The Descendants of Giants:

In Search of Exemplary Specimens of At Risk Trees in Southern Ontario's Oak Ridges Moraine

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Foreword: Regarding Conservation

Popular science is the conceptual framework in which I have situated all my work at York University. Continuing in that spirit, I have written this report in the hope that it might be readable and accessible to anyone with an interest in trees and forests. I have long been drawn to the concept of communicating seemingly complex environmental realities to the general public in simple yet incontrovertible terms. This desire stems from my conviction that a public that understands the importance of a healthy natural environment will begin to demand that actions be taken to conserve or augment environmental health.

Little ecological research comparable to the work that I have conducted in the pursuit of my masters degree has been undertaken in the Carolinian zone of southern Ontario. Trees Ontario maintains the online “Ontario Heritage Tree Program,” in which members of the public can nominate a tree that is noteworthy for some extraordinary aspect of its physiology, its old age, its role as a community landmark, or its association with a historical event or person (Trees Ontario, 2013). The list of heritage trees compiled thus far is rather disappointing even to casual observers, and most are noted not for their extraordinary genes, but for where they happen to be situated. The Ontario Forestry Association maintains “The Honour Roll of Ontario Trees,” which catalogues the tallest known specimens of each native tree species in the province (OFA, 2013). Unfortunately, most of the trees on the honour roll were measured and registered decades ago. Many more of the trees are clearly not even close to being amongst the largest specimens in the province, and it is apparent that it is simply a lack of awareness or interest that has prevented larger trees from being registered in the case of certain species.

I undertook this work simply because information on the location, health, and abundance of at risk trees in Ontario's protected areas is not available in any semblance of uniformity or comprehensiveness. A patchwork of tree conservation organizations in Ontario has accumulated piecemeal data on rare trees in isolated protected areas, but this data can be harder to locate than the trees themselves. When managing a natural resource, a first and critical step in the process is taking stock of that resource. Finding information on where to locate at risk species or vibrant, healthy forest stands is exceedingly difficult. There are but a few key places in Ontario which one can visit to see at risk and rare tree species (Royal Botanical Gardens in Burlington and the University of Guelph's arboretum come to mind), but beyond these there is little in the way of publicly available resources on tree locations, numbers, health, etc. Perhaps in the not-too-distant future humanity will develop some kind of drone technology that will be able to efficiently take comprehensive forest inventories, identifying the species, dimensions, and perhaps even health of every tree on a given piece of land. Until such a time comes, however, we need to acquire a better understanding of where the rare tree species are so we can better strategize their management. There are many individuals out there who know a great deal about their local forests, they may know where at risk individuals are, or where exemplary specimens are, but they have little available means to share their knowledge and contribute positively to forest management and conservation efforts. Just as the provincial government asks fishers who target vulnerable species to log their catches in order to inform conservation strategies, the provincial government should take advantage of the existing knowledge (and free labour) of the general public as well as people who work in the forestry, resource management , and conservation sectors. A central database for the results of forest surveys with a simple and easily replicable methodology like the one I have developed through this work would be of great help to all forest conservation and restoration efforts. In addition to logging (as in cataloguing—not harvesting, of course) individuals from rare or at risk species, I would also recommend that a simple schema be set up for logging forest type (e.g., maple-beech) and approximate age at every surveyed area—a schema which would capture the dominant species in a given stand, as well as make general notes about the local health of species who are susceptible to ill-health and/or pathogens (e.g., white elm, ash, beech).

When the idea for this research project first dawned on me, I thought that surely there must be more left of the Carolinian than I had learned about in my forestry courses and readings. I thought that perhaps the experts had just not looked hard enough for champion trees, that surely there were ancient giants out there still waiting to be discovered and mapped and written about. But the truth is the experts were right—the Carolinian forests of southern Ontario are for the most part dead and gone, and a mere inkling of their former grandeur remains. Some genes remain, sure, a few lucky alleles from the ancient giants are still floating around here and there, but intact, pristine, old growth forests are nowhere to be found. So what can we, as those with a desire to conserve what remains, do?

Regarding conservation, we cannot simply fence off a select number of areas as sanctuaries from human meddling, for we have meddled far too much already and have left scars so deep they cannot heal on their own. If we value and respect natural systems enough to acknowledge their vital role in the maintenance of a functioning biosphere, if we have learned that human societies cannot prosper without a flourishing natural world, and if we accept that we have brought our natural systems to the brink of irreparable ruin, then we must take the fate of those systems in our hands in a conscious and calculating way and give that fate a fighting chance.

