. Three of the cucumber trees reported in this study came from a well-established native tree nursery. Although the owner of this "boutique" nursery does not list *M. acuminata* or cucumber trees in his/her catalogue, he/she did state that he/she frequently offered this species for sale. The seed source for these trees was a well-known planted specimen (not the previously discussed specimen). Interestingly, though, the nursery owner suggested that it had recently become difficult to obtain seed because other collectors had also begun collecting seeds from this tree. Similarly, there appears to be competition for seeds from the offspring of the Dundas specimen (previously discussed) that were growing in an arboretum. Both a large commercial tree grower (key informant #12, 2006) and another avid hobbyist grower of native trees (key informant #13, 2006) stated that they collect seed from these trees. This hobbyist also stated that for many years there was little or no seed available because the previously observed fruit (not simply the seed) appears to have been already collected[9].

These three popular seed sources for *M. acuminata* all share characteristics that are favoured by seed collectors: easy access, reliable seed set and fecundity, and clean surrounding ground/mowed lawn.

Figure 5 – Imported *Magnolia acuminata* Saplings

The planted population of *M. acuminata* in the Carolinian zone and, quite likely, southern Ontario, does not simply appear to represent a biased sampling of the native occurrences of the species. At least some, and perhaps many, of the planted examples of this species in the Carolinian zone are from non-Carolinian seed sources. Indeed, 100 of the 184 horticultural specimens of *M. acuminata* were saplings imported from a nursery in the United States from

[9] One of the primary natural means of seed dispersal for *M. acuminata* is birds (Ambrose and Kirk, 2007; Callaway, 1994; Stiles, 1980). Furthermore, seed set on *M. acuminata* is often very low (McDaniel, 1963). Therefore, the absence of seeds in the fall does not necessarily indicate prior collection.

seed collected in West Virginia (see Figure 5). Despite the southern provenance, observations of two of these saplings planted in an exposed location with a Natural Resources Canada (2000) hardiness zone 5b rating over one winter suggest that they are apparently hardy in southern Ontario. During this study two other commercial nurseries in the Carolinian zone also stated that they imported *M. acuminata* seed from the United States. Furthermore, several of the *M. acuminata* growing within the Carolinian zone that were identified in this study as popular seed sources may be of non-Carolinian provenances (Ambrose, 2007; Ambrose & Aboud, 1984). Even the previously mentioned Dundas specimen, from which several currently popular seed sources were grown, was likely not of Carolinian provenance (key informant #14, 2005). Thus, this study would suggest that many planted *M. acuminata* in the Carolinian zone may be of non-native provenance.

Although it was not possible to obtain detailed provenance information about the planted population of *M. acuminata* within the Carolinian zone, some meaningful insights were provided. The number of planted specimens of *M. acuminata* may rivall or exceed the total number of individuals within the remnant populations. Also, given the preference of current seed collectors to concentrate their collecting activities on a very limited number of specimens, it is likely that the planted *M. acuminata* grown from seed collected within the region represents a biased sampling of the remnant populations. Furthermore, it appears that at least some, and perhaps many, of the planted specimens are from non-Carolinian provenances. Therefore, the genetic diversity within the relatively large population of planted examples of *M. acuminata* within the Carolinian zone is likely quite different than within remnant populations.

Chapter 7 - Carolinian Rare Plant Provenance Survey

7.1 Introduction

This study also included a survey that asked potential respondents about the provenances of planted examples of 20 rare Carolinian plant species, including 10 woody species (trees and shrubs) and 10 herbaceous species (see Table 3). The Ontario Natural Heritage Information Centre (NHIC) identifies more than 400 species that occur within the Carolinian zone as provincially rare (Jalava, 2000). Therefore, the list of species in this survey represents just a small fraction of the rare species within the region. However, this list is not simply a random selection from the potential candidate species; the species in the survey were selected based on a number of criteria. For example, all of the species had to be ranked by the NHIC with a sub-national conservation ranking of at least S3: S3 is defined by the Ontario Ministry of Natural Resources (2007) as a species in Ontario which is “at moderate risk of extinction due to restricted range, relatively few populations (often 80 or fewer), recent widespread declines, or other factors” (p. 20). Sub-national conservation ratings of S2 or S1 represent higher risks of extinction, fewer populations, more widespread decline or other increased risk factors compared to S3 species. The species in this survey also had to be Carolinian species, with known natural occurrences (i.e. occurrences identified on the NHIC database) either restricted to or largely occurring within the Carolinian zone. Half of the species were to be woody species, and the other half, herbaceous species. Approximately half of the species should be listed species under SARA. Finally, each of the species must either have been identified in the earlier study (see Morris, 2005) or through first-hand experience as being cultivated regionally. Although this list was not intended to be comprehensive, it was meant to provide a meaningful understanding of the provenances of planted examples of rare

Botanical Name	**Common Name**	**Exclusiveness as Carolinian**	**Subnational (S) Rank**	**Listing under SARA**
Woody Species				
Asimina triloba	Pawpaw	restricted	S3	
Carya glabra	Sweet Pignut Hickory	restricted	S3	
Castanea dentata	American Chestnut	restricted	S2	**END**
Celtis tenuifolia	Dwarf Hackberry	largely	S2	**THR**
Euonymus atropurpurea	Burning Bush	largely	S3	
Magnolia acuminata	Cucumber Tree	restricted	S2	**END**
Morus rubra	Red Mulberry	restricted	S2	**END**
Nyssa sylvatica	Black Gum	restricted	S3	
Ptelea trifoliata	Common Hoptree	restricted	S3	**THR**
Quercus prinoides	Dwarf Chinquapin Oak	restricted	S2	
Herbaceous Species				
Arisaema dracontium	Green Dragon	largely	S3	**SC**
Asclepias purpurascens	Purple Milkweed	restricted	S2	
Frasera caroliniensis	American Columbo	restricted	S2	**END**
Hypoxis hirsuta	E.Yellow Star-grass	largely	S3	
Lespedeza virginica	Slender Bush-clover	restricted	S1	**END**
Lupinus perennis	Wild Lupine	largely	S3	
Mertensia virginica	Virginia Bluebells	largely	S3	
Pycnanthemum incanum	Hoary Mountain-mint	restricted	S1	**END**
Stylophorum diphyllum	Wood-poppy	restricted	S1	**END**
Viola pedata	Bird's-foot Violet	restricted	S1	**END**

Table 3 – Species in Survey
This table lists the species included in the survey distributed to native plant hobbyists. It lists the species' botanical name (Linnaean binomial); its common name; whether the species' range is restricted to the Carolinian zone in Canada or its occurrences are largely within the Carolinian zone; the species' S Rank, as ranked by the NHIC, which is a reflection of its relative abundance within Ontario; and the species' listing under the Species at Risk Act, if any (END – Endangered, THR – Threatened, SC – Special Concern)

species in the Carolinian zone.

This survey was not intended to use a truly random sample. Rather, survey questionnaires (see Appendix) were distributed at meetings of naturalist clubs and gardening/horticultural clubs, as well as to individuals who I met through previous research and other parts of this study. A total of 231 questionnaires were given out and 55 completed questionnaires were returned, representing a return rate of 23.4%. This return rate is relatively high and undoubtedly reflects the targeted nature of this study. It is important to note that the choice not to participate in this survey does not necessarily mean that the individual does not grow any of the species listed in the survey. Indeed, quite a few potential participants who suggested that they had grown one or more of the species listed in this study or were known to be avid native gardeners chose not to accept the questionnaire. Although no explanation for refusal was ever solicited, several suggested that they either did not remember where they obtained their plants or did not wish to disclose information about their plants.

This survey asked potential respondents to identify the provenances and ages of any or all of 20 rare Carolinian plant species that they had grown (see Table 2). To qualify as "rare," each species had to be ranked by the Ontario Ministry of Natural Resource's Natural Heritage Information Centre as at least S3, a provincial or sub-national abundance ranking identifying the species as rare to uncommon, with between 20 to 100 known occurrences in the province (Natural Heritage Information Centre, 2006). Of the 20 species in this study, seven were ranked as S3 yet not listed under SARA or Ontario's ESA; one species was ranked as S3 and was also listed as Threatened under SARA and ESA. One species was ranked as S2 yet not listed under SARA or ESA. All of the other species in this study were ranked as either S1 or S2 and were listed as either Endangered, Threatened or Special Concern under SARA and ESA. Seven of the species in this species are listed as Endangered under SARA and ESA. Thus, this study examined species with varying levels of rarity. The choice of species was also informed by the results of Morris (2005) and included only those species which, in my experience, have been cultivated by at least one person in or near the Carolinian zone.

More occurrences of rare woody species were reported than rare herbaceous species in this study. However, this result does not necessarily mean that there were more occurrences of rare woody species (155) than occurrences of herbaceous species (74) since each occurrence may represent several individual specimens. The questionnaire used in this study focused on the provenance and did not specifically ask how many specimens of each species were owned or had been planted. The only indication that multiple specimens were owned or had been planted would be if multiple provenances for a species were reported. Nevertheless, these findings seem noteworthy, particularly since an earlier study (see Morris, 2005) showed a similar disproportionate representation of woody species. Since trees and shrubs typically take up more room than herbaceous, one might expect woody species to occur in smaller numbers than herbaceous plants in a garden or residential yard. Thus, these results may seem counterintuitive.

There are several possible explanations for the overrepresentation of woody plants in this survey. For example, Head and Muir (2006) found that most native plant gardeners grow a combination of native and exotic species and tend to focus on native trees rather than native understory plants. This emphasis may be because trees and shrubs are important structural elements within a garden that play a central role in providing a garden with a “native” character (Hightshoe, 1984; Simmons & Starke, 2006; Sternberg & Wilson, 1995). Since there are far fewer species of trees and shrubs within the Carolinian zone than herbaceous species (Morris, 2005; Waldron, 2003), there are also fewer choices of native trees than native herbaceous species for the native gardener; a gardener seeking a truly distinctive species may be more likely to select a rare tree than a rare plant. The overrepresentation of rare woody species in this study may also simply be a reflection of the greater longevity of most woody species. Indeed, the average age of the occurrences of herbaceous plants in this study (8.9 years) was lower than the average age of the woody species (13.1 years).

The survey does suggest that planted examples of some rare Carolinian plants may represent a restricted number of sources. Among woody species, 11.6% of occurrences with identified sources came from a well-established commercial "boutique" grower, and 16.8% of occurrences were from one committed hobby grower and collector, identified in this study as the "champion hobbyist." Together, these two sources provided 28.4% of the planted rare woody species. No sources dominated the herbaceous species, although the champion hobbyist grower was the source of all three of the occurrences (one of which was reported as having died) of *Lespedeza virginica* (slender bush clover) and four out of five occurrences of *Asclepias purpurascens* (purple milkweed).

Although the six committed hobbyist growers interviewed for this study all stated that they often or frequently gave away specimens of rare Carolinian plants, only the champion hobbyist grower was explicitly identified in this survey as the source of a specimen. To some extent, this finding is surprising because it was verified by some of their recipients that they had all distributed native plants. However, although these recipients were willing to verify that they had indeed received specimens of specific rare species, none of them chose to complete the survey. This highlights an important limitation in the use of voluntary surveys when dealing with such a potentially sensitive subject.

There was a significant difference between the percentage of woody species grown from collected seed or other propagules (35.5%) and the percentage of herbaceous species grown from collected seed or other propagules (16.2%). These percentages reflect the specimens or occurrences grown from propagules collected from sources that are believed to be either naturally occurring specimens or planted specimens; they do not include specimens or occurrences grown from propagules given by another grower or collector. If known or suspected horticultural sources are excluded, thus leaving sources that are believed to be either naturally occurring specimens or planted specimens, the percentage drops to 30.3% for woody species and remains unchanged for herbaceous species. The reason for the higher percentage for woody species may simply reflect the more predictable dehiscence of seed from woody species and the larger seed of many woody species. Although the seed of most temperate species of trees and shrubs ripens in the late summer or early fall, the seed of different temperate herbaceous species often ripens at quite different rates (Willson & Traveset, 2000). Furthermore, while the mature seed of many woody species may persist on the plant for some time, the seed of herbaceous species may be difficult to find and collect once dehiscence has occurred. Because of this, many commercial growers and collectors, as well as many hobbyists, suggested that it was usually easier to collect the seeds of trees and shrubs than those of herbaceous species, unless the herbaceous species was relatively common.

Since there are important differences between the species listed in this survey, it is useful to examine each one individually. The species will be examined as they appeared on the questionnaire, separated into groups of woody species and herbaceous species, with individual species listed alphabetically within each group by their botanical name/Linnaean binomial.

7.2 Trees and Shrubs/Woody Species

7.2.1 *Asimina triloba*

Asimina triloba, or pawpaw (see Figure 6), is a rare (S3), deciduous, small tree or large shrub that is restricted to the Carolinian zone[10]. As the most northerly-occurring member of the neotropical custard apple family (Annonacaea), it is fairly well-known for its tropical appearance and its very sweet tasting and aromatic fruit[11]. This species' occurrence at the northern edges of its range has been a bio-geographic curiosity: it appears to be an anachronistic species whose pre-European settlement distribution in the northern reaches of its range appears to be largely or wholly the result of anthropogenic introductions by First Nations peoples (Galbraith, 2003; Keener & Kuhns, 1997). Indeed, humans may be the current primary dispersal agent for this species; a well known "natural" occurrence in the Niagara Region of Ontario is supposed coincidental with a campsite of the invading American army during the War of 1812 (Lamb, 2008). Because of its existing intimate relationship with humans in this region, this species was chosen for this study.

Figure 6 – Planted Specimen of *Asimina triloba*

This species was one of the most commonly planted rare species in this study: 26 of the 55 respondents listed provenances for *A. triloba*. This is equivalent to 51% of the 51 known

[10] Range information for all species in the provenance study is determined from known occurrences as listed on the Natural Heritage Information Centre database.
[11] I have found the Carolinian provenances to have a rather "gamey," turpentine-like taste that is more novel than appealing.

“natural” occurrences in Canada (Natural Heritage Information Centre), although these planted occurrences likely include far fewer individuals than the natural occurrences. The average age of the occurrences was 13.6 ± 9.3 years. Most of the respondents listed just one source for their examples of *A. triloba*, although three respondents listed two different sources. The sources were varied, with seven “wild” sources listed (including one by a respondent who listed two sources), including one source in Virginia. There was no duplication of sources for these plants grown from propagules collected from “natural” populations.

Although the planted specimens of *A. triloba* grown from propagules collected from “natural” populations appear to be diverse, there appears to be much less diversity among the other occurrences in this sample. The source of one occurrence is another respondent’s occurrence grown from seed collected in southwestern Ontario. Two respondents have purchased their examples of *A. triloba* from the same boutique grower. However, the most common source for *A. triloba* in this study was the champion committed hobbyist grower: nine of the 26 (34.6%) respondents who grew this species (including two respondents with two different sources) cited this hobbyist as the source of their occurrences. Since the champion grew his/her examples of *A. triloba* from a single, nearby “natural” population, this population’s genetic lines are likely over-represented in the planted population.

It is also quite possible, even likely, that the genetic lines of the champion hobbyist’s examples of *A. triloba* are even more overrepresented among the planted examples of this species in southern Ontario than is reflected in this study. The champion distributes fruit collected from his/her specimens to many of the native plant enthusiasts who seek out his/her advice. Furthermore, four of the other five committed hobbyist growers interviewed for this study obtained their *A. triloba* from the champion hobbyist, although one also has *A. triloba* grown from seed collected from a “natural” population other than the one from which the champion obtained propagules. These champions all distribute specimens of *A. triloba* to other people, increasing the presence of the champion’s provenance among planted *A. triloba*.

Although the champion’s provenance appears to be currently overrepresented among planted examples of *A. triloba,* this is likely to change dramatically. Since this survey was completed, at least two major tree sellers in southern Ontario have begun to sell this species. One of these suppliers is a major mail-order seller of horticultural plants and seeds with mass distribution of their catalogues. This represents a notable change for the distribution of this species in Ontario. This species has traditionally been difficult to grow commercially because of its long taproot and slow growth: transplanting “saleable” sized young tree is very difficult and expensive. Now that *A. triloba* is being grown in apparently large quantities for sale in the southern Ontario, the “champion’s” provenance may become less dominant. However, as previously discussed, the practices of commercial seed collectors and growers may introduce a different yet similarly limited dominant provenance.

7.2.2 *Carya glabra*

Carya glabra, or (sweet) pignut hickory, is a rare (S3) tree species whose distribution in Canada is restricted to the eastern end of the Carolinian zone. There has been ongoing debate over the taxonomic relationship between *C. glabra* and *C. ovalis* [syn. *C. glabra* var. *odorata* (Marsh.)] (see, for example, Little, 1969; Smalley, 1990) and which species or subspecies occurs in southern Ontario (Hosie, 1969; Farrar, 2003; Waldron, 2003). Although this study did not intend to resolve these disputes, they did present a potential source of confusion for knowledgeable potential respondents. However, since Ontario’s Natural

Heritage Information Centre (NHIC) and the currently most widely used field guides on Canadian trees treat the two as conspecific, the questionnaire simply listed "*Carya glabra*" along with one of the most widely used common names, "sweet pignut hickory."

It should be noted that most sources, including the Natural Heritage Information Centre, appear to question the occurrence in Ontario of any varieties of this species other than var. *odorata.* However, during this study, a planted specimen, reportedly from a "natural" source in Niagara Region, was observed that was more typical of *C. glabra* var. *glabra* than var. *odorata*. A similar example was noted in Niagara that appeared to be "naturally" occurring. At the very least, it does suggest that the morphological complexity that appears to characterize this species is reflected in the occurrences within Canada.