Every conservationist seems bound to experience more failure than success. For the most part it is a thankless task, and especially so in the case of plants that can live for millennia, and can take decades to reach maturity. It is a task, however, that somebody, some group of people, must undertake if we hope to continue sharing this planet with such a rich diversity of fellow species. The diversity of tree species that once occupied the wide expanses of southern Ontario is dwindling fast, and will continue to dwindle unchecked unless we decide that they deserve to co-exist alongside us. Making that decision is the easy part of the conservationist ethic. The hard part is figuring out what exactly to do once the decision has been made.

I have made my decision—the easy one of course. From here, I have to chart a course to figure out how to use what little time and effort I have to give to effectuate whatever change for the better I can. There are many others who too have made the easy decision, and many still who have made the harder one, and finding ways to combine our time and efforts is surely a defining part of our collective struggle. I just hope that enough people decide that conservation is a worthy and crucial struggle of which to be a part so that we can form a critical mass that can turn the tide of destruction and harness our collective passion and ingenuity to bring about a future in which all species and all ecosystems have a place in the world.

Introduction: Outline of and rationale for study

Prior to widespread settlement by Europeans in the early to mid 19^{th} century, southern Ontario (i.e., the region south of Lake Simcoe) was blanketed by dense mixed deciduous forests that had been shaping, and were being shaped by, the landscape for over 10,000 years. Today, over 95% of these once expansive forests have been cleared for agriculture and other forms of development (see Figures 1 and 2) (Berger, 2008; McLachlan and Bazely, 2003). This extensive clearance and land use alteration has imperiled the continued existence of many of southern Ontario's native tree species.

Compounding this predicament has been a long history of over-harvesting the fittest trees in the forest, as well as the more recent introduction and spread of alien and native invasive species and diseases. There are no longer any old growth forests of significance left in southern Ontario. Over 95% of remnant Carolinian forest patches are less than 10 hectares in area and most are over 1.5 km apart (McLachlan and Bazely, 2003). The largest remaining stand of Carolinian forest in Canada is in Rondeau Provincial Park and is a mere 11 km^2 (Tanentzap et al., 2011). Most remaining patches of Carolinian are tiny, scattered, and situated on marginal lands with poor soils that are ill-suited to agriculture (and thus ill-suited to supporting vibrant, diverse forests). As most of the healthiest and genetically superior specimens of rare southern Ontario trees were harvested for wood in centuries past, the genetic stock that remains in the region's patchwork of forests tends to be anything but robust (Schaberg et al., 2008).

Not only are southern Ontario's Carolinian forests the most biologically diverse forests in all of Canada, but they are also the most threatened (Tanentzap et al., 2011). The Carolinian biome supports over half of Canada's total biodiversity, and over half of its tree species (roughly 100 tree species of the 180 in the country) (Feagan, 2013; Tree Canada, 2013). It is home to roughly 165 species officially recognized as vulnerable, of special concern, threatened, or endangered, 12 of which are trees (OMNR, 2011). In addition to these recognized species, there are also over 500 species considered to be rare in Canada's Carolinian forest region (CCC, n.d.). The Carolinian occupies roughly 0.25% of Canada's land area yet is home to over 25% of the country's population (McLachlan and Bazely, 2003; Tanentzap et al., 2011). The fact that such a densely populated and developed area also hosts such a rich array of native biodiversity poses many unique and formidable conservation challenges.

The purpose of this research was to survey a series of five protected areas in the western Oak Ridges Moraine region of southern Ontario, locate exemplary specimens of rare native trees, catalogue their exact location, write about my experiences, and make all of the information and resources I gather available to the general public.

Figure 1: Forest Clearance and Land Use Alteration in Southern Ontario

Areas shaded in orange show where southern Ontario's original forests were cleared by settlers. The study area is circled, and the black line indicates a crude

Figure 2: Scattered Remnants of the Carolinian Forest

Canada's only remaining intact Carolinian forests, which are almost entirely secondary forests, are shown in green.

Source: http://nhic.mnr.gov.on.ca/MNR/nhic/projects/BP/bigpict_2002_main.cfm

This report summarizes that research in what is hopefully a manner that is accessible to people from all walks of life and areas of expertise. I have tried to give a comprehensive background to the challenge of forest conservation and restoration in southern Ontario, beginning with an overview of the Carolinian forest biome and its post-settlement history. I then examine, from the perspective of forest conservation, the spectre of climate change and the pressures it is imposing on natural areas that are already on the brink of collapse. I examine the importance of genetic diversity to forest health, and the importance of the ecological services provided by forests to societal health. I then narrow the scope of my analysis from the Carolinian biome to the western end of the Oak Ridges Moraine, examining specific social and environmental factors influencing forest conservation in the region. From there I overview some of the target species of my research, offering general biological information as well as the status of ongoing conservation and restoration efforts. I explain the methodology that guided my field surveys and informed by findings before sharing my results and survey site descriptions. I then provide a series of tips on the collection, storage, and cultivation of tree seeds in the region, in order to balance the level of practical and theoretical knowledge provided in this report. In the "Steps Forward" section I describe the means by which research like mine can be shared with the public and experts alike. Lastly, I offer readers some recommendations based on my background research and field work which I feel would expedite conservation and restoration efforts; and discuss how ongoing efforts are trying to take a holistic approach.

By locating and cataloguing exemplary specimens of rare native trees (which I will refer to as ***natural heritage trees***), I hope to accomplish the following objectives: a) allow individuals and public and private conservation organizations to gather seeds from the individual trees I find, for use in large or small scale conservation efforts; b) establish a starting point for this type of conservation work in southern Ontario, with the hope that amateur and professional tree conservationists alike will expand on my work in the future, eventually creating a comprehensive online database cataloguing all accessible natural heritage trees in southern Ontario's protected areas and green spaces; c) help to preserve and augment the genetic diversity within local populations of rare native trees; d) increase public awareness about forest conservation and ecology; and e) facilitate conservation efforts in general by providing society with a service that is not currently being provided [establish a framework which could ultimately lead to the improvement of forest and species management strategies through the provision of integral data by collaborative means].

Through my research I have striven to answer the question of how resilient the remaining populations of rare Carolinian tree species in southern Ontario are. More specifically, my research was predicated on the question of how many exemplary specimens of locally rare trees remain in southern Ontario's protected areas. By describing the species compositions, site conditions, and states of stand development at the conservation areas I surveyed, I hoped to gain and communicate a clear picture of the general health of these forests, and assess their potential to one day return to historical levels of biodiversity.

If we ever hope to achieve such levels of biodiversity in a such fractured and developed landscape, it is not enough to simply focus on cultivating as many rare trees as possible, but we should be focussing on cultivating the offspring of the best remaining wild specimens of rare trees. Ideally, the offspring of these specimens should be planted in areas where they can multiply and disperse naturally, or at least where their seeds could be easily gathered for further dispersal by humans and other forms of wildlife. Just as selective harvesting has long been the norm in small-scale logging operations, selective seed gathering and dispersal should become more common in restoration and conservation efforts.

Schmitt and Suffling (2006) stress that society needs to acknowledge that all remaining woodlots in southern Ontario are of great social and ecological value, and that we should not fall into the trap of protecting only those woodlands that are deemed significant sites of natural heritage by government agencies. Every woodlot, no matter how small, has a meaningful role to play in both conservation and ecological service provision. Indeed, even small, isolated conservation plots enshrouded by development can serve as refuges from pathogens, pests, weather extremes, and competition for rare native trees. Furthermore, we must acknowledge that we have unwittingly inherited the responsibility to protect and direct the future of all of our remaining Carolinian forests, none of which have escaped the inexorable influence of development. Southern Ontario's forests are no longer described by most as wilderness, but as cultural features, and thus need to be managed as such (Schmitt and Suffling, 2006). It is crucial that in managing our future forests we do not get caught up in antiquated approaches to conservation that attempt first and foremost to fence off areas perceived to be wilderness and minimize human interaction with them. Instead, new modes of ecological thought view humans as keystone species within ecosystems, and attempt to remind us that, wittingly or unwittingly, we are now directing the evolution of all the earth's ecosystems (Schmitt and Suffling, 2006). Not only can we expedite forest dispersal and succession to keep pace with climate change, but we can engage actively in other forest restoration practices like: thinning woodlots to create canopy gaps, removing invasive species, facilitating the re-establishment of past nutrient, hydrological, and disturbance regimes, introducing native mast trees to attract wildlife, constructing wildlife habitat, and increasing the structural and biological diversity of mono-cohort secondary forests (Berger, 2006; McLachlan and Bazely, 2003). Unfortunately, however, most reforestation efforts consist of planting a few select tree species on highly degraded farmland or brownfield sites, mainly for timber production or to reduce topsoil erosion (McLachlan and Bazely, 2003).