The examples of *C. glabra* reported in this survey were, as a group, rather different from the other species in the survey in that they all appear to be grown from propagules collected from known natural occurrences. There were relatively few occurrences listed (n=8, 14.8% of respondents) and the average age, 11.3±6.7 years, was low, at least by the standards of *Carya* spp., a typically long-lived and late maturing genus of hardwood trees. Still, even this low number of occurrences was somewhat surprising because this species is not commonly available from commercial growers: during this study, only one "boutique" grower in southern Ontario was found to be selling this species[12]. This lack of commercial availability also likely explains why all of the examples in this survey were grown from collected propagules rather than purchased. The propagules were quite likely seed, since grafting *Carya* spp. takes considerable expertise and the propagation of this *Carya* spp. from cuttings is extremely difficult (Dirr, 2009).

[12] This grower was selling seedlings of *C. glabra* var. *odorata* of Brant County, Ontario, provenance.

The difficulty of vegetative propagation may explain why a committed hobbyist grower accompanied the champion hobbyist grower to collect seeds from a "wild" specimen rather than simply being proffered propagules from his/her own collection: it is too difficult for most amateurs to propagate *C. glabra* vegetatively and, at just 18 years old, the champion's specimen was too young to yet produce seed. However, this example illustrates that the champion hobbyist grower was not merely a source of seeds and plants, but an important source of information for other enthusiasts.

7.2.3 *Castanea dentata*

Castanea dentata, the American or sweet chestnut (see Figure 7), is listed as an endangered species under both SARA and ESA. Although once one of the most common tree species of the Carolinian zone, its populations throughout its native range have been decimated by chestnut blight, *Cryphonectria parasitica*, a fungal pathogen which was introduced in the early 20th century (McKeen, 1995). Although conservation and reintroduction efforts for this species have been hampered by the persistence of *C. parasitica* in the environment, this species appears to be unique in the Carolinian zone in having its own non-governmental organization whose focus is solely on the reintroduction of this species: the Canadian Chestnut Council (CCC), founded in 1988 (COSEWIC, 2004).

Figure 7 – Isolated Specimen of *Castanea dentata*

Similar conservation efforts are underway in the United States through the American Chestnut Foundation. Thus, although this species is listed as endangered in Canada, planted specimens may be found throughout the Carolinian zone, sometimes in fairly large stands, as a result of the efforts of these organizations and many individual chestnut enthusiasts.

Quite a large number of *C. dentata* occurrences were reported in this study: 20, or 36.4% of respondents (average reported age 12.1±7.8 years). Although this was one of the most frequently planted rare plant species reported in Morris (2005), this number of occurrences is still somewhat higher than expected. Only one occurrence could be verified as being grown from seed collected from a "naturally" occurring specimen: a 38 year old specimen grown by the champion hobbyist. Given the intensive and extensive work of the Canadian Chestnut Council, it is, perhaps, surprising that just six occurrences contained specimens grown by the CCC or from seed provided by the council. However, eight other occurrences were reported as having been from trees obtained through a nursery run by a governmental agency, and the manager of this nursery is closely aligned with the CCC. Two other occurrences were reported as being acquired from an individual who was a well-known member of the CCC. Thus, 16 of 20 occurrences were attained through sources with strong affiliations with the CCC. Three occurrences contained tree(s) purchased through local nurseries. Although the provenances of these nursery-grown trees are uncertain, one of the nurseries has previously used seed obtained through a member of the CCC.

The propagation and widespread distribution of this species by the CCC and its members or affiliates illustrates the benefits of having an organization whose sole focus is the conservation of one rare species. No doubt, many other rare Carolinian species would benefit from their own enthusiastic support groups. However, although the CCC is playing a critical role in the conservation of Canadian genetic lines of *C. dentata*, it is also attempting to create *Cryphonectria parasitica* resistant hybrids from complex crosses between *C. dentata* and *C. mollissima* (Canadian Chestnut Council, 2009; McKeen, 2009). Although these hybrids are undoubtedly undertaken with rigorous scientific oversight and the best intentions, COSEWIC (2004) has recognized that such hybrids are a potential threat to the species in Canada. However, it is unknown if any of the specimens identified in this study are hybrids.

7.2.4 *Celtis tenuifolia*

Celtis tenuifolia, known commonly as dwarf hackberry (see Figure 8), is a species of small tree or shrub (S2; threatened under SARA and ESA) whose distribution is largely restricted to the Carolinian zone (COSEWIC, 2003). Within the Carolinian zone, distribution of this species is restricted to the extreme north-western edges of the zone.

Figure 8 - Planted Specimen of *Celtis tenufolia*

Although rarely praised for its aesthetic qualities within horticultural publications, this species appears to be relatively popular among native plant enthusiasts within the Carolinian zone. In this study, 22 of 55 respondents (40%) had planted this species. The average age of these occurrences was 12.8±8.2 years, with the oldest examples reportedly being 38 years old. This popularity among native plant enthusiasts, in spite of its detractors, is likely at least partially a product of its rarity and its compact form (desirable for small gardens and yards).

There are other possible explanations for this species apparent popularity, though. For example, one of the six known “natural” occurrences in Canada was purchased by a Lambton-area naturalist club, increasing the profile of the species, at least locally, and potentially simplifying access to reliable seed for some enthusiasts. It is also a favoured species of the champion hobbyist grower; during this study, I experienced and witnessed him/her vigorously proselytizing about the virtues of this species. Thus, this species has quite likely acquired considerable notoriety among native plant enthusiasts.

There are some important factors that are likely restricting the genetic diversity among the planted occurrences of this species in the Carolinian zone. Since the champion hobbyist grower is an enthusiastic advocate for the cultivation of this species, it is not surprising that a third (32%) of the occurrences reported in this study were grown from seed from the champion’s single specimen of this species. Occurrences grown from this tree included four of the five other committed hobbyist growers interviewed for this study. Therefore, it is quite likely that genes of the champion’s tree will continue to be common in the Carolinian zone for quite some time.

It is important to note that there is some uncertainty about the taxonomy of the offspring of the champion’s tree. The champion’s tree is certainly consistent with the morphology of *C. tenuifolia*. A cursory examination of three specimens grown from seed from this tree also appears to be consistent with *C. tenuifolia*. However, in a test of seeds from the champion’s sole specimen of *Celtis tenuifolia* and grown over four years, almost half (7/15) displayed physiological traits, such as leaf size and shape, that were inconsistent with the typical morphology of the species. COSEWIC (2003) notes that although this species is self-fertile, it will hybridize with *C. occidentalis.* Since mature specimens of *C. occidentalis* were in close proximity to the seed tree, these offspring may represent intermediate forms between the two species. Although the planting of hybrids of *C. occidentalis* and *C. tenuifolia* is not necessarily problematic, it may be a concern when hybrids are taken to be examples of the species in conservation efforts or educational programs.

Most of the occurrences reported in this study were grown from seed collected from the Lambton County population or from trees grown from seed collected from this population. This includes six occurrences (27%) grown from seed collected at either Ipperwash, Port Franks, or Pinery Provincial Park, all parts of the Lambton County population. It also includes three occurrences (14%) containing specimens purchased from a boutique commercial grower who stated that he/she collects seed for this species from Pinery Provincial Park[13]. Since, the champion's tree was grown from seed collected at Ipperwash, the seven occurrences (32%) grown from this tree may also be included in this group. Thus, 16/22 occurrences (73%) of *C. tenuifolia* in this study had provenances from the Lambton population.

Although most of the occurrences were related to the Lambton population, it is uncertain how representative a sample of the population this represents. The Lambton population is quite large: COSEWIC (2003) estimated that there were about 1550 individuals in this population. Certainly, the specimens grown from the champion's tree represent a very limited sample (one or, perhaps two, parent trees) of the Lambton population. The tendency of seed collectors to return to the same seed sources suggests that the three occurrences containing trees purchased from the boutique commercial grower/collector may be related. Furthermore restrictions in the diversity of seed sources may also be caused by the reported marking of examples of at least some individual trees within this population with marking tape.

[13] Although the owner/collector of this boutique nursery stated that he/she collected seed of *C. tenuifolia* in Pinery Provincial Park, there is at least one mature specimen of this species growing on the grounds of the nursery. It is possible that this specimen may sometimes be used as a seed source.

As previously discussed, the use of marking tapes simplifies the communication of information between collectors about where to find seed trees. It also undoubtedly draws more attention to marked trees relative to unmarked trees. Therefore, although the planted occurrences undoubtedly represent a variety of the trees in the Lambton population, they quite likely represent a biased sample of this population.

7.2.5 *Euonymus atropurpureus*

Euonymus atropurpureus, known commonly as eastern wahoo or burning bush euonymus, is a rare (S3) species in Ontario whose distribution is largely restricted to the Carolinian zone. Like the widely planted Asian species *Euonymus alatus*, a species also commonly known as burning bush euonymus, *E. atropurpureus* is known for its spectacular red fall foliage. However, the Carolinian species is infrequently found in cultivation and rarely found for sale in Ontario nurseries. Thus, it is not only a rare Carolinian species but a rarely planted species.

In this study, six respondents (10.9%) claimed to have planted this species. The average reported age of these planted occurrences was 22±10.5 years. One of these respondents reportedly grew their example(s) from seed collected in Norfolk. The champion hobbyist grower possessed a single specimen grown from seed collected from a natural occurrence in the Niagara Region. The other four occurrences were all grown from seed given to them by the champion from his/her specimen. This highlights the important role that the champion plays in shaping the genetic lines represented among the planted examples of some rare species.

The genetic legacy of the champion hobbyist's example of *E. atropurpureus* is even greater than suggested by this survey. During this study, at least three other planted occurrences (all single specimens) were found that are direct descendents of the champion's specimen. Unfortunately, the owners of these three occurrences did not participate in the questionnaire of this study. These occurrences, together with the six examples reported in the study, represent a planted population with one quarter as many occurrences as the 38 occurrences known to the Natural Heritage Information Centre in 2009; all but one of these planted occurrences are descended from just one "naturally occurring" plant.

7.2.6 *Magnolia acuminata*

Magnolia acuminata (see Figure 9), the cucumber tree, is an endangered species (S2) whose range in Canada is restricted to the Carolinian zone. Since this species was intended to be the focus of a more comprehensive study of provenances, it was already discussed in some detail. However, it was also included as a candidate species in the questionnaire part of this research. Although there is some overlap in the findings of the two parts of this research, it is useful to highlight them here. It is important to note, however, that many of the provenances reported in the more focused part of the research are not included in this section:

Figure 9 – Planted Specimen of *Magnolia acuminata*

the owners of these specimens were unable or chose not to participate in the survey section of this research.

Magnolia acuminata appears to be a very widely planted tree in southern Ontario, including many examples outside of the Carolinian zone. Indeed, mature specimens were identified growing as far north as Alliston, Ontario. It was the most commonly reported specimen in this study: there were 30 occurrences, some with multiple specimens. The average reported age of the occurrences was 18.5±10.0 years. However, the actual average age of these occurrences is likely somewhat lower because one respondent claimed multiple specimens yet reported only the age of the oldest specimen. Slightly more than half of the occurrences (16/30) contained specimens that were obtained from commercial growers or plant sales, although at least one occurrence contained both purchased and collected specimens. The most commonly cited source (8 occurrences) was the commercial grower described earlier. This grower would not confirm their seed source although it was reported by others within the native plant enthusiast community to be a single tree used by a hobbyist who specializes in growing cucumber trees. Four occurrences contained specimens purchased from a grower who collects seed from a planted specimen in Woodstock. Interestingly, although the champion hobbyist possessed a single specimen, grown from seed from a large tree in an urban area, there were no other occurrences attributable to this tree. Since isolated examples of *M. acuminata* may not set seed reliably (McDaniel, 1963), it may simply be that the champion did not have seed to share. From this study, it appears that although this endangered species is widely planted, the planted examples represent a biased sampling of the natural populations in Canada as well as some non-native provenances.

Several other issues are highlighted by the provenances listed for *M. acuminata* in this study. For example, three respondents stated that the sources of their specimens were large arboreta/botanical gardens. One of these specimens was purchased at a large arboretum in southern Ontario but slightly outside of the Carolinian zone. An employee of this arboretum stated that he/she did not see a problem with the selling of an endangered Carolinian species since they were not located in the Carolinian zone (key informant #29, 2008). The other two respondents listed the Royal Botanical Gardens in Hamilton as the source of their examples of *M. acuminata*. One of these respondents qualified the provenance as the "RBG sale." Since these specimens sold at the annual RBG plant sale may be either donated by RBG members or propagated in-house, it was not possible to determine the provenance of this occurrence. The other occurrence identified as originating from the RBG may also mean the annual RBG plant sale, or it may mean that it was grown from seed collected from one of the RBG's specimens of *M. acuminata*. As previously discussed, the RBG is a popular source for commercial seed collectors. Since during this study and the previous study (see Morris, 2005), individuals other than RBG staff were seen at the Gardens collecting very small quantities of seed (presumably too small for commercial production), it is quite possible that this occurrence was grown from seed collected there.

Whether their sale was sanctioned by these institutions or they were grown from seed collected surreptitiously, having planted examples of *M. acuminata* originate from large arboreta or botanical gardens raises some important concerns. Certainly, given that the growing of protected species is regulated, there are potential legal concerns about the sale of protected species to the public by arboreta and/or botanical gardens. Even if the sales are made in a way that is consistent with restrictions imposed by species at risk legislation, they may contravene the spirit or the goals of the legislation. Furthermore, since there are reasons to believe that the genetic lines of specimens in arboreta or botanical gardens, particularly some specimens of some rare species, are overrepresented within planted populations because of the activities of commercial seed collectors, the sale of yet more specimens grown from these specimens would potentially compound the problem. Finally, cultural practices within such institutions may further limit the diversity within their specimens of rare species. As previously discussed, a large tree in Dundas, Ontario provided seed from which many of the specimens of *M. acuminata* at the RBG were grown. Thus, even if a seed collector was careful to collect seed from a variety of specimens of this species at the Gardens, the genetic diversity may be limited.

7.2.7 *Morus rubra*

Morus rubra (see Figure 10), commonly known as red mulberry, is a rare (S2) tree species that occurs naturally only within the Carolinian zone. It is a protected species, designated as Endangered under both SARA and ESA. Indeed, it is one of Canada's most endangered tree species (Canadian Forest Service, 2000). Although this species is facing many of the same threats as other rare floral species in Canada, such as loss of habitat, its principle threat is from genetic swamping through hybridization with a closely related and regionally

Figure 10 – Grafted *Morus rubra*

much more abundant non-native species, *Morus alba* (Burgess & Husband, 2006; Burgess, Morgan, Deverno & Husband, 2005; Canadian Forest Service, 2000). Given this hybridization, propagation of this species by seed can be extremely problematic.

Although *M. rubra*, like *Magnolia acuminata*, is an endangered tree species whose range in Canada is restricted to the Carolinian zone, it does not seem to be as widely planted as *M. acuminata.* In this study, only 13 respondents stated that they possessed specimens of *M. rubra* although at least three of these occurrences contain more than one specimen. The average age of these occurrences was 14.3±9.5 years. Six of the occurrences in this study contained specimens grown from propagules collected from areas with known remnant "natural" populations. One of these occurrences also contained specimens that were propagated from the champion hobbyist collector's trees. Indeed, the champion's two specimens of *M. rubra*, a quite fecund pistillate specimen and a much smaller staminate specimen, were the source listed by almost half (6/13, or 46%) of the respondents growing this species. This once again highlights the apparent heavy representation of the champion's specimens among the planted populations of many rare species.

Since the propagation of this species by seed is problematic due to concerns about hybridization with *M. alba*, the method of propagation of this species for planted examples is an important consideration for determining the nature of planted populations. Unfortunately, the questionnaire used in this study did not specifically ask about the method of propagation. Through further investigation, though, some important insights were attained.

Despite the recognized problem of hybridization in *M. rubra*, it is likely that many, if not most, of the planted examples were grown from seed. There were, however, two occurrences that contained vegetatively propagated examples of *M. rubra*. One respondent contained several specimens: one had been grown from seed and all of the others were grafted onto *M. alba* (or *M. alba* x *M. rubra* hybrid) rootstock. It is noteworthy that the seed-grown specimen and one of the observed grafted specimens possessed leaf morphologies that were more typical of hybrid mulberries than *M. rubra* (see Figure 11). The champion hobbyist's two trees, the oldest in this study, were both grown from cuttings taken from a "wild" specimen and rooted by a conservation professional almost 40 years ago. However, although both of the champion hobbyist's trees possessed phenotypic characteristics that were consistent with *M. rubra*, the champion propagated this species by seed and produced seedlings that often appeared to be hybrids. Indeed, the seed-grown apparent hybrid grown by the respondent who possessed several grafted specimens was grown from seed from the champion. The champion also possessed a small, backyard nursery containing a number of *Morus* spp. seedlings for future distribution to other enthusiasts. Although I was only able to make a cursory observation of these seedlings, at least two seedlings had leaves which were noticeably glabrous, a distinguishing feature of *M. alba* and many hybrids. Also, six seedlings grown from seed proffered to me by the champion and grown for several years all possessed

Figure 11 – Grafted *Morus rubra* with leaf morphology more typical of hybrid mulberry

leaf morphologies that were intermediate between *M. alba* and *M. rubra*. Since it is quite likely that many, if not most or all, of the *M. rubra* occurrences that originated from the champion were seed grown, it is likely that many of these seedlings are hybrids between *M. rubra* and *M. alba*.