Nonetheless, practices are changing with an increasing awareness that it is critical that southern Ontario's tree biodiversity be conserved in order to maximize ecosystem resilience in the face of climate change and growing anthropogenic pressure. There is an increasingly pressing need to maximize the ecological service provision of trees and forests in order to mitigate the impacts of climate change and to ensure continued human health and well-being. The virtues of southern Ontario's forests, and the importance of restoring and recreating them so they continue to provide for Ontarians indefinitely cannot be understated. We have eradicated most of our native forests, crippling their ability to provide ecosystem services and imperilling their rich biodiversity. We are therefore obligated to begin to build them anew from the scattered remnants that remain.

Overview of the Carolinian forest biome

The Carolinian forest biome extends north approximately to the Barrie area, hugging the shorelines of Lake Huron and Lake Ontario, while extending southwards all the way to northern Georgia, and west to the Mississippi River Valley.

A combination of the rich diversity of deciduous trees and deep deposits of nutrient-rich glacial till have made the soils of the Carolinian region highly amenable to agriculture, which is responsible for the majority of the forest clearance. The region contains primarily class one soils, which are considered the best agricultural soils in the world, and is home to over 50% of all the class one soils in Canada (primarily luvisols (AAFC, 2013)) (TPH, 2008).

Shade tolerant hardwoods tend to thrive in the Carolinian, with the most common pre-settlement type of climax forest in southern Ontario being dominated by sugar maple and beech. The Carolinian is noted for its mild disturbance regimes, not being particularly susceptible to fires or droughts, with the most serious type of disturbance being wind (Henry and Quinby, 2010). The region is characterized by an annual precipitation range between 750 and 1150 millimetres, and a continuous frost-free period of at least four months per year (Christopherson and Byrne, 2009; Kock, 2008).

As one moves north through Ontario's three primary forest biomes—the Carolinian in the south, the Great Lakes-St. Lawrence (GLSL) forest in the middle, and the Boreal in the north—native tree diversity decreases markedly. The Carolinian is home to roughly 100 native tree species, the GLSL to roughly 50, and the Boreal to roughly 25 (see Figure 3). This decline is attributable to a combination of shorter daylength in the north, colder temperatures (i.e., fewer frost-free months—most Carolinian species require at least four per year), and poorer soils (which tend to be thin, acidic and moist podzols (Christopherson and Byrne, 2009).

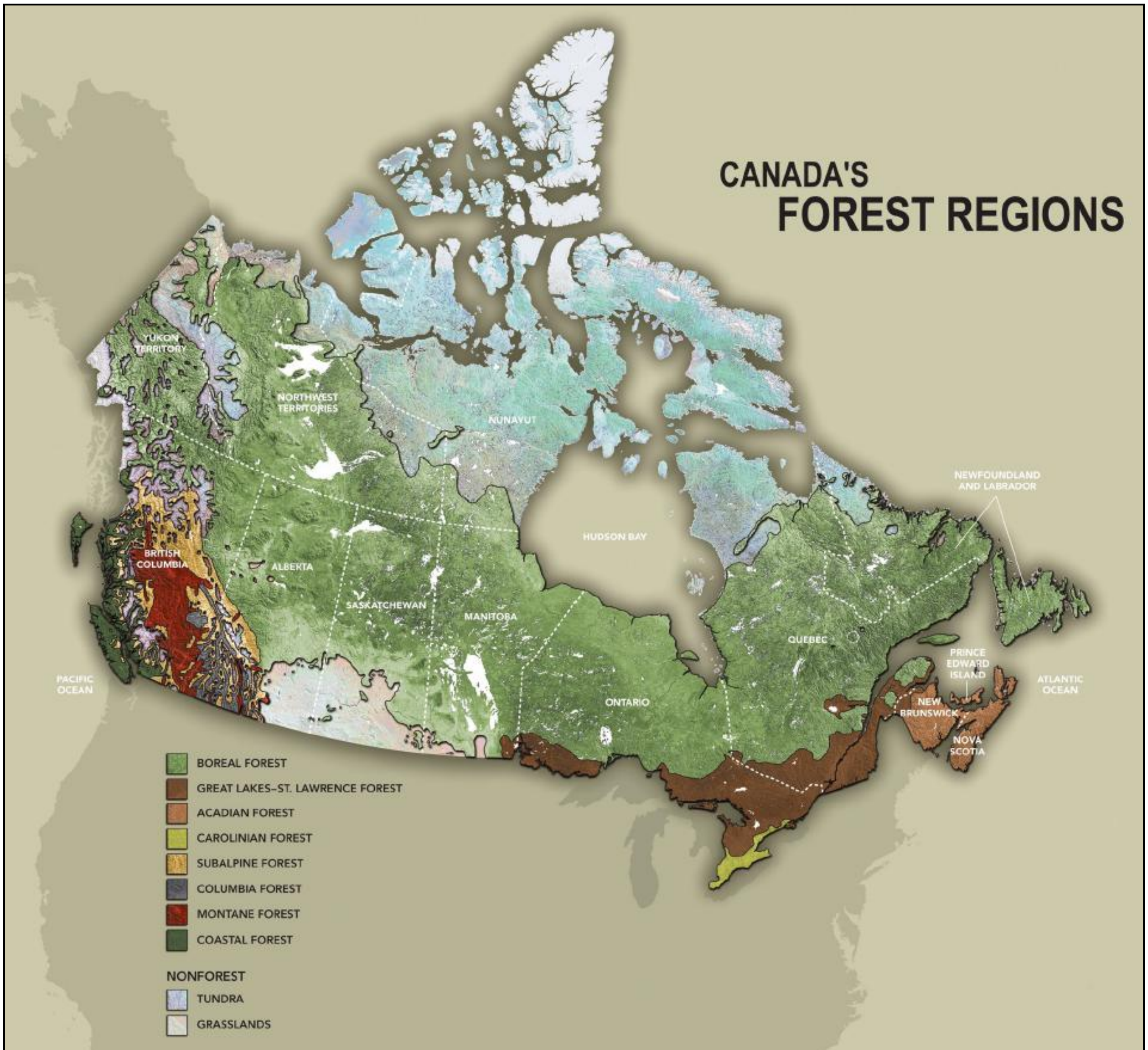


Figure 3: The Forest Biomes of Canada

Note that the Carolinian's only foothold in Canada is in the extreme south of Ontario.

In Canada, many Carolinian species are now facing extinction or extirpation due to introduced diseases (like the Dutch elm disease, butternut canker, or chestnut blight), alien pests (like the gypsy moth, whose young are voracious defoliators of Carolinian hardwood genera like oak, poplar, and birch; and the emerald ash borer, a bark beetle whose larvae tap into the vascular tissue of ash species and cut off the exchange of sugar and water between their leaves and roots), over-harvesting, hybridization with introduced species (as is the case with the red and white mulberry, and American and Asian sycamore), and habitat loss and fragmentation (Berger, 2008). The Carolinian has also suffered greatly from anthropogenic pollutants like nitrous and sulfur oxides and CO_2—all of which cause acid rain, which can defoliate trees, stunt their growth, make them more susceptible to disease, or cause death, as well as acidify soils), and near surface ozone (Berger, 2008).

The clearance of the Carolinian also created an abundance of habitat for introduced and native invasive plants, which have in many cases been able to outcompete and further imperil native forest species, compounding restoration difficulties (Berger, 2008). Dog-strangling vine, garlic mustard, purple loosestrife, European buckthorn, Scots pine, and Norway maple are all common examples of introduced plants that are able to outcompete and prevent the re-establishment of native tree species in disturbed environments. The most common and most harmful invasive plant that I regularly come across in the region is, however, a native plant—*Vitis riparia*, commonly known as riverbank grape. As its name would suggest, the habitat of riverbank grape was traditionally confined to the edges of rivers and lakes, as these were once amongst the only areas in southern Ontario that received enough sunlight to support its establishment. When the dense Carolinian forests of the southern Ontario were cleared by European settlers, however, a great deal of habitat was created for the riverbank grape, which began to spread into the few remaining natural woodlots, wiping out entire stands of native trees. A single riverbank grape plant, whose seeds are dispersed primarily by songbirds, can kill mature and juvenile trees alike (see Figures 5, 6, and 7).