Commercial growers of this species also appear to propagate this species principally from seed. Indeed, three of the four commercial growers who were identified during this study as selling *M. rubra* were growing this species from seed and possessed many seedlings with hybrid leaf characteristics. The fourth commercial grower would not state how they propagated this species and no specimens from this grower were observed. Two respondents in the provenance study stated that their specimens of *M. rubra* came from one of the three commercial growers who grew this species from seed. Therefore, it is possible that their specimens are hybrids rather than *M. rubra*. Indeed, this study suggests that many planted examples of *M. rubra* in the Carolinian zone may actually hybrids between *M. alba* and *M. rubra*.

The propagation and planting of hybrids between *M. alba* and *M. rubra* would not seem to be problematic, even when the hybrid is planted in the erroneous belief that is *M. rubra*. Although such hybrids pose a similar threat to *M. rubra* as *M. alba* (Burgess & Husband, 2006; Burgess et al., 2005), *M. alba* and hybrids are so ubiquitous within southern Ontario that it is unlikely that a few more hybrids would increase the threat significantly. The potential exception might be the planting of hybrids in close proximity to remnant populations of *M. rubra*. However, as Burgess and Husband (2006) note, most remnant populations in southern Ontario already occur with *M. alba* and hybrids.

Perhaps the greatest concern with the planting of hybrid mulberries, or, given their iniquitousness, even *M. alba*, instead of *M. rubra*, is not the potential damage that they may do to remnant populations of *M. rubra*, but the opportunity costs of not planting more of the native species. Since the greatest threats to this species are ultimately demographic (too few non-hybrid individuals and lack of recruitment of non-hybrid offspring), the widespread planting of vegetatively propagated specimens of *M. rubra* would seem to be desirable. However, it is likely that such efforts would be significantly restricted by existing species at risk legislation in Canada.

Should it be decided that vegetative propagation of this species is a desirable strategy for its conservation, the experience of at least one of the growers in this study suggests that it may be quite efficient and cost-effective simply to field graft authenticated non-hybrid specimens onto *M. alba* or hybrid rootstock. Although the grower found it difficult to propagate *M. rubra* cuttings without a misting system, he/she found that cleft grafting onto field-grown *M. alba* in the spring was extremely simple and generally very successful. Suitable rootstocks were widely available: seedling *M. alba* are widely available in southern Ontario and volunteer seedlings are so common that, in places, they seem invasive. Suckering of the rootstock did not appear to be a problem, although this would be a concern for plantings with little or minimal aftercare. It was also claimed that the *M. alba* rootstock produced a *M. rubra* specimen that was adaptable to more soil conditions than is typical for the species. This claim was not verified although further investigation would seem desirable.

7.2.8 *Nyssa sylvatica*

Nyssa sylvatica, known commonly as black tupelo, black gum or sour gum, is a rare (S3) tree species which occurs in Canada only within the Carolinian zone. Although rare, this species is widely available from nurseries, including very large nurseries, in southern Ontario. Perhaps because of this perceived commonness, only four occurrences were identified in this study. Only one of these occurrences, a specimen grown by the champion hobbyist, was grown from wild-collected seed by the respondent. The other three occurrences contained trees purchased at commercial nurseries. The champion's specimen was also much older than the other specimens: his/her *N. sylvatica* was 42 years old while three others were between 5 and 10 years old. However, since the three nursery-grown occurrences were purchased from nurseries that only sell caliper-sized *N. sylvatica*, it is likely that these occurrences are somewhat older than reported (10-20 years, assuming between five and ten years to produce a two-inch caliper specimen of *N. sylvatica* under southern Ontario field conditions).

7.2.9 *Ptelea trifoliata*

Ptelea trifoliata (see Figure 12), common hoptree, is a rare (S3) tree whose distribution within Canada is restricted to the Carolinian zone. It is listed as a threatened species under both SARA and ESA. This species is typically found in Ontario in highly disturbed sites, sandy habitats along or near Lake Erie (COSEWIC, 2002a). Because its shoreline habitats are also highly valued for residential and recreational use, the populations of these species in Ontario have diminished due to extensive cottage development and intensive shoreline vegetation removal and ongoing beach management (COSEWIC, 2002a).

Given its rarity, small size, readily apparent and desirable aesthetic qualities (attractive fruit clusters, sweet-scented flowers), its relative ease of propagation from seed, as well as the festive associations with its common name, it is not particularly surprising that this species was well grown by a fairly large percentage (27%) of the respondents in this study. Since it is relatively easy to collect the seeds of this tree (short trees with fairly long retention of seeds), it was also expected that many of the respondents would have grown this tree themselves. However, only three respondents (20% of those reportedly growing this species) had grown this species from seed. One of these respondents stated he/she had "several" specimens: a "couple" which had been grown from seed and one which was purchased from a commercial grower. Another of those who had grown their own specimens was the champion hobbyist. Another respondent stated that their occurrence had come from the champion although it is unclear whether seed or young tree(s). One respondent stated that they had been given their *P. trifoliata* by a friend but in a conversation with this respondent it was disclosed that this friend was the champion hobbyist. All of the other occurrences contained specimens which had been purchased either at plant sales (n=3) or from commercial growers.

Figure 12 - Planted Specimen of *Ptelea trifoliata*

Given the diversity of provenances identified in this study and the relatively large number of natural occurrences (35) listed by the NHIC, it may be that there is considerable diversity within the planted populations. However, there are also some potential sources of bias that may limit this diversity. One such bias is the champion's specimen. Although only two other respondents identified the champion as the source of their occurrences, they were both committed hobbyist who, like the champion, frequently gave away native plants. Also, four of the respondents identified one grower as the source of their occurrences. During this research, it was found that this grower grows their *P. trifoliata* seedlings for sale from a single fecund specimen on their property[14]. Although one commercial grower and two of the respondents who grew their own specimens of *P. trifoliata* stated that they collected their seed from "Pelee," it is doubtful that this represents a problem: there are almost 600 individuals within the populations of this species at Pt. Pelee National Park and Pelee Island (COSEWIC, 2002a). Of course, the overrepresentation of male trees within populations of this species (COSEWIC, 2002a) would likely mean that less than half of this number would be expected to be female (seed) trees. Also, the cultural practices of seed collectors would likely introduce biases despite a relatively large number of potential seed sources.

7.2.10 *Quercus prinoides*

Quercus prinoides (see Figure 13), commonly known by a variety of names, including dwarf chinquapin oak, dwarf chestnut oak or scrub oak, is a rare (S2) shrubby oak whose range in Canada is restricted to the Carolinian zone. This species is very similar to *Q. muehlenbergii* and, to a lesser extent, *Q. montana* (syn. *Q. prinus* L.), although both species are considerably larger in all features (Farrar, 2003; Waldron, 2003). Despite earlier claims for occurrences of *Q. montana*, there is no convincing evidence for this and the NHIC now lists this species as introduced. Despite differences in size between *Q. muehlenbergii* and *Q. prinoides*, the two

[14] Since this species is dioecious (COSEWIC, 2002a), there is quite likely at least one more specimen relatively nearby.

species are extremely similar. Indeed, Gleason (1952) considers the two species to be conspecific, in which case, the larger form, having been described later than the dwarf form is classified as the variety [*Q. prinoides* var. *acuminata* (Michx.) Gleason].

Figure 13 – *Quercus prinoides*

This species was relatively extensively planted by the respondents of this study: 14 respondents, or 25.5% of respondents, reported growing this species. The average age of these plantings was 15.4±10.87 years. The oldest occurrence was a specimen grown by the champion hobbyist: 40 years. Almost half (43%) of the occurrences were grown from seed collected from known natural occurrences in St. Williams, Ontario, and Pinery Provincial Park. Two occurrences were gifts: plants given to the respondents by other growers. Three of the occurrences were purchased specimens from two different nurseries. Both of these nurseries use seed trees located on the nurseries grounds: one nursery uses seed trees from only one provenance while the other has seed trees from two different provenances. There are, therefore, potential sources of biases among planted examples of *Q. prinoides*, but there does not seem to be a dominant process that is creating biases.

The responses for the planted occurrences of this species do highlight an important source of bias among planted rare species. One of the conservation agencies within the Carolinian zone operates its own large nursery to produce seedlings for a diversity of reforestation programs. Although these programs are driven by higher order goals within the conservation organization, the nursery seems to operate with considerable flexibility and a degree of autonomy; the manager of the nursery seems to be able to use considerable discretion in choosing which species to grow and how to grow them (key informant #30, 2007). Although common species dominant the production at this nursery, a wide range of rare species are grown, although there are typically very few different rare species at any one time (key informant #30, 2006, 2007). One of the more commonly grown rare species appears to be *Q. prinoides*; I have observed it being grown at the nursery on several occasions. In this provenance study, three occurrences of *Q. prinoides* were obtained from this nursery. I have also seen an additional five plantings of this species, each containing at least six specimens, which were obtained through this nursery. Thus, this nursery appears to be an important source of this species in southern Ontario. However, the seeds for this nursery's *Q. prinoides* seedlings come from the same small occurrence in Brantford (key informant #31, 2007). Observations over five years (2003 – 2008) suggest that although there are several trees in this population, there are only two relatively large and three small specimens which reliably set seed. This could represent an important limitation in the diversity within the planted examples. However, the decisions which create these limitations should be easily remedied.

7.3 Herbaceous Species

7.3.1 *Arisaema dracontium*

Arisaema dracontium (see Figure 14), commonly known as either green dragon or dragon-root, is a perennial herbaceous species of special concern (S3) whose natural occurrences in Canada are largely restricted to the Carolinian zone. Like many Carolinian species considered rare in Canada, *A. dracontium* is relatively widespread throughout much of the eastern United States (Yang, Lovett-Doust, & Lovett-Doust, 1999). An important limiting factor for populations of this species in Ontario appears to be low recruitment (Yang, Lovett-Doust, & Lovett-Doust, 1999).

In this study, five respondents noted that they possessed specimens of *A. dracontium*. Only one respondent, the champion hobbyist grower, had grown plants from propagules collected from known "natural" occurrences. The champion's occurrence was listed as being 40 years old. All of the other four occurrences were grown from propagules from the champion's occurrence and ranged in age from four to twenty years old. Three of these four respondents were committed native plants growers with strong connections to the champion; they also frequently give any plants to other interested individuals. Therefore, it appears that the champion's provenance is not only dominant among the planted populations of this species within the Carolinian zone, but it is also likely that the champion's provenance will continue to be dominant for some time.

Figure 14 – Planted Specimen of *Arisaema dracontium*

7.3.2 *Asclepias purpurascens*

Asclepias purpurascens, purple milkweed, is a rare (S2) herbaceous perennial whose distribution in Canada is restricted to the Carolinian zone. Although considered rare in Canada, this species is widely available through many boutique nurseries and even mass market garden centres. Indeed, this species was the most commonly reported herbaceous species in this survey: there were 19 occurrences, representing 35% of respondents. The popularity of this prairie species is likely a product of its aesthetic appeal and ease of propagation, as well as its tolerance of the dry-mesic, calcareous soils that are typical of southern Ontario gardens (Wasowski, 2002). However, many other *Asclepias* spp. share these qualities and confusion between species is relatively common: during this study, one boutique grower and one mass market garden centre had other species of *Asclepias* mislabeled as *A. purpurascens*. This confusion between species of *Asclepias* was not noted among any of the committed gardeners interviewed for this study. However, although this study assumes proper identification of species by respondents, it is possible that for some species, such as *A. purpurascens*, the total number of occurrences may be inflated due to misidentification.

The occurrences of *A. purpurascens* reported in this study (average age: 7.7±4.3 years) originate from a wide variety of sources. Twelve of the occurrences, including some plants within the champion hobbyist grower's occurrence, were purchased at nurseries or garden centres. Two occurrences were purchases at local plant sales. Two occurrences were grown from seed obtained through seed exchanges. Only two occurrences, including some of the plants within the champion hobbyist grower's occurrence, were grown from seed collected from known natural occurrences. The remainder of the occurrences were either given to the respondent by friends or were of unknown provenances. Although this suggests that there is likely considerable diversity within the planted populations of this species, care must be exercised in drawing conclusions about the representativeness of local genotypes within the planted group. The cultural practices of collectors and growers may impose unexpected biases. Also, because this species was widely available at mass market garden centres, it is possible that some of these planted occurrences represent non-Carolinian provenances. Although the introduction of non-local genotypes may be desirable if it reduces inbreeding depression within remnant populations, it is not necessarily consistent with the goal of preserving local or regional genetic diversity.

7.3.3 *Frasera caroliniensis*

Frasera caroliniensis (see Figure 15), commonly known as American columbo, is an endangered rare (S2) species whose distribution in Canada is restricted to the Carolinian zone (COSEWIC, 2006). This long-lived perennial is monocarpic (i.e. flowering once, setting seed and dying), persisting as a basal rosette for most of its life (Threadfill, Basking & Basking, 1981). Although this species would require considerable patience under cultivation, the towering flower spikes of this species are so distinctive and aesthetically interesting that some committed native gardeners would undoubtedly consider the wait worthwhile.

Figure 15 – *Frasera caroliniensis* Rosette

This species does not appear to be widely grown. Only three respondents in this study stated that they grew or had grown this species. Two respondents appear to have obtained their plants from a known "naturally" occurring population and both examples were only one year old. Although the provenance of one of the respondents vaguely stated the provenance as a population "near Dundas," it is likely a population on land owned by a local naturalist club. The other collected occurrence is reportedly from this population as well. This may once again highlight the importance of ease of access to both knowledge about occurrences and the populations themselves in determining the favoured sources for collection: this occurrence is widely known within the local naturalist/native plant gardening community and is often a featured attraction of guided nature walks in this area.

The third planted occurrence in this study was one owned by the champion hobbyist grower. This occurrence was listed as having died after two years. Interestingly, this occurrence was listed as being given to the respondent by a named conservation professional working for a large regional conservation organization. It is not known if this gift was authorized by the conservation organization. Although I interviewed the professional who was named as the source of the plant(s), he/she would not confirm this gift. However, a colleague of this professional suggested that unauthorized distribution of propagated rare species does occur in this organization. Indeed, this person stated that they usually propagate "a bunch" of a targeted species and "take a few of what is needed" (key informant #33, 2008). This person also stated that "there is always extra seed." This unauthorized distribution of rare species that have been propagated as part of authorized conservation efforts for the species deserves further investigation.

All of the examples of this species were relatively young. It is unknown if this is a result of recent interest in the species or difficulty in maintaining the species under cultivation. Threadgill et al. (1981) appeared to have little difficulty in germinating seed of this species and noted relatively old (15 years) examples under cultivation. However, the persistence of this species as a relatively small, innocuous basal rosette would seem to make cultivated examples vulnerable to inadvertent "weeding out" or intentional removal due to impatience or changing interests. It is also unknown if the reported ages reflect the actual ages of the occurrences or the years in the respondents' possession. Since the champion hobbyist was given a plant, it is quite possible that the plant was somewhat older than two years. It is also possible that the other planted occurrences represent plants that were collected from the remnant population rather than one year old seedlings.

7.3.4 *Hypoxis hirsuta*

Hypoxis hirsuta, commonly known as Eastern yellow star-grass, is a rare (S3) perennial species whose range within Canada is largely within the Carolinian zone. Although this small adaptable species is relatively easy to grow and propagate by either seed or corms (Cullina, 2000), no occurrences were reported in this survey. However, I have seen this species in cultivation in gardens in southern Ontario, although only rarely. Indeed, I had previously seen this species being grown in the garden of one of the respondents in this study although I believe that it had died by the time that this survey was undertaken.

7.3.5 *Lespedeza virginica*

Lespedeza virginica, or slender bush clover, is an endangered (S1) perennial prairie species with a very restricted range within the Carolinian zone. Indeed, there are only two known occurrences in southern Ontario, both in the Windsor area (COSEWIC, 2000). Despite its rarity within Canada, three occurrences were reported in this study. One of the occurrences was reported by the champion hobbyist grower. The other two occurrences were reported by committed native plant growers and both were propagated from the champion grower's plants.

The provenance of the champion hobbyist grower's occurrences of this species raises some important questions not only about the role of planted specimens of species-at-risk but about the role of non-professionals in conservation science. The champion hobbyist reported that his/her occurrence was collected in the Short Hills area in the Niagara region approximately forty years ago. However, the Natural Resource Information Centre does not list this occurrence; it lists only the two remnant occurrences and an observation of the species in Leamington, Ontario in 1892. Despite several biological inventories of the Short Hills area during the past thirty years, there are no records of *L. virginica* occurrences in this area (Durley, 1997; Lindsay, 1982; MacDonald & Beechy, 1971). The NHIC also does not record any existing or historic occurrences of this species in this area. Therefore, does the lack of official records of occurrences of this species in the Short Hills area, or even in the eastern Carolinian zone, suggest that the champion hobbyist's occurrence of *L. virginica* should be assumed to be an introduced provenance? Should the champion hobbyist's record of a "natural" occurrence be given any less credence than an official record or a herbarium sample? If credence were given to the claims of the champion hobbyist grower, then the champion's occurrence, as well as the two other occurrences grown from propagules from the champion's occurrence, might be considered to be the only legacies of an extirpated population.

The authenticity of the champion hobbyist's claims about the origin of his/her occurrence of *L. virginica* may be difficult or impossible to determine scientifically. Even molecular studies may be of little use. There are, however, reasons to suggest that unauthenticated reports of a "natural" occurrence in Niagara may be trustworthy. For example, COSEWIC (2000) suggests that, even in the absence of more widespread occurrences of this species in Ontario, it was quite likely once more widespread. Also, despite the amateur status of the champion hobbyist, he/she is generally accepted as a reliable source of information within the conservation community: his/her reported occurrences of other species have been accepted by the Natural Heritage Information Centre and a number of respected references on species occurrences in Ontario (see, for example, Argus, Pryer, White & Keddy, 1987). Thus, even if the provenance of the champion hobbyist's occurrence of this species cannot be authenticated in a scientifically rigorous manner, there would seem to be reasons to suspect its authenticity. If we assume that this provenance is authentic and assume that the original population is extirpated, the champion hobbyist's occurrence of this species becomes a critical genetic legacy. Recognizing such legacies would seem to be an important supplemental strategy for the preservation of genetic diversity.

Despite the potential importance of the champion's occurrences of *L. virginica*, some caution would seem to be necessary when examining claims like those of the champion hobbyist. Although the claim of a "lost" population of a rare species is compelling, and the promise of living legacies of this population even more tantalizing, the inability to adequately substantiate these claims demands at least some skepticism. This should not be misconstrued as a positivist demand for certainty; the obligation to conserve the genetic diversity of species at risk would seem to demand a more liberal standard of proof. At the same time, this obligation demands a reasonable level of certainty because misdirected actions may be as damaging as inaction. Finding the balance between recognition of the value of such local knowledge[15] and the necessary skepticism about unsubstantiated claims is undoubtedly one of the great current changes for conservation practitioners. At the very least, identifying and preserving such local knowledge (and the tangible products of this knowledge) would seem to be a useful and necessary exercise.

[15] Local knowledge is used to simply describe "the knowledge one obtains from residing in a particular area, and observing and interacting with it for an extended period of time" (Widdowson & Howard, 2008, 235). It should not be conflated with postmodernist interpretations of local or indigenous knowledge which demand recognition of the cultural or spiritual context of knowledge.

7.3.6 *Lupinus perennis*

Lupinus perennis, known commonly as the blue or wild lupine, is a rare (S3) perennial species in Canada whose natural distribution is largely restricted to Carolinian zone. However, this genus is widely grown as a garden plant and occasionally as an agricultural crop (Strydhorst, King & Lopetinsky, 2008). Although *L. perennis* is not as widely grown as other species, it is receiving increasing attention as a way to find horticultural selections with improved characteristics (particularly colour range) for garden use (Leopold, 2005). Thus, this species provided an interesting opportunity to see if native plant growers would preferentially seek out native provenances of a rare species over horticultural selections.

As expected, this species was reported by a relatively high proportion of the respondents in this study: almost a quarter (23.6%) of respondents stated that they grew this species. The average age of the occurrences was 6.5±3.3 years. Despite its popularly, only one occurrence was reported as having been grown by the respondent from seed collected from known "natural" occurrences in Ontario: this occurrence was grown by the champion hobbyist grower. The other occurrences came from a variety of other source. Some (n=7) were purchased from nurseries or at plant sales, or were grown from purchased seed. A couple occurrences contained plants which were given to the respondents by friends or acquaintances. The other occurrences were from unknown sources. These results would seem to suggest that native provenances may not be an overriding concern for many native plant enthusiasts or gardeners. However, it does not indicate whether growers would preferentially choose native provenances if given a choice of provenances with similar availability.

7.3.7 *Mertensia virginica*

Like wild lupine, *Mertensia virginica* is a rare (S3) perennial species whose natural range in Canada is largely limited to the Carolinian zone. Also like *Lupinus perennis*, *M. virginica* is widely available in the horticultural trade and there are a number of named cultivars and varieties of this species available (Leopold, 2005). The common name of this species, Virginia bluebells, may provide opportunities for confusion with other species: the name "bluebells" is shared by other superficially-similar species within the genus *Mertensia*, as well as species within *Campanula* and *Hyacinthoides*.

Despite the opportunities for confusion with other species and the wide availability of this species in the horticultural trade, there were surprisingly few reported occurrences of this species in this study: only five respondents reported this species. The average reported age of these occurrences was 14.0±17.5 years; the average was distorted by the 40 year old occurrence of the champion's occurrence. Only the champion hobbyist's occurrence was grown from propagules collected from known "natural" occurrences. One of the occurrences contained plants which were originally purchased at a supermarket.

The relative lack of popularity of this species with the native plant enthusiasts in this study is somewhat perplexing. However, one of the committed native growers suggested a potential explanation. This grower suggested that he/she did not grow this species simply because it is popular; it was this popularity within what might be described as mainstream horticulture that made it unattractive to this native plant enthusiast. An earlier study (see Morris, 2005) as well as studies by other researchers (see, for example, Head & Muir, 2006; Head, Muir & Hampel, 2004), have found an underlying critique of mainstream horticulture among native plant enthusiasts. This suggests that as a regionally rare plant species becomes increasingly popular among mainstream gardeners, the remnant natural populations may not only become increasingly numerically overwhelmed by introduced genetic lines, but those who might typically be expected to be interested in preserving the local provenances may instead become less interested. However, caution would seem advisable when accepting this apparent inverse relationship between a species' popularity within mainstream horticulture and its popularity among native plant enthusiasts. Other species in this study which appear to be popular garden plants, such as *Lupinus perennis* and *Stylophorum diphyllum*, appear to also be popular with the respondents in this study. Although there may indeed be the inverse relationship as described, it is likely often obscured by the complexity of motivations among native plant enthusiasts and the difficulty in sometimes distinguishing between native plant enthusiasts and other gardeners (see, for example, Head & Muir, 2006).

7.3.8 *Pycnanthemum incanum*

Pycnanthemum incanum, commonly known as hoary mountain mint, is rare (S1) with an extremely limited distribution in Canada: existing and historic populations occur within a few kilometres of each other at the western end of Lake Ontario (Thomson & Rothfels, 2006). Only two small populations of this endangered species remain, both easily accessible to the public (Thomson & Rothfels). At least one of these populations is relatively well known to the native plant hobbyists: although relatively few respondents (n=5) stated that they grew this species, four other hobbyist or commercial growers in the eastern Carolinian zone stated they either knew of, had visited or intended to visit the one population[16].

[16] No information about the locations of populations of this or any species in this study was provided to participants. Determination of knowledge of this population was volunteered by participants.

The Hoary Mountain-mint Recovery Team suggests that the collection and growing of this species may pose a threat to this species. However, they found no evidence of collection activities from the remnant populations (Thomson & Rothfels, 2006). They did, however, find several small native plant vendors selling this species, although "… the origin of plants and/or seed used for this purpose is unknown" (Thomson & Rothfels, 8-9).

This study found that plants and/or propagules are being collected from the remnant populations. Indeed, five respondents stated that they possessed this species. Three of the respondents stated that they grew this species from seed or plants collected from one of the remnant populations[17]. Two of the respondents obtained this species from a commercial grower who grows this species, although it is not known whether they were gifts or purchased specimens.

This species highlights a phenomenon that would benefit from further research: the species-specific champion. The commercial grower of this species appears to be an ardent promoter of further growing of this species, often proselytizing about the virtues of this species in preference to other species. During an interview with this grower, he/she even suggested that we immediately visit the nearby occurrence to collect some seed (the offer was declined). During this study, similar species-specific champions were found for *Morus rubra*, *Celtis tenufolia* and *Magnolia acuminata.* Although increased distribution because of these champions was only noted for the champion for *M. acuminata*, it is possible that the other champions also increased distribution of their focal species: both of these other species-specific champions stated they often or frequently gave away specimens of their apparent favourite species. There appears to be an association between these species-specific champions and the

[17] There is also a planted occurrence of this species, grown from the nearby population from seed collected by the commercial grower of this species. It is possible that some or all of these occurrences were grown from seed or plants collected from this planted source.

species upon which they focus their attention: all of these champions lived in the area where the species had relatively large populations.

7.3.9 *Stylophorum diphyllum*

Stylophorum diphyllum (see Figure 16), commonly known as the wood poppy, is an endangered (S1) perennial species with a very limited distribution: there are only three known populations in Canada, all of them within the Carolinian zone, near London, Ontario (COSEWIC, 2007). Because of its large, showy flowers and its tolerance for shade, this forest species is claimed to be a popular garden plant that is widely available at nurseries (COSEWIC, 2007; Bowles, 2007). Because of its popularity and the suspicion that most planted occurrences are "almost certainly not Canadian" (Bowles, 2007, 14), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (20007) has suggested that genetic contamination of the remaining populations from planted specimens is a significant threat to the species.

This study appears to support the claim that *S. diphyllum* is a popular garden plant: 25.5% (n=14) of the respondents in this study had specimens of this species. However, if this species is truly a popular garden plant and, as claimed by one committed native plant enthusiast, native plant enthusiasts tend to avoid plants which are perceived as popular, why would such a high proportion of participants in this study have

Figure 16 - Planted Specimen of *Stylophorum diphyllum*

this species? One explanation may be that it is not sufficiently popular within mainstream gardening to deter native plant enthusiasts. Indeed, only two regional boutique growers list this species in their catalogues and only four of the respondents in this survey obtained their specimens from nurseries or commercial growers. It may also simply be that this is a very appealing, easy to grow, and prolific seeding plant (Leopold, 2005) that attracts the attention of even the most committed native plant gardener. Although there appears to be a complex mix of motivations for planting rare species, aesthetics appears to play an important role. At the very least, this study suggests that this is a popular garden plant among native plant gardeners.

This species appears to be widely traded among native plant enthusiasts: 64.2% (9/14) of the respondents who reported owning this species stated that they either received their specimen(s) from a friend or acquaintance (6/14), or bought it at community, club or private plant sales (3/14). It could be argued that such plant sales, despite their overt money-making motivation, have more in common with individual plant exchanges than larger commercial operations; although they involve monetary exchanges, they are usually relatively small-scale, infrequent, and typically involve vegetative divisions for volunteers from garden collections (Reichard & White, 2001). Two occurrences were grown from propagules obtained from the champion hobbyist's occurrence. Interestingly, the champion's occurrence was originally purchased from a local nursery. It was not possible to determine the source population of any of the planted occurrences. Thus, this study cannot refute Bowles' (2007) claim that planted examples of this species are not from a Canadian provenance. Given the small size and relative inaccessibility of the remnant populations in Canada (COSEWIC, 2007), its wide range within the United States, the apparent extensive trading of this species among native plant gardeners, and the ease of propagation of *S. diphyllum* from seed (i.e. easily transported propagules), it is quite possible that the planted populations of this species in Canada represent a wide variety and complex mix of provenances.

The relationship between the planting of this species outside recognized recovery efforts, the need to provide demographic security for this species in Canada, and the desire to conserve the regional genetic diversity of the species, highlights what may be considered the *protected plant paradox*. Although the unauthorized planting of the species provides demographic security for the species, the introduction of non-regional genetic lines may compromise the existing genetic diversity of the species in Canada. At the same time, authorized conservation efforts are restricted through policy, if not through species-at-risk legislation, from facilitating the introduction of regional provenances into the unauthorized "garden" populations. This would seem to represent a significant opportunity cost in the form of lost opportunities to exploit the widespread trade in the species to increase the occurrences of regionally-sourced plants. At the same time, it misses the opportunity to potentially slow the further introduction of non-local provenances.

The recovery strategy for *S. diphyllum* in Canada illustrates this paradox. It recognizes that this species is widely grown as a garden plant and argues that since these planted occurrences are likely not from Canadian provenances, they are a threat to the genetic diversity of the species in Canada (Bowles, 2007). Accordingly, it recommends that gardeners be cautioned against further planting of this species. Apparently recognizing the futility of this recommendation, it further recommends that gardeners avoid the propagation and planting of "material that does not originate in Canada" (Bowles, 2007, 20). At the same time, the strategy recognizes the demographic threats to the remnant populations, suggesting that new occurrences be established through the out-planting of propagules from the remnant populations. However, it apparently fails to recognize that the need to diminish the genetic threats to the species may be reconciled with the need to increase the demographic security for the species by providing appropriate genetic material to members of the gardening community. The lack of this kind of reconciliation is not a failure of imagination, though. Rather, as a protected plant, such efforts would likely be incompatible with the intent, and, perhaps, the provisions of the Species at Risk Act and the Ontario Endangered Species Act. No doubt there are also cultural reasons that support the inability to reconcile the two conservation goals. The long-standing view of gardening activities as a threat to native plant populations (see, for example, Reichard & White, 2001) would seem likely to promote a perspective that would be unwilling to facilitate such activities. Paradoxically, this problem would be most pronounced for protected species, those species in need of creative conservation efforts.

7.3.10 *Viola pedata*

Viola pedata, or bird's foot violet, is an endangered (S1) species that occurs in Canada at only five sites within the Carolinian zone (COSEWIC, 2002b). This species is extremely intolerant of shade and is generally associated with black oak savanna[18] (COSEWIC). Unlike many other *Viola* spp., *V. pedata* does not set seed in isolation; it requires cross-pollination (COSEWIC).

Although this species is relatively easy to grow under cultivation (given the required light and drainage conditions), I have rarely seen it growing in gardens. Thus, it provided a useful contrasting example to the relatively widely grown species, *Stylophorum diphyllum*. Somewhat surprisingly, five respondents stated that they grew this species; all of these occurrences are less than ten years old. Three of these occurrences were obtained from

[18] In Brant County, this species occurs on Hill's oak-dominated savanna (personal observation).

commercial growers; the two growers noted by these respondents appear to be the only commercial growers offering this species for sale during this study. One of the other respondents stated that their specimen(s) came from Norfolk, a county known to have three remnant occurrences yet apparently no commercial growers of this species. The other occurrence was that of the champion hobbyist grower; this occurrence demands a more in-depth examination.

The champion hobbyist grower stated that his/her occurrence of *V. pedata* was collected from a privately-owned woodlot in Niagara Region. The presence of a presumably natural occurrence of this species in Niagara was unexpected. It is quite possible that this reported source is erroneous. As previously stated, though, the information provided by the champion hobbyist about extant occurrences, including previously undocumented occurrences, has been found to be extremely reliable. Furthermore, there are historic records of this species in the Niagara Region, although the Niagara population was believed to be extirpated; a search of remnant habitat in this region for this species in 1988 found no examples (COSEWIC, 2002b). It is noteworthy that the champion hobbyist's occurrence was grown from seed collected approximately 15 years after this search and was from an area described as a woodlot, a type of setting that may not be considered a typical type of "remnant habitat" for *V. pedata*. However, although this species is shade-intolerant, the presence of this species in relatively densely wooded areas is not uncommon: I have seen this species growing along trails in wooded areas with relatively dense canopies. In these instances, openings in the canopy were maintained by motorized vehicle activity along the trail (although this activity undoubtedly also posed a significant threat to the trailside specimens of *V. pedata*). Thus, it is not necessarily unexpected that an occurrence of *V. pedata* might be found in an area that is described as a woodlot. However, if such an occurrence is not managed to preserve this species, it should be considered vulnerable to extirpation.

It is also possible that the site where the champion hobbyist's *V. pedata* was collected did not contain this species when the last search was made in 1988 but did contain it approximately 15 years later, when the champion claims to have collected seed from the site. In Brant County, when an overgrown savanna that had never been known to contain *V. pedata* underwent a prescribed burn, this species appeared, suggesting a long persistence within the soil seed bank (Hodgins, 2009). Thus, it is possible that a population that was believed to be extirpated may reappear after site disturbance.

This rather protracted discussion about the potential legitimacy of the identified provenance of the champion hobbyist's occurrence of *V. pedata* cannot prove that there is an unidentified remnant population of this species in Niagara or that the champion hobbyist collected seeds from this population. Only documented evidence of this population can affirm the population's existence and a molecular comparison of samples from this population and the champion hobbyist's specimens would be necessary to confirm a potential relationship between the two occurrences. However, there is reason to believe the champion hobbyist's claims; enough reason to encourage further study.

7.4 Provenance Questionnaire Study: Summary and Discussion

The questionnaire part of this study suggests that the planted examples of rare species in the Carolinian zone do not represent a representative sampling of the remnant populations of the species. For both woody and herbaceous groups of species, purchased examples of species represent a minority of the occurrences; more occurrences contained either plants or propagules collected from natural or cultivated occurrences. In some cases, such as the planted examples of *Magnolia acuminata* and *Stylophorum diphyllum,* the planted examples of this species contain some or predominantly non-regional (United States) provenances. Some species, such as *Carya glabra*, were predominately grown from parent plants in areas with known remnant populations.

More woody species were reported than herbaceous species. There are a number of possible explanations for this result, although it may simply be that there are more rare Carolinian herbaceous species than rare Carolinian woody species. Thus, in a survey such as this, any one woody species may be more likely to be planted. Since the woody species occurrences were older, it may be that these species are more likely to persist over a longer period. This may be particularly relevant because the ages of occurrences reported by individual respondents often suggested periods of increased acquisition, perhaps as a property is landscaped or interest emerges or intensifies. In such cases, longer-lived species, like trees, may simply be the only remaining legacies of these periods of increased interest and/or acquisition.

The availability of the rare species in this study from commercial growers varied greatly between species. Some species, such as *Magnolia acuminata* and *Lupinus perennis*, are available from a number of different commercial growers. Many other species in this study were available from only one or two boutique growers. A few species, such as *Carya glabra* or *Frasera caroliniensis*, did not include any purchased occurrences. One relatively large boutique grower accounted for 20.7% of purchased occurrences. The relatively small number of commercial growers and the influence of one grower in particular would seem to be potentially important factors in limiting the diversity within some rare species. These factors appear particularly important in light of the cultural practices discussed earlier.