Before European settlement, forestry expert John Berger (2008) estimates that a typical 1.6 km^2 area of Carolinian forest could support "*as many as five black bears, two to three pumas and an equal number of gray wolves, 200 turkeys, 400 white-tailed deer, and up to 20,000 gray squirrels.*" I find his squirrel estimate particularly interesting, as they are the primary dispersers of seeds from trees in the walnut, chestnut, hickory, and oak genera, and disperse the seeds of all mast trees (Berger, 2008).

Prior to European settlement, the Carolinian region of North America was *blanketed* with trees. More than one forestry professor of mine has said that in pre-settlement times, a squirrel could travel from the Mississippi River to the Atlantic Ocean without touching the ground. And it was not just the extent of the Carolinian that was so impressive, but the size of its individual trees (see Figure 4). The trees of pre-settlement southern Ontario were estimated to grow to average heights of 37 to 40 metres—almost twice the average heights of today's remaining forests (Henry and Quinby, 2010). As Henry and Quinby (2010) explained:

"One of the largest trees that was reliably documented in Ontario was cut in 1862. It was over 2 metres in diameter and 67 metres tall, or about 20 stories, and the first branch was more than 10 stories above the ground—higher than the tops of most pine trees today." (p. 102)

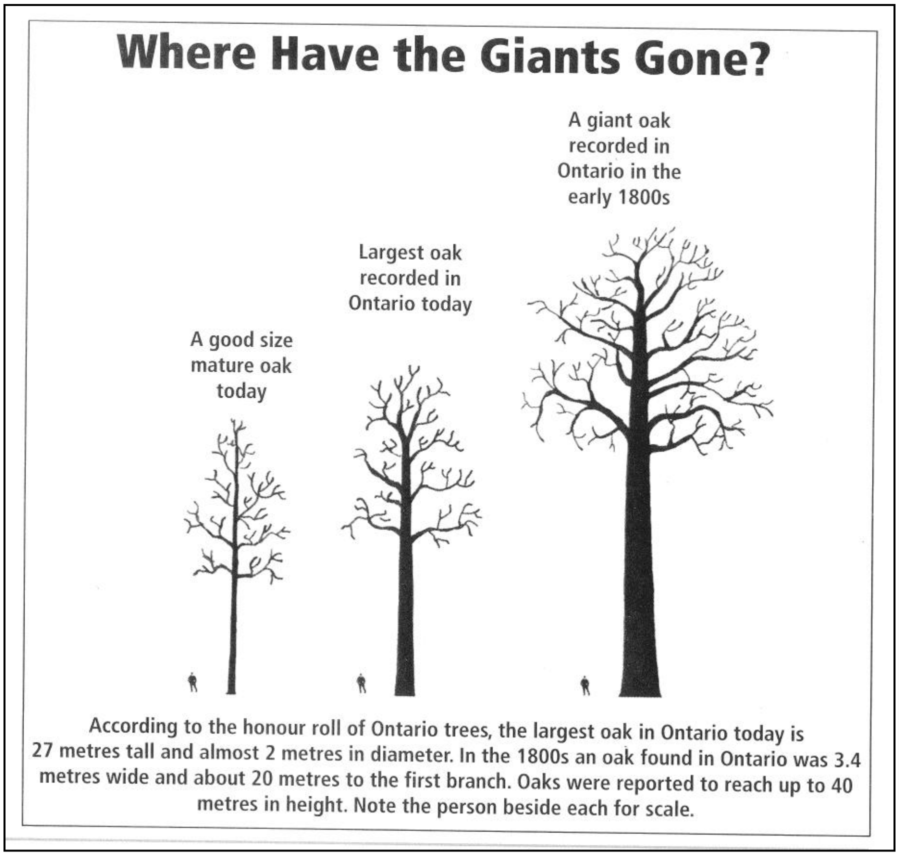


Figure 4: The scale of modern versus historical trees. Competition was fierce in the dark and crowded pre-settlement Carolinian forests, and in their fight for light, trees grew to enormous heights.