This study illustrated the extent of trading of species at risk between native plant enthusiasts. This trading can be useful in providing redundant planted occurrences or small or extirpated populations. However, since the planted occurrences observed during this study are typically very small and likely isolated from other occurrences[19], often with only one or two specimens, there would appear to be increased opportunity for inbreeding compared to plants propagated from seed collected from remnant populations.

This part of the study also highlighted the influence of one individual, described in this study as the champion hobbyist. This individual accounted for almost half (49.4%) of all occurrences which originated as trades from other growers. This undoubtedly plays a significant role in shaping the genetic character of plantings of rare Carolinian species outside of authorized conservation or species recovery efforts. Given the size and focus of the champion hobbyist's plant collection, it is unlikely that a similar influence would be experienced for more common species. There is also a possibility that other champion hobbyists exist within the Carolinian zone, although none were confirmed in this study. It may also be that such champions only emerge when there is a need within the community, such as when a champion loses interest or moves. Furthermore, this study suggests that there are species-specific champions, like the champion for *Pycnanthemum incanum*.

[19] Although this study did not involve interviews with the neighbours of native plant enthusiasts, the practice of giving away specimens of plants to neighbours and friends seems to be common. However, given the assumed proximity of neighbour's plantings and the likelihood that these plants are very closely related to the original plantings, neighbour's plantings are often little more than extensions of the same occurrence.

Chapter 8 – Conclusion

This final chapter summarizes the key findings of this research and evaluates the results within the context of the research questions outlined in Chapter 1. This chapter also examines the implications of this research on our understanding of the collecting and planting of rare floral species, and offers recommendations to better understand or facilitate practices which would promote the conservation of the diversity within rare plant species.

8.1 Summary

The first chapter established the motivation and goals for this study. It presented four research questions that were used in this research to better understand the role of collectors and growers of rare native plant species and the diversity within planted examples of these species. It also outlined the case study area used in this study: the Carolinian zone of southern Ontario. This area was chosen not only because of its large number of rare plant species but because the conservation challenges in this region demand innovative approaches in which conservation must be reconciled with human activities.

Chapter 2 outlined the conceptual framework for this research. It argued that the loss of biodiversity is a crisis which demands not just the protection of species and their habitats but the diversity within the species. It also argued that it is insufficient to conserve biodiversity within state-run conservation reserves. Instead, what is needed are flexible approaches that recognize the important roles of non-state actors and the matrix lands outside of reserves. This chapter also examined the challenges of conserving floral species within fragmented landscapes. Because of limitations in pollen and seed dispersal, isolated populations of plant species are vulnerable to demographic and genetic stochasticity. By planting these species in areas between remnant populations, existing populations may be supplemented and their genetic diversity conserved. However, very little research has been undertaken about such plantings to see if the promise of these supplemental plantings may be realized. This study chose to examine the nature of these plantings by studying the practices of those who collect and plant them.

Chapter 3 outlined the methodology used in this study. Because there was no established model for this kind of study, a variety of complementary research methods were used. Semi-structured interviews were conducted with commercial seed collectors, commercial growers, hobbyist collectors and growers, as well as a variety of conservation professionals. A survey of hobbyist growers also examined the provenances of 20 rare Carolinian species. A comprehensive study of the planted examples of *Magnolia acuminata* was also undertaken.

Since the planting of rare species is sometimes restricted by law, chapter 4 examined the legality of planting rare species. It examined the implications of the Canadian Species at Risk Act (2002) and the Ontario Endangered Species Act (2007) on the planting of species which are listed under the acts. An analysis of these acts suggested that the collecting, growing, and planting of listed plant species is illegal if the collections are made from remnant "wild" populations and/or the plants are planted close enough to remnant populations that the plantings may interbreed with the remnant populations. It was found that conservation professionals support these restrictions for a variety of reasons. However, the regulations are widely ignored. It was also shown that the planting restriction is problematic because the locations of remnant populations are generally privileged information; those planting listed species may not know if there are any nearby populations.

Chapter 5 examined the practices used by different types of collectors in accessing propagules (typically seeds) from source plants. Since guidelines have been established for the collection of tree seeds by commercial collectors in Ontario, these guidelines were examined. It was found that while the guidelines made some effort to ensure a diversity of seed sources, they emphasized the collection of seeds from trees which had qualities most desirable to the forestry industry. The guidelines also suggested that collectors avoid collecting from rare species and from stands with less than 100 specimens or poor seed set.

These guidelines were generally ignored by the collectors interviewed in this study. Not only did collectors often collect seed from rare species, often to endear themselves to their customers, they also frequently trespassed on protected or private lands to collect seeds. Collectors preferred easily accessible sites and sites with level ground and short grass, such as roadsides, arboreta, parks, or cemeteries. They also tended to return to the same seed sources each year.

Commercial growers face some of the same challenges as commercial collectors. Many growers, particularly large growers, buy seed from commercial collectors. Several growers may rely on the same collector from some species, propagating the collector's collection biases more widely. Like commercial seed collectors, growers also trespass in order to collect seed. They also tend to return to the same source plants each year. To overcome the challenges and dangers of trespassing, many growers often grow their own seed, typically establishing a very small number of source plants which are used each year. Trading of seed and plants between growers was also common. All of these practices will limit the diversity within the rare species grown by nursery operators.

The practices of non-commercial or hobbyist growers were also examined. As for commercial growers, finding information about seed/plant sources was a challenge for hobbyist growers. The sharing of information about sources was common although information about the most valued species was less widely shared. Information, seed (and other propagules) and plants were shared through a network of committed hobbyists who were widely distributed throughout the region. These hobbyists then shared with other, less committed or experienced growers. Much of the information and many of the source plants originated from one key, highly experienced individual: the champion hobbyist. This individual's knowledge about source plants as well as and his/her sharing of plants creates biases which narrow the diversity with planted populations. It was argued that although the champion's expertise is widely recognized with the hobbyist community, his/her knowledge has not been as widely accepted by conservation professionals.

Chapter 6 discussed the comprehensive study of planted examples of *Magnolia acuminata*. This part of the study was not completed because of the very large numbers of planted examples of the species and the lack of knowledge about the provenances of most of the specimens. However, this study did provide useful information which supplemented the findings of other parts of this research. For example, among those specimens whose provenance was known, it was found that a few trees were heavily used as seed sources. Mirroring the findings of the interview portion of this study, it was determined that these trees shared the characteristics valued most by seed collectors: easy access, reliable seed set and fecundity, and clean surrounding ground. It was also found that large numbers of this species are imported by nurseries from non-regional sources.

Chapter 7 examined the results of a survey of planted examples of 20 rare Carolinian species. It was found that the planted specimens in this survey do not represent a representative sample of the remnant populations within the Carolinian zone. Although some species were purchased, most specimens were either grown from collected seed (or other propagules) or acquired through trade. One individual, the hobbyist known as the champion, was the source for much of the information about where to find seed sources. The champion hobbyist also provided seeds and plants to many other enthusiasts. There was also evidence of species-specific champions: individuals who focused on championing the more widespread growing of one species.

Ultimately, this study found that the practices of commercial seed collectors, growers, and hobbyist create biases which limit the diversity within populations of planted rare species.

8.2 Revisiting the Research Question

This study sought to better understand the activities of plant and seed collectors and growers and how these activities might impact efforts to conserve rare floral species. To achieve this better understanding, four primary research questions were asked. These questions were:

1. What are the provenances of planted examples of rare Carolinian floral species?
2. What is the relationship of these planted examples to the remnant populations of the species?
3. How do seed and plant collectors and growers find, gain access to, and collect rare plants or their seeds (or other types of propagules)?

4. What are the relationships between those who collect, grow, and/or plant these species, and how do these relationships influence the character of the planted populations of rare species?

To determine if the goal of this research was accomplished, it is useful to determine what the answers to these questions are.

As suggested by the *Magnolia acuminata* provenance tracking part of this study, a comprehensive study of the planted examples of a species is extremely difficult. However, such a study may be possible for an infrequently planted species within a restricted area. As in the *M. acuminata* study, though, it is likely that there will be a significant number of occurrences for which their owners are either unable or unwilling to provide provenance information.

Despite the difficulty in undertaking a comprehensive provenance study, much was learned about the nature of the provenances of planted rare species and their relationship to the remnant “natural” populations. It is clear that planted examples of rare Carolinian species do not adequately represent the diversity within the remnant populations. Collecting and growing practices among collectors and growers of rare species favour easily accessible, well marked, and reliably productive seed sources. The same source plants are often revisited each year by commercial collectors. Growers, whether commercial growers or hobbyists, will also frequently establish small (sometimes very small) planted populations which serve as ongoing sources of propagules for plants which are to be distributed. The diversity within planted examples of many rare species is further limited by the dominance of a few key players; their source plants are heavily represented among planted populations.

Socio-economic factors have an important influence on the diversity within planted populations, at least among commercial collectors and growers. Incomes from seed collecting are extremely low. Thus, collectors must be as efficient as possible in their collecting activities. Because they allow efficient collection, easily accessible and highly productive seed sources are highly prized. The locations of these sources are typically kept secret, sometimes even from close family members. This secrecy not only makes the study of collecting activities challenging, it also sometimes leads to the loss of knowledge of these productive sources when a collector stops collecting. The need for efficiency also explains why growers, particularly boutique growers, will often establish small seed sources: it is much more efficient to collect seeds close to home than to pay for the expense of finding them. Because of the need for efficient collection of seeds, collectors and growers have little time to worry about concerns about diversity within their seeds.

The diversity within planted populations is also limited by access to knowledge: collectors and growers can only collect or grow species for which they can find seed. This information is generally proprietary and difficult to obtain. Sharing of information does occur, but the information shared is often limited in some way, repetitive (sharing the same occurrences with many different people) and conditional. Because of the difficulty in finding reliable sources of seeds or other propagules, known sources are often overexploited. These known specimens are often planted horticultural specimens which may be of non-regional provenances.

Because the overwhelmingly majority of land in the Carolinian zone is privately owned or protected public lands, gaining access to reliable source plants is problematic for collectors and growers. Thus, trespass and/or illegal collecting are common. Because of the danger in this kind of illegal activity, the quantities collected are often small. Source specimens in secluded areas are also selected where the danger of being seen and/or caught are minimized. This tends to further restrict the potential pool of source plants.

Despite collection guidelines which suggest collecting from a diversity of specimens of any species, collectors tend to collect seed from a very small number of sources. Although this is often the result of concerns about trespass or lack of knowledge about alternative sources, it is also encouraged by interest in collecting efficiently: it is far easier to collect from a small number of fecund specimens than to find and collect from many sources. Ultimately, though, these favourite occurrences, or, more commonly, favourite specimens, become heavily represented among planted occurrences.

It is apparent that there are relatively small networks of those collecting and growing rare Carolinian plant specimens for distribution. A relatively small group of commercial boutique growers relies on a small number of commercial seed collectors; several growers often obtain seed from the same collectors. Growers will also trade between each other, although the trade is uneven: one large boutique grower is a common source for other growers. Hobbyist native plant enthusiasts also obtain specimens from these commercial growers. They also trade with other hobbyist growers. Some of these trades may include monetary exchanges, others simply gifts. Although these trades typically involve plants or propagules, they sometimes involve the exchange of knowledge. As between commercial growers, trade between hobbyist growers is uneven. One champion hobbyist grower is a common source although other committed hobbyist growers are often the conduit through which the champion’s plants are distributed.

Perhaps one of the most important findings of this study is the influence of a few key individuals. The owner(s) of one of the larger boutique nurseries were not only responsible for a relatively high proportion of the occurrences reported in the survey of hobbyists, they provided propagules and plants to other growers. The owner(s) also possessed extensive knowledge of known occurrences and had access to information and conservation professionals which was either limited or restricted from other growers.

The other key individual was the hobbyist referred to in this study as the champion hobbyist grower. This hobbyist shared many of the same advantages of his/her commercial counterpart: extensive knowledge of known occurrences (although little formal access to restricted information) and a large network of connections to other growers and hobbyists. The champion appears to play an important role in shaping the genetic diversity of the planted populations of many rare species. This is achieved partly through the distribution of plants and propagules from his/her collection. Since the champion has relatively few specimens of any species, this distribution would likely represent limited genetic diversity. The champion also distributes information to other enthusiasts about where to find rare species. Although this information is sometimes about the same provenance as the champion hobbyist's specimens of the species, the champion's stated tendency to provide information about the same occurrences would also tend to limit the diversity within the planted population of some rare Carolinian species.

Ultimately, this study suggests that planted occurrences of rare Carolinian plant species represent a biased sampling of the natural population. Non-regional provenances of some species are also common. Therefore, this study suggests that the diversity within the planted population of these species, as a group, is quite different from the remnant populations.

8.3 Implications

This study was ultimately motivated by the need to conserve the floral diversity of the Carolinian zone. It focused on rare species because they are, presumably, most at risk of loss. An earlier study (see Morris, 2005) found that a wide variety of rare Carolinian floral species were being grown by rural landowners and suggested that such plantings may constitute *ex-situ* populations that could potentially offer increased demographic security for the species. This is not a trivial consideration; demographic security must be considered of primary importance in the conservation of rare species (Lacy, 1988). However, rarity is not necessarily an intrinsic characteristic of most rare Carolinian floral species; most are much more common and widespread within their main ranges within the United States. Thus, their rarity could be seen as little more than an aberration created by political boundaries and of little ecological consequence. As previously discussed, though, Carolinian species are typically at the northern margins of their ranges and marginal populations generally contain a disproportionate amount of the genetic diversity within the species (Millar & Libby, 1991). Therefore, given the imperative to conserve biodiversity, it is not sufficient to merely conserve Carolinian species; the genetic diversity of the species must be conserved. Consequently, this study attempted to examine whether there is reason to believe that planted examples of rare Carolinian species capture the diversity within the species.

The collecting and growing of rare plant species by those outside of formal conservation institutions has been poorly understood and not commonly studied before this research. Thus, claims like Rosenzweig's (2003a) suggestion that the seed collectors frequently collect from protected plant species, were unsupported. This study can now provide support to such a claim, albeit with the qualification that not all rare or protected species are equally of interest to collectors. Rosenzweig (2003a) also claimed that such collections constitute an important form of reconciliation ecology. This study cannot offer support to such a claim. Certainly, it appears that the planting of rare species outside of recognized recovery programs do, by their mere existence, contribute a degree of demographic security to the species within the region. However, since these plantings represent a narrow selection of the remnant population and/or represent introduced genetic lines, the conservation value in protecting local or regional genetic diversity must be questioned.

This study supplements our understanding of the important role of humans in long distance dispersal of plants. Hodkinson and Thompson (1997) identified humans as currently being “a major (perhaps *the* major) dispersal vector” (p.1492) for plants. Often, though, the focus of research about anthropogenic long distance dispersal in plants has been on inadvertent plant dispersal and/or plant invasions (see, for example, Hodkinson & Thompson, 1997; Mack & Lonsdale, 2001; Reichard & White, 2001). Less well understood is the purposeful long distance dispersal of plants that do not become invasive. This study not only supplements our knowledge about the purposeful dispersal of plants, it provides some understanding about the factors which help determine which individuals within a population or region will be chosen for human-assisted dispersal.

Assisted or facilitated dispersal by humans has increasingly been recognized as a useful adaptive strategy to help plant species to track their climatic niches as these niches move to higher altitudes and/or latitudes in response to anthropogenic climate change (Aitken et al., 2008; Bower & Aitken, 2008; Woodall et al., 2010). While this study neither supports nor refutes the necessity for facilitated migration, it does offer important caveats that must be addressed if and/or when facilitated migration is undertaken. The results of this study suggest that for some species, collection and growing practices will limit the diversity within newly established populations. It also suggests that modifying these practices in order to capture a more representative diversity within species will likely be difficult.

This study has implications for species at risk legislation. For example, Ontario's Endangered Species Act (2007) prohibits the collecting of propagules from "wild" specimens yet permits the propagation of specimens that are not in the "wild" as long as they are planted in locations where they will not "compromise the genetic integrity of wild populations" (Endangered Species Act – Ontario Regulation 242/08, 2007). This is problematic because it encourages greater representation of a few easily accessible or horticultural provenances within the planted populations. It may also encourage the importation of non-regional provenances from jurisdictions where the species is not protected. The restriction preventing the planting of listed species in places where they might interbreed with remnant populations is also problematic because the location of remnant occurrences is typically privileged information; those planting rare species must be able to know where the "wild" occurrences are in order to avoid planting close to them. Equally concerning is that these restrictions on the collecting and planting of plant species at risk criminalize behaviour which may otherwise be consistent with the goals of the legislation. Existing species at risk legislation should at least recognize these implications in their enforcement of the regulations. Future legislation should address them directly.

This research also has implications for ecological restoration managers who rely on outside sources of plants and/or seeds. Many of the practices of commercial collectors and growers noted in this study are also used when collecting and growing more common species.

Thus, the genetic diversity within the seeds or specimens of even a common species obtained from a single supplier may be limited. Since collectors generally return to preferred (i.e. reliably fecund, easily accessed, convenient and safe) collection locations, this limitation in diversity may persist over a number of years. Although the overall impact of this limited diversity may be less profound for common species than for rare species, it could impact the outcome or success of specific restoration projects.

This study also has implications for hobbyist growers of native plants. As suggested in Morris (2005), hobbyist growers are often attracted to native species because they seem more "natural" or regionally appropriate than cultivated plants. However, the practices noted in this study, such as the use of cultivated seed plants by commercial growers and the trading of seed or plants with other hobbyist growers may make these plants distinctly different from their "wild" counterparts. Cultivation, whether in a nursery or a garden, imposes selective pressures on the plants (Barrett & Kuhn, 1991): the qualities that all plants require to survive, flourish, and set seed under cultivation are often qualitatively different from those which favour survival under "natural" conditions. Thus, over several generations, a species may become increasingly domesticated. In the long term, though, this may be beneficial for the species' survival within a settled landscape.

The results of this study also have implications for the management of plant species at risk. The collection of plant species at risk and/or their seeds is already recognized as a risk factor in many federal and provincial species status reports and recovery strategies. Few, if any, such management strategies recognize the biases in unauthorized collection which may impose selective pressures on certain specimens or populations. While some management strategies recognize that interaction between remnant occurrences of a species at risk with planted occurrences of the species may occur, lack of understanding about the nature or location of the planted occurrences has prevented managers from making informed decisions about these interactions. Although this study has suggested that comprehensive provenance tracking for a species may be impractical, it does suggest that it may be possible to identify the provenances of the species of interest which are grown by key commercial growers and champion hobbyist growers. It may also be possible to influence the practices of these key individuals, not through prohibitions but through assistance.

This study may also allow conservation managers to better understand the potential value of planted occurrences of rare species, including those in gardens. As suggested in this study, such occurrences may contain the living legacies of extinct populations, even those populations whose existence had not previously been recognized. Because of the active management of the hobbyists/gardener, such populations are able to persist in remarkable low numbers, even in the face of genetic bottlenecks which might imperil "wild" populations (Thompson et al., 2003). Exploiting these legacies for their genetic heritage, of course, requires finding them. Although this study suggests that this can be challenging and time consuming, the benefit may be worth the effort.

8.4 Limitations

The use of a case study inevitably raises questions about the findings' broader application. Although many of the findings may have wide application, there are some limitations that must be recognized.

The practices of the collectors and growers may vary with the socio-cultural, economic and political context of the region in which their activities occur. For example, differences within and between legal system may be important. Within the Carolinian zone of southern Ontario, some flexibility and ambiguity within the federal and provincial species at risk legislations allows the growing of protected plant species. However, stricter prohibitions and/or changes in enforcement priorities could potentially further restrict these activities or make them more covert. Similarly, since different jurisdictions will have different legal frameworks for dealing with species at risk (or none at all), the actions of collectors and growers of rare plants may be quite different elsewhere. Social mores and laws about private property and trespass may also be important variables.

A variety of social attitudes, cultural preferences, and economic factors can also potentially limit the broader application of this study's findings. Interest in environmental issues and the conservation of nature varies between cultures and through time. Changes in the economy will also shape this interest, as well as the ability to express this interest.

Although those species which are rare vary between places, almost all regions will have some species which are native but regionally rare. The species examined in this study were all rare within the Carolinian zone where they were all at the margin of their ranges. Many of these species, though, are common within the main parts of the ranges within the United States. In these areas, species-specific details about collecting and growing activities may be quite different. The species chosen for this survey were also chosen using criteria described earlier. The conclusions drawn from this study may not apply to some other rare species, such as those with different aesthetic characteristics or more complicated methods of propagation.

The study also highlighted the importance of key individuals, such as the champion hobbyist grower. Although there were indications that new champions are emerging and there were hints of other champions in other regions, the presence of such a key individual may be spatially and temporally unique. Similar studies in other regions and at other times would be useful in establishing whether or not the emergence of such key individuals is common.

8.5 Recommendations

This study was undertaken under the assumption that the planting of rare species, whether through authorized conservation programs or uncoordinated efforts, was potentially desirable. The assumption was that such plantings may constitute ex-situ collections which may supplement remnant populations, maintain gene flow to otherwise isolated populations, and provide educational opportunities to highlight those species which demand increased attention. The findings of this study do not necessarily challenge these assumptions. However, it is apparent that the socio-political context of these plantings, as well as the practices of collectors and growers of rare species, likely limits the diversity within and between these plantings in ways which should raise questions about their conservation value. If there is even a possibility that, as Ontario's Endangered Species Act worries, such plantings might "compromise the genetic integrity of wild populations," their conservation value should be re-evaluated. Ultimately, though, this study did not intend to determine whether the benefits of such plantings outweigh the potential harm that they could do.

Perhaps a precautionary approach would be justified; in the absence of proof that such plantings do not harm remnant populations, perhaps all such plantings should be forbidden by law. Such laws may have some utility in preventing harm to some species, but would undoubtedly require vigorous enforcement for, as the study has shown, unauthorized plantings of rare species already often involve law-breaking, either through trespass or interfering with protected species. Such laws also risk alienating groups that traditionally support conservation efforts. It also risks losing some of the benefits identified in this study: for example, some of the champion hobbyist's plantings may represent the only living legacies of extinct populations. Thus, the precautionary banning of such plantings would not only short-sightedly dismiss the benefits of such plantings, it would seem to be both impractical and costly.

An alternative approach might be to assure that such plantings are made in the most beneficial places with the most appropriate provenances. However, such an approach would undoubtedly require considerable effort and demand considerable resources. The expense could, of course, be recovered through some kind of licensing fee, but this would also likely increase the bureaucratic burden and divert attention from other pressing conservation issues.

Perhaps a simpler and less costly way to help improve the representativeness of the genetic diversity with such collections might be to exploit our understanding of the collection and distribution system for rare (and more common) Carolinian plants. The following recommendations reflect this approach.

Wherever possible, plant a diversity of provenances of a species in readily accessible, public places often favoured by seed collectors. Public plantings of some species at risk, such as *Magnolia acuminata*, are already relatively common and often serve an educational purpose. However, as suggested by the grove of *M. acuminata* specimens at the Royal Botanical Gardens grown from a single seed source, such plantings may currently contain little diversity. Since seed collectors prefer sources which are relatively conveniently located, it may be possible to make such plantings representative of local populations. Such plantings would need to have relatively short surrounding lines of sight so that collectors would feel secure in their collecting activities. Since access to knowledge about seed sources is an important limiting factor in the diversity of collections, knowledge about such public plantings would need to be easily available. The Internet makes this relatively easy and, like the plantings themselves, could be presented as educational materials about native species.

To avoid over-collection from certain, easily accessible remnant specimens of species-at-risk, all external markings should be removed. Although such markings are undoubtedly meant to aide in ongoing monitoring of the species, they are also used by collectors to find species.

Wherever possible, key collectors and growers should be identified and their activities should be constructively guided. Since a few key individuals, such as the champion hobbyist and the owner(s) of the one of the most popular boutique nurseries, play an important role in shaping the nature of the planted populations of some species, their efforts should be facilitated in a manner which is consistent with the goal of protecting regional genetic diversity. However, providing material assistance to such individuals might be politically untenable and difficult to maintain financially. Furthermore, by the time such individuals have emerged as “champions,” their collections are likely already established. It also might be difficult to provide advice to these key players because it is quite likely that they would resent being offered advice by someone who might have less experience but more formal credentials than them. This has certainly been the case with the champion hobbyist; he/she suggests that most conservation professionals and researchers are little more than dilettantes. Ultimately, facilitation of these key individuals’ efforts would have to be through the slow development of relationships with them. Such efforts would also have to remain watchful of the native plant growing community in order to notice the emergence of other champions. Such efforts need not be expensive or burdensome. They would, however, demand an ongoing effort, an unthreatening manner, and a demonstrable knowledge of local species.

When genetic diversity within planned plantings is an important consideration, as in facilitated migration programs or ecological restoration projects, collection activities should be monitored. It is not sufficient to have collection guidelines or protocols. Collectors already disregard established protocols in order to achieve efficiencies in their collection activities. Although the establishment of a comprehensive seed collection monitoring program could potentially ensure greater compliance with collection guidelines, it would likely be relatively expensive and/or bureaucratically complex. However, for planting projects where the maintenance of genetic diversity is of paramount importance, the establishment of limited, short-term monitoring programs may be useful. These programs may be as simple as requiring observers to accompany collectors on their activities. Care would have to be taken to avoid alienating collectors, though.

If collection activities cannot be monitored, ecological restoration project managers should consider using several suppliers for plants and/or seeds for each species for a project. Unless an ecological restoration manager has specific guidelines for a restoration project, it may be desirable to use seeds and/or plants from different suppliers to ensure an adequate level of genetic diversity to ensure long-term success.

There should be further research into the nature of the planted populations of rare species in the Carolinian zone and elsewhere. Such studies may include molecular studies to determine a detailed understanding of the representativeness of planted examples of a species. Given the practices examined in this study, though, it is likely that the occurrences of many if not most species would constitute a biased sampling of extant populations and/or individuals. However, from a management perspective, a species-specific molecular study may be useful for identifying potential sources of contamination around an at-risk population.

The final recommendation to come out of this study may be the most straightforward to implement. **It should be recognized that those collecting and growing rare species outside of recognized recovery efforts are having an influence on the diversity within the species**. Conservation efforts and recovery strategies should recognize this influence. Such recognition should not be limited to those dealing with rare species, though. Conservation professionals, particularly those involved in ecological restoration, should recognize that many of the practices highlighted in this study would likely also influence the diversity within plantings of more common species. Although the implications of these practices for a common species may be less significant than for a rare species, they may influence the long-term success of sites or projects.

The practices of those involved in collecting and growing plant species may have a significant role on the conservation of those species. Conservation managers should be aware of this influence and try to ensure that it works for the long-term benefit of the species.

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Appendices

Appendix 1: Information Letter Accompanying Survey

Carolinian Rare Plant Provenance Survey

If you have grown any of the rare Carolinian plant species listed on the following page, your help would be an invaluable assistance in this study.   If you would like to participate, you will be asked to provide some information about your examples of these plants. There are only three parts to this questionnaire:

1) You will first be asked to provide the **address or location of the plantings** in as much precision as you are comfortable in providing. If you have planted any of these species in other locations, please indicate the location when asked specifically about that species.

2) For each plant species, you will then be asked **the source of the plant and the approximate age** of your plant. If you grew the plant yourself, this would be the location from which the seed or cutting was collected. This could include a wild population, a plant in a park or along a street, or a friend's garden. If you purchased the plant or seed, please indicate the name of the nursery or seed supplier. If you obtained the seeds or plants from a friend, simply state say that it is a friend. Please do not provide the name of this friend without their expressed permission. If you have received seed or plants from a friend, it would be quite helpful if we could contact you to discussion how permission might be sought to speak to this friend (see next section).

   Also, please indicate if you grew the plant from seed, a cutting, or as a plant.

3) Finally, you will be asked if you would agree to talk about your plantings in greater depth. If so, you will be asked to provide contact information (e.g. phone number, email address). If you have listed a friend as the source of some of your plants and would like to discuss how permission might be sought to talk to this friend, this is where you would provide your preferred contact information.

All information provided will be treated as **STRICTLY CONFIDENTIAL**. Please see the information sheet for further information.

Once you have completed the survey, please return in the stamped, addressed envelope provided.

If you have any questions or concerns about this survey, please contact me.

David N. Morris,
Department of Geography,
University of Waterloo,
Waterloo, Ontario.
Email: dnmorris@fes.uwaterloo.ca

Appendix 2: Survey

Carolinian Rare Plant Provenance Survey

All information provided will be treated as **STRICTLY CONFIDENTIAL**

1) What is the location or address of your plantings? Please be as precise as you are comfortable in providing. If some of the plantings are in other locations, please indicate when asked specifically about that species.

Note: This page will be stored separately from the species information to ensure your anonymity.

2) Sources of plants : Please be as precise as you are comfortable in providing (e.g. grown from seed collected near Pelham; purchased from XYZ Native Plant Nursery; given to me a friend; grown by me from seed from a friend)

Trees and Shrubs

Pawpaw (*Asimina triloba*)
Source: ____
Approximate age of plant (best guess) ________________________

Sweet Pignut Hickory (*Carya glabra*)
Source: ____
Approximate age of plant (best guess) ________________________

American Chestnut (*Castanea dentata*)
Source: ____
Approximate age of plant (best guess) ________________________

Dwarf Hackberry (*Celtis tenuifolia*)
Source: ____
Approximate age of plant (best guess) ________________________

Burning Bush (*Euonymus atropurpurea*)
Source: ____
Approximate age of plant (best guess) ________________________

Cucumber Tree (*Magnolia acuminata*)
Source: ____
Approximate age of plant (best guess) ________________________

Red Mulberry (*Morus rubra*)
Source: ____
Approximate age of plant (best guess) ________________________

Black Gum (*Nyssa sylvatica*)
Source: ____
Approximate age of plant (best guess) ________________________

Common Hoptree (*Ptelea trifoliata*)
Source: ____
Approximate age of plant (best guess) ________________________

Dwarf Chinquapin Oak (*Quercus prinoides*)
Source: ____
Approximate age of plant (best guess) ________________________

Herbacious Plants

Green Dragon (*Arisaema dracontium*)
Source: ______________________________
Approximate age of plant (best guess) ______________________

Purple Milkweed (*Asclepias purpurascens*)
Source: ______________________________
Approximate age of plant (best guess) ______________________

American Columbo (*Frasera caroliniensis*)
Source: ______________________________
Approximate age of plant (best guess) ______________________

Eastern Yellow Star-grass (*Hypoxis hirsute*)
Source: ______________________________
Approximate age of plant (best guess) ______________________

Slender Bush Clover (*Lespedeza virginica*)
Source: ______________________________
Approximate age of plant (best guess) ______________________

Wild Lupine (*Lupinus perennis*)
Source: ______________________________
Approximate age of plant (best guess) ______________________

Virginia Bluebells (*Mertensia virginica*)
Source: ______________________________
Approximate age of plant (best guess) ______________________

Hoary Mountain-mint (*Pycnanthemum incanum*)
Source: ______________________________
Approximate age of plant (best guess) ______________________

Wood-poppy (*Stylophorum diphyllum*)
Source: ______________________________
Approximate age of plant (best guess) ______________________

Bird's-foot Violet (*Viola pedata*)
Source: ______________________________
Approximate age of plant (best guess) ______________________

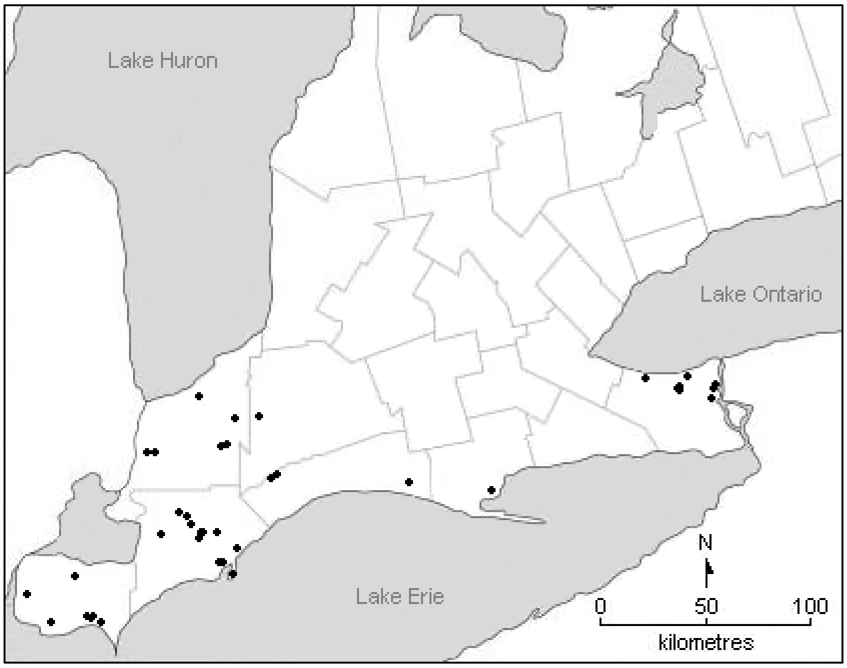
3) If you are interested in talking in greater detail about the sources of your rare Carolinian plants, including those not listed here, please provide contact information (telephone number, email address). Also, feel free to offer any comments in the space below.

The results of this study will be published upon completion of this study.
Thank you for your participation.

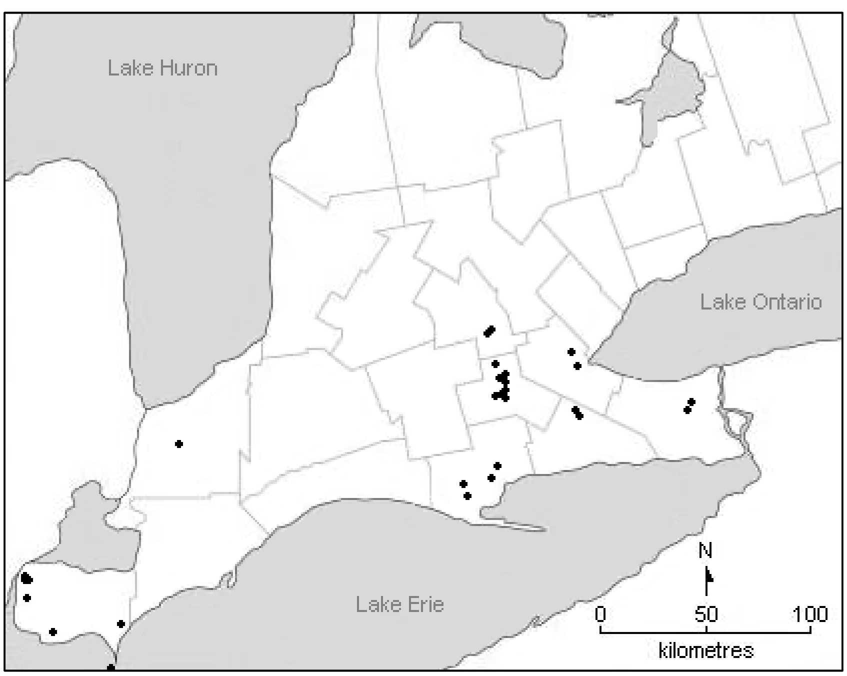
Appendix 3 - Known Natural Occurrences of Species in Provenance Survey

All occurrences reflect extant occurrences within the Carolinian Zone as listed by the Natural Heritage Information Centre of Ontario's Ministry of Natural Resources.