Source: Henry and Quinby, 2010

Early foresters in the province told stories of how in the towering virgin forests of oak, elm, beech, butternut, ash, and maple, there would sometimes be only five mature trees per acre of ground, their sprawling canopies blocking out the sun almost completely (Henry and Quinby, 2010). Today the sunlight reaches the fertile soil of the Carolinian region almost without obstruction, in order to accommodate the commercial cultivation of food. The region is now the most extensively developed and managed area of North America, and there is little room left for once expansive forests.

Figure 5: Leaves of *Vitis riparia,* riverbank grape. The leaves can take multiple forms. I have found that the form with less pronounced notches tends to grow from segments of the vine that have previously been cut.

Source: http://www.uwgb.edu/biodiversity/herbarium/shrubs/vitrip01.htm

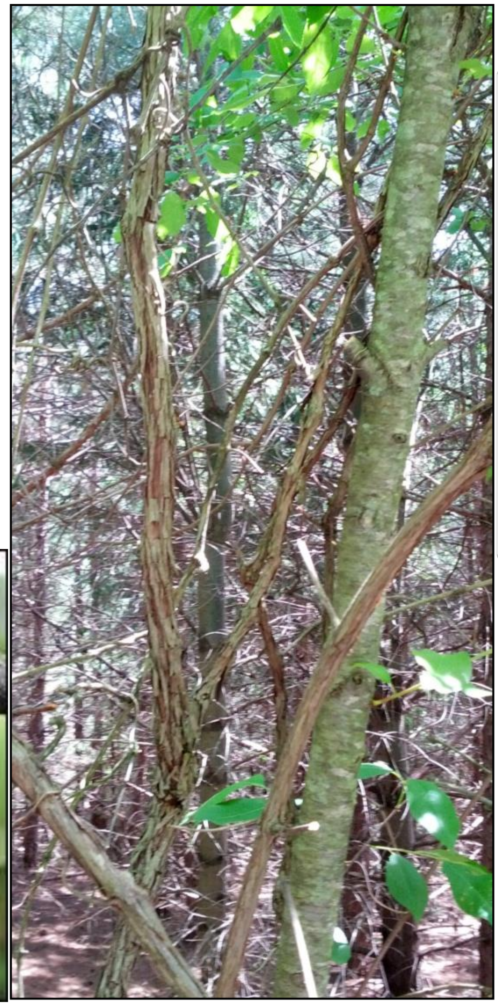


Figure 7: The reddish-coloured vines of riverbank grape beside a parasitized young white ash.

Figure 6: The tendrils of the riverbank grape will not easily relinquish their grip

A brief history of the settlement of southern Ontario

Prior to European colonization, the southern Ontario region was home to many semi-nomadic Indigenous groups who traditionally practiced some level of intentional tree dispersal. Important mast trees like paw-paw, American chestnut and shagbark hickory were transported well outside of their natural range and cultivated by Indigenous peoples (Kershaw, 2001). This intentional cultivation is evidenced by modern ranges of certain trees having conspicuous outlying populations far to the north of what is supposed to be their natural distributions (Kershaw, 2001). Many Indigenous groups in the region were becoming increasingly adept at farming shortly before colonization, and were beginning to clear patches of forest to cultivate crops like corn and beans, which had been domesticated in more southerly climes and had arrived via trade networks (Chazan, 2012). It would be fascinating to see what this increasing trend towards sedentism would have meant for the region's trees—whether forests would have been left unaltered for the most part, whether certain tree species would have been cultivated at the expense of others, or whether forests would have been indiscriminately felled in a short-sighted rush to develop and domesticate the land.

The vast majority of the Carolinian forest of southern Ontario was cleared for agriculture beginning in the early nineteenth century, as the soils produced by its species-rich deciduous forests were and are some of the most productive in the world (Berger, 2008). After agriculture and settlement became widespread, the woodlots that remained were selectively harvested for the biggest and healthiest of the remaining trees—a practice known as high-grading (Kock, 2008; Schaberg et al., 2008). By 1920, roughly 94% of the Carolinian forest of southern Ontario had been cleared (Henry and Quinby, 2010). Research conducted by the Federation of Ontario Naturalists in 1999 found that only a “trace” amount of old-growth Carolinian forest remains in Canada (Henry and Quinby, 2010). This fact becomes all the more startling when considering that the Carolinian region is home to one third of all the at risk species in the country, including well-known mammals like the badger and gray fox, as well as lesser-known trees such as the paw-paw, red mulberry, and cucumber tree (Henry and Quinby, 2010). As the dominant primary producers in southern Ontario, trees are the backbone of this threatened eco-region. Thus the future of one third of the country’s threatened species depends on the habitat and resources provided by the region’s forests.