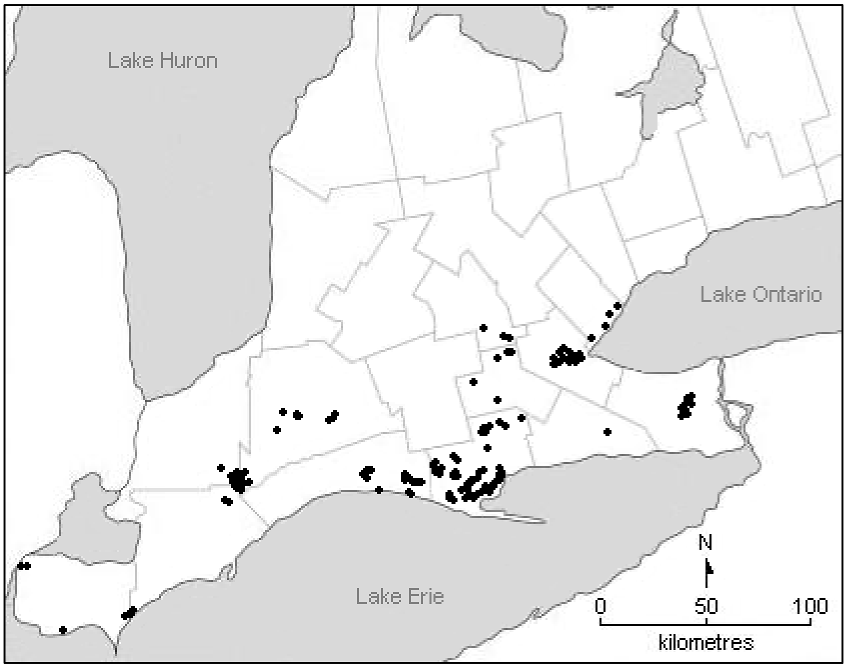
Woody Species



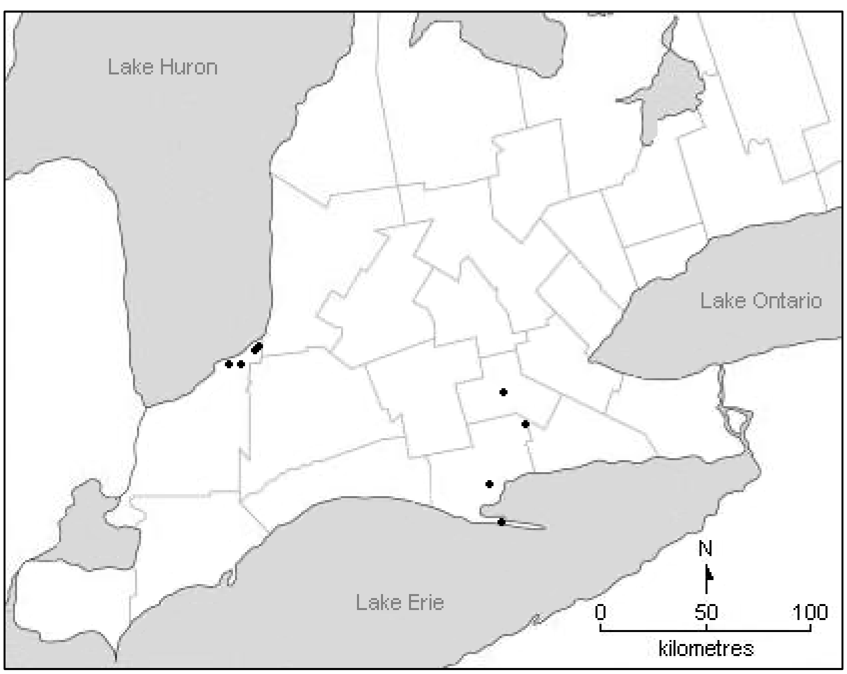
Asimina triloba (above)



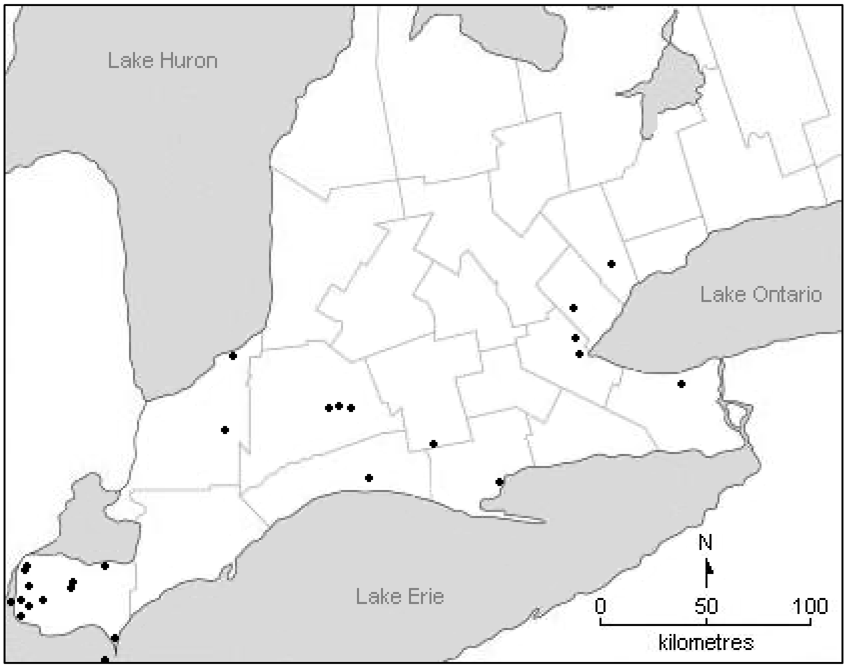
Carya glabra



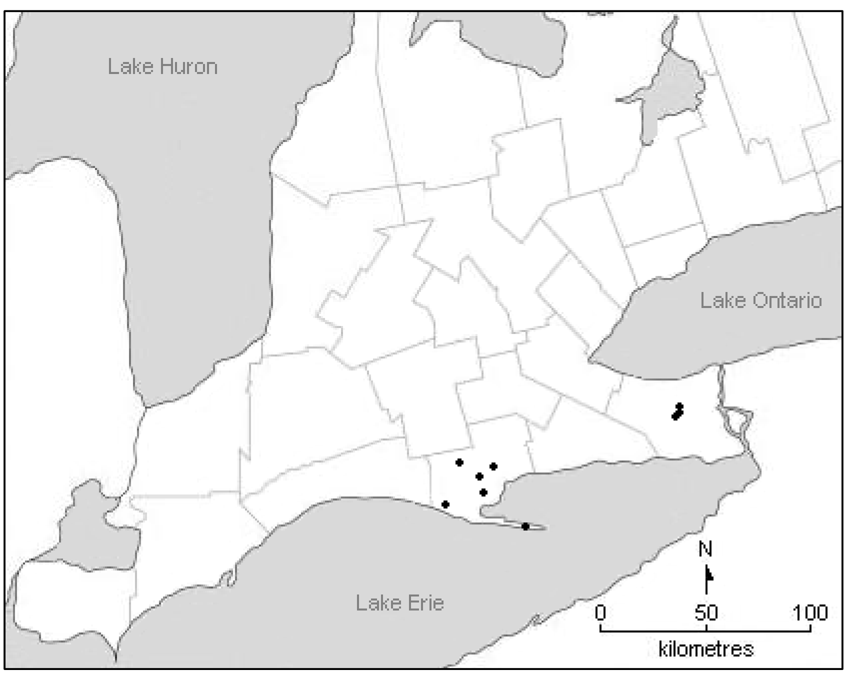
Castanea dentata



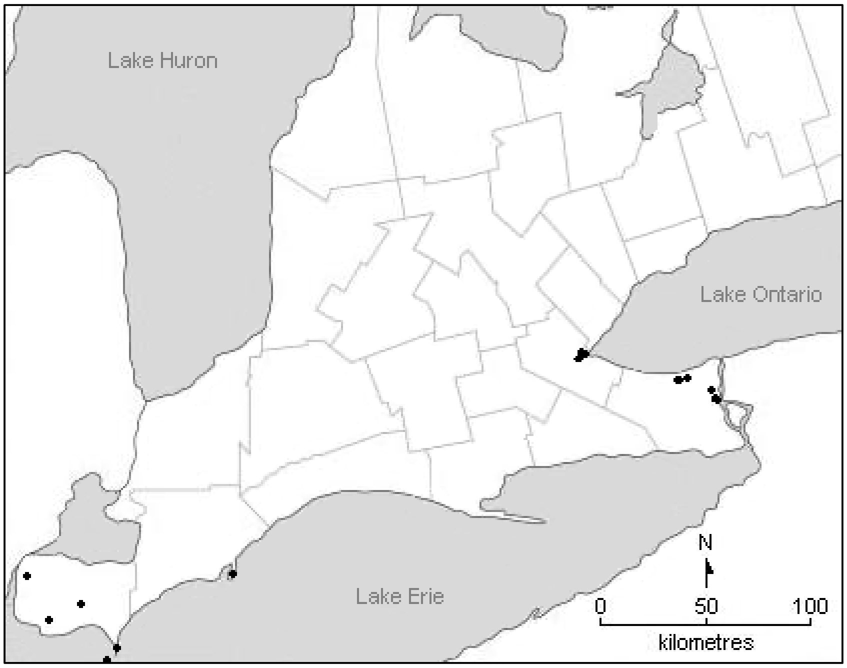
Celtis tenufolia



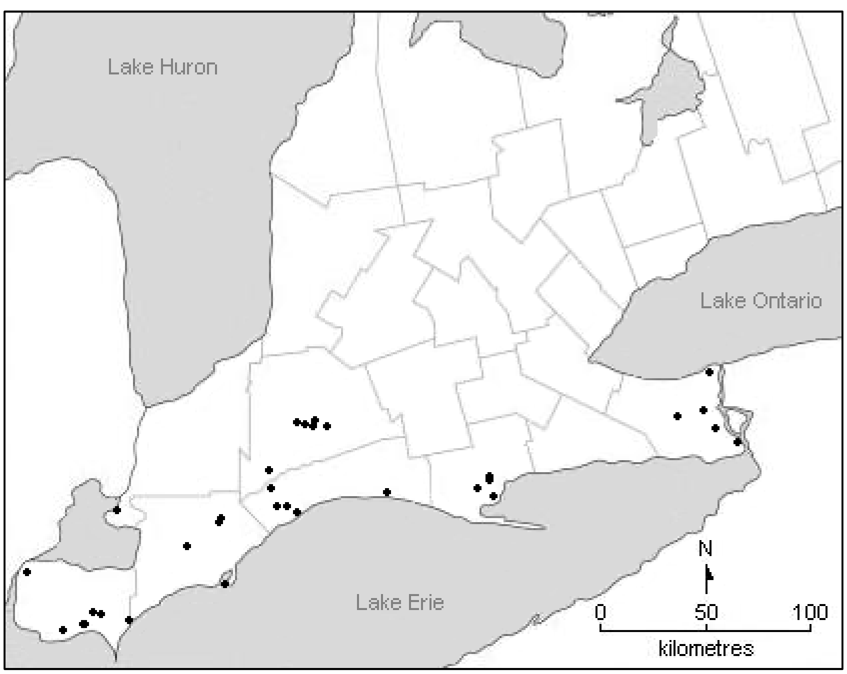
Euonymus atropurpurea



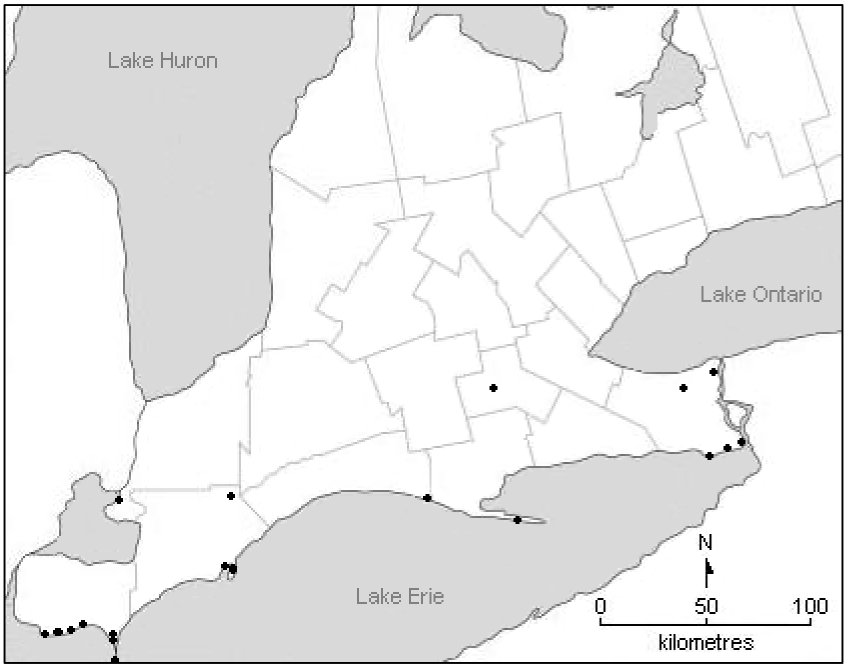
Magnolia acuminata



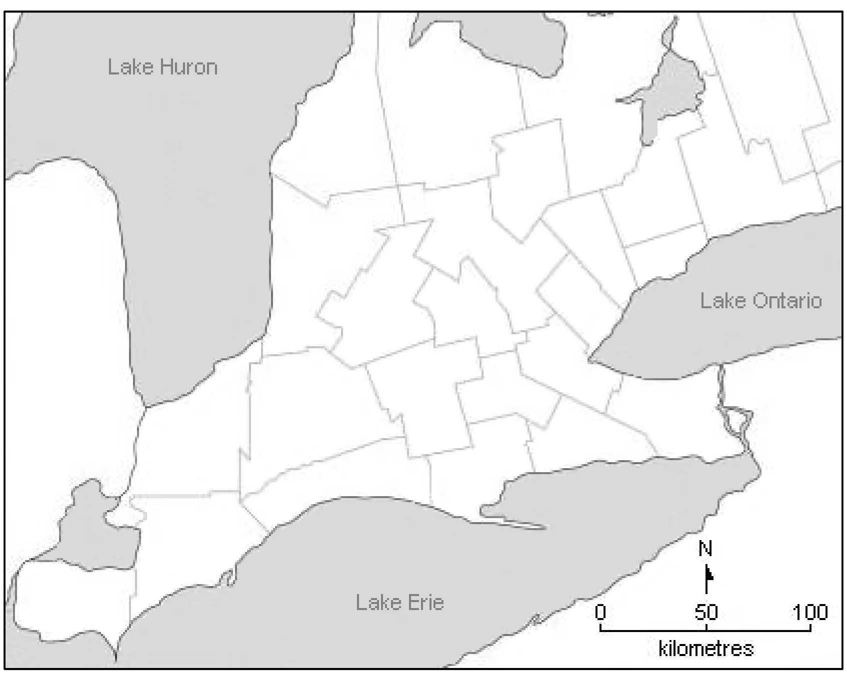
Morus rubra



Nyssa sylvatica

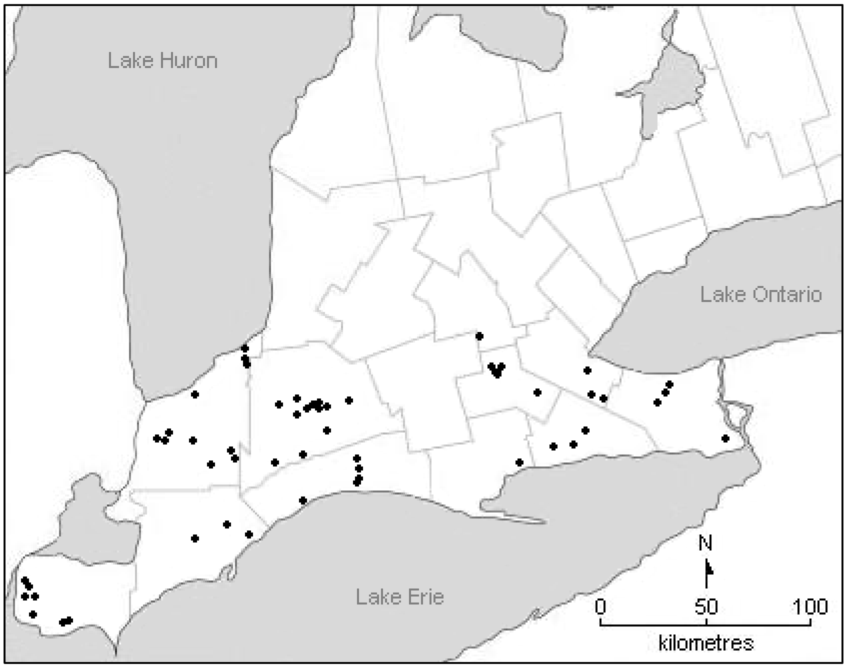


Ptelea trifoliata

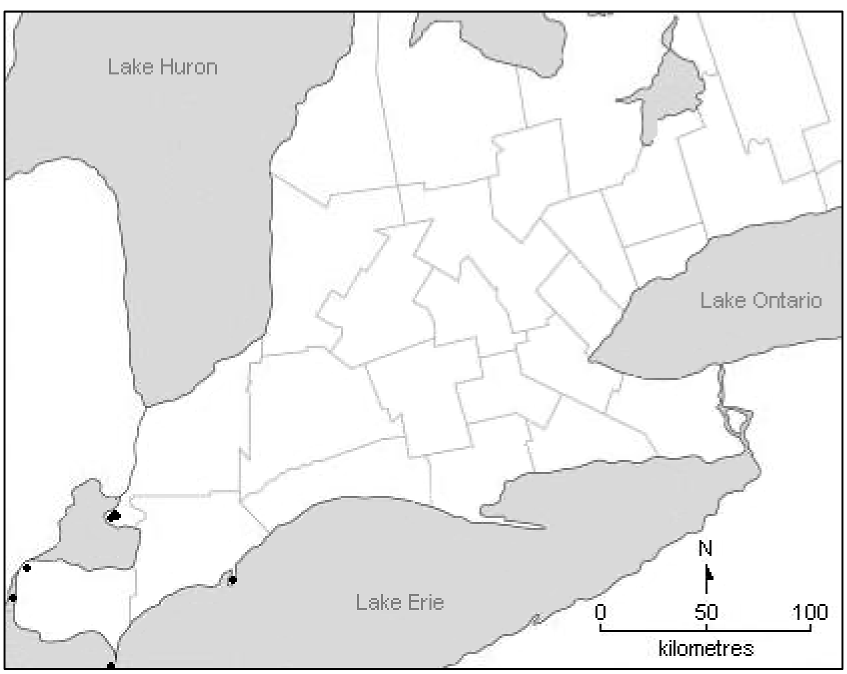


Quercus prinoides

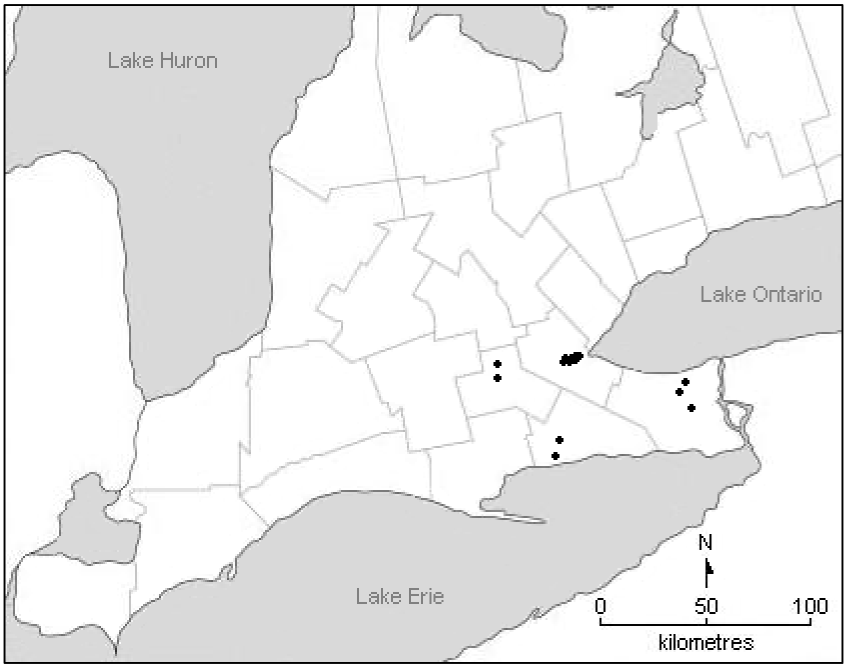
Herbaceous Species



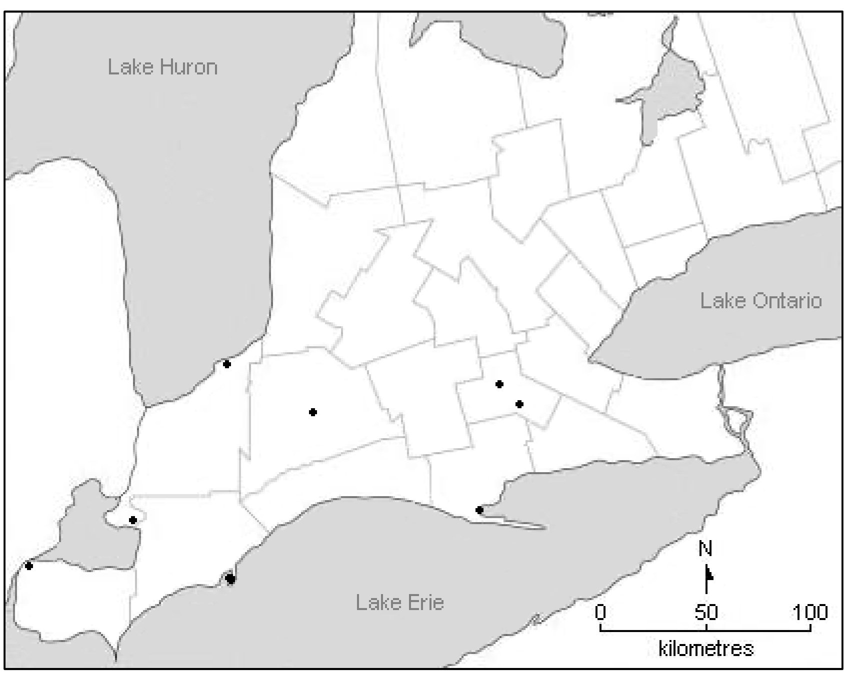
Arisaema dracontium



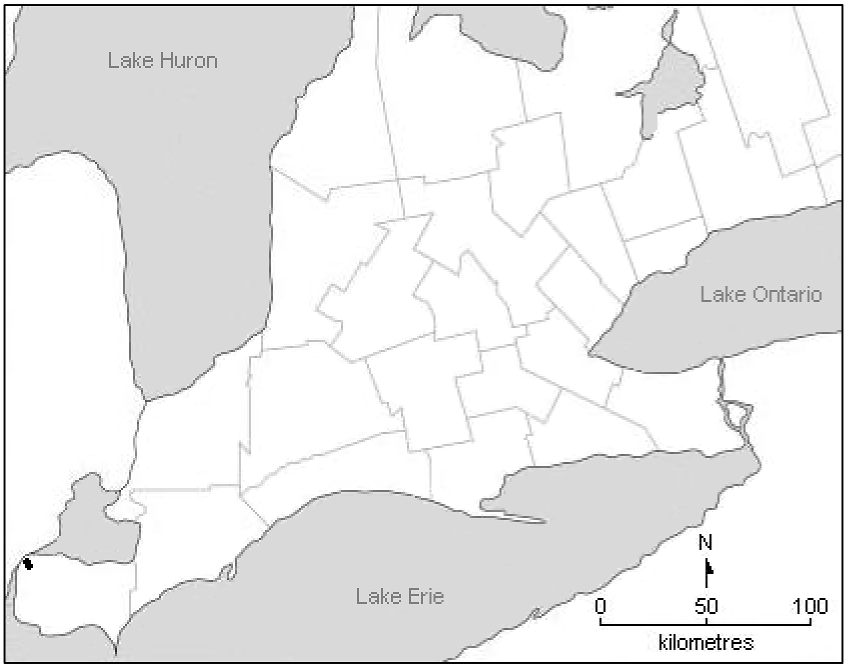
Asclepias purpurascens



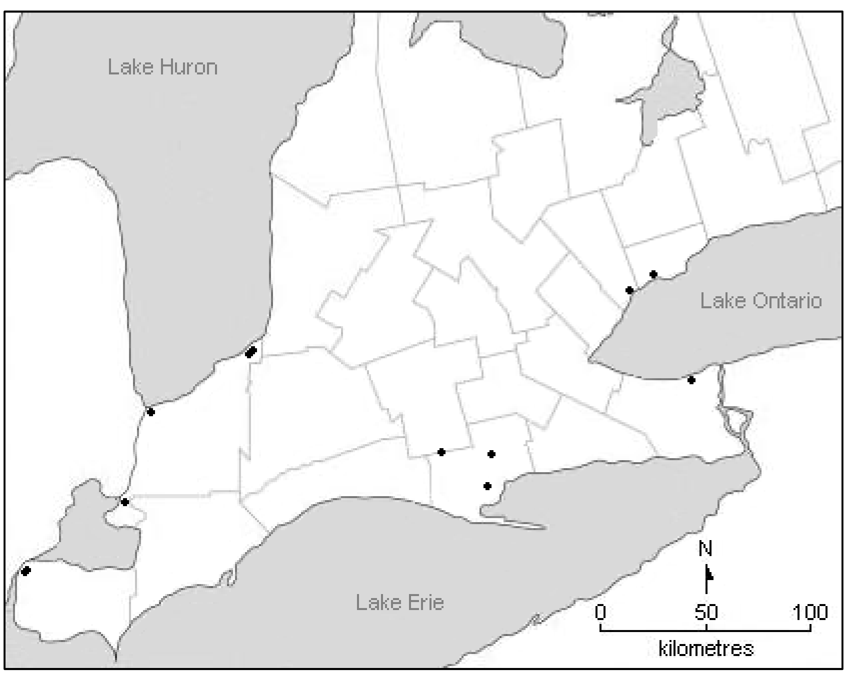
Frasera caroliniensis



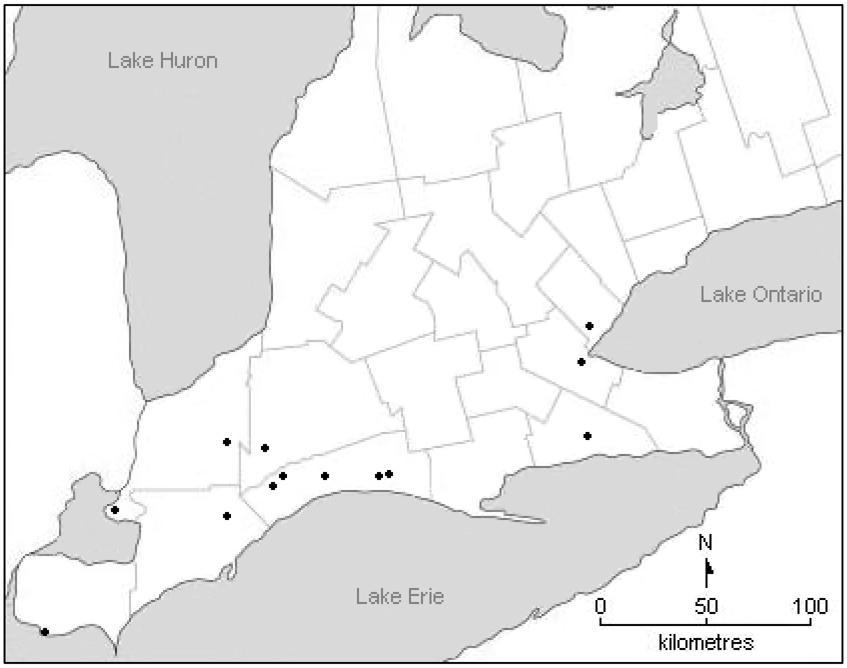
Hypoxis hirsuta



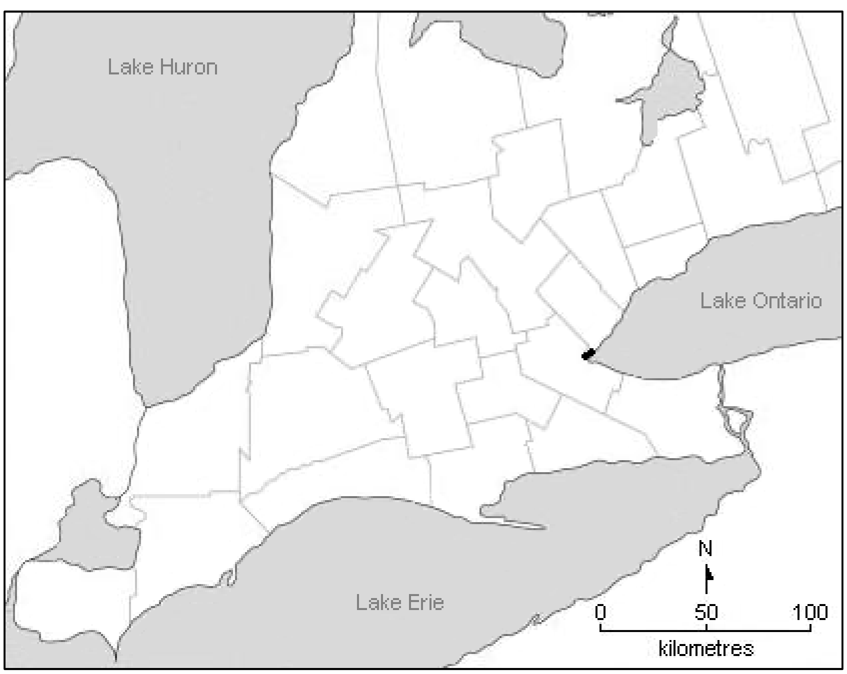
Lespedeza virginica



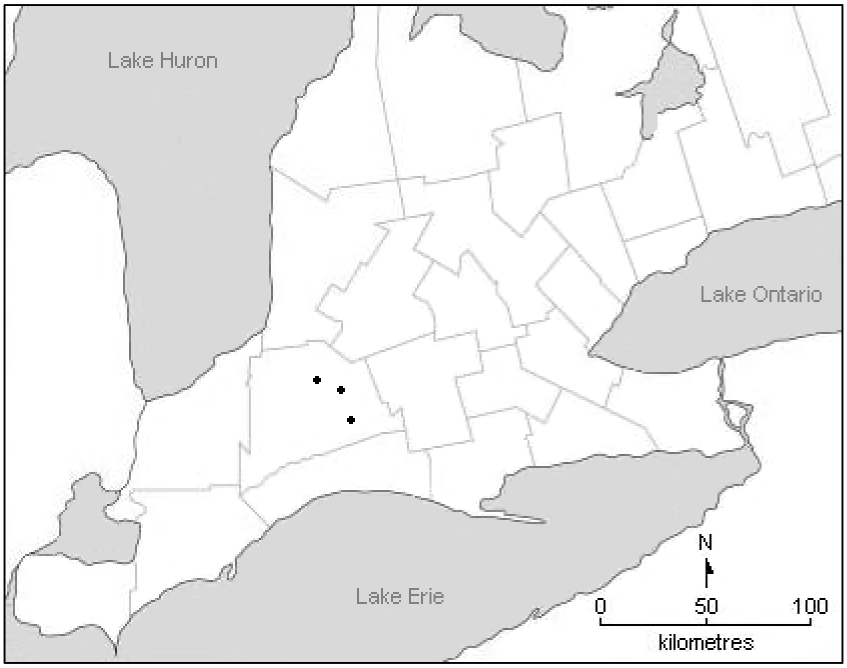
Lupinus perennis



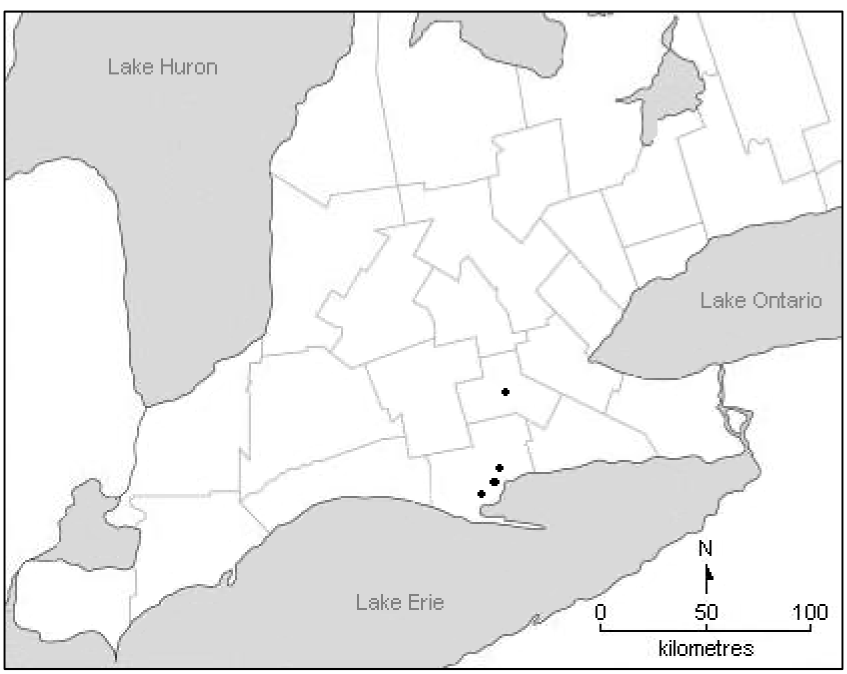
Mertensia virginica



Pycnanthemum incanum



Stylophorum diphyllum



Viola pedata