Most of the reforestation that has occurred since the 1920s has consisted of the planting of monoculture stands for timber production or soil remediation (Berger, 2008). Remaining Carolinian stands in southern Ontario now mainly consist of small, species poor, and isolated woodlots on farmland or on marginally fertile and inaccessible sites like Mount Nemo and Rattlesnake Point, both of which are rugged outcrops of the Niagara Escarpment. Less than 1% of today's Carolinian forests are considered old growth.

There are likely no patches of Carolinian forest in Ontario that have remained untouched by logging (Henry and Quinby, 2010). Less than 1% of Ontario’s Carolinian today is considered old growth, which can be defined as forests with mixed level canopies and a high volume of snags (dead standing trees used as habitat by a multitude of wildlife), downed woody debris, and veteran trees (those at least roughly 200 years in age who are still reproductively active), and that which remains tends to be on rugged terrain with poor soil (Berger, 2008). Traditionally, the fertile soils, moderate climate, and moderate disturbance regimes of southern Ontario allowed for the growth of massive trees that would dwarf their modern-day cousins.

Ontario's population is expected to grow by over 50% by 2040, to 18 million people (Henry and Quinby, 2010). By that time, more than one thousand square kilometres of additional land is expected to become urbanized (Henry and Quinby, 2010). Most of this urbanization is expected to take place in the most fertile regions of southern and central Ontario, on our most productive farmland—the same land that also has the potential to host the most productive and biodiverse forests. This increased development will also lead to increased habitat fragmentation, which will hinder the ability of the region's tree species to maintain healthy, genetically diverse populations (Henry and Quinby, 2010).

The importance of genetic diversity

Ontario's Old Growth Forests (Henry and Quinby, 2010) begins with an anecdote closely related to the topic of my thesis project. It relates the story of a traveller to southern Ontario in 1830 passing through a small town and asking a local about an exceptional oak tree he had come to hear about. The local took him to the tree, which was over 3 metres in diameter, and while the traveller revelled at the tree's size and form, the local began to tell him about how he wished he had a saw big enough to cut the tree down because "... it is mighty straight in the grain, and would split like a ribbon" (Henry and Quinby, 2010). If one assumes that trees of old age and extraordinary height and/or girth have a genetic code extremely well-adapted to their locality (or good genes in general), then that unfortunately means that since southern Ontario was first settled by Europeans, humans have been a dominant selective force against the fittest gene pools of the region's tree species. In dense forests, individual trees that grow the straightest and tallest in the constant competition for sunlight tend to thrive, but these were the same qualities most highly sought after by settlers. Species thrive genetically when their weakest members fall prey to any number of natural threats and the fittest are able to procreate and spread their genes (Kock, 2008). In the forests of southern Ontario, humans imposed the opposite effect—we selectively harvested the biggest and healthiest trees, forcing remnant populations to fight to become re-established with the depleted gene pools of sickly, stunted, or otherwise less-than-fit individuals (Schaberg et al., 2008).

This behaviour would be the equivalent of hunters taking only the healthiest and most robust individuals from populations of their prey animals, forcing those populations to regenerate (and degenerate) with less genetically fit individuals. In nature, predators tend to kill the weakest and most vulnerable members of their prey species, leaving the fittest individuals (those who are the hardest to kill) to thrive and multiply, thus strengthening the genetic stock of that species. Competition and natural disturbances perform a similar role in forest ecosystems, allowing individual trees with strong competitive advantages to thrive and multiply. Because humans have long been discouraging the proliferation of healthy and productive forests in the Carolinian region, the difficulties of re-establishing Carolinian stands that even superficially resemble ancestral forests are compounded.

Although the current day situation appears dire for many of Ontario's Carolinian tree species, many forest experts are cautiously optimistic about the future, recognizing that a vast store of genetic wealth remains in remnant populations (Berger, 2008; Kock, 2008). Just as the resilience of forests increases with species diversity, genetic diversity helps to ensure the survival of tree species in the face of threats like climate change, pests, and diseases (Kock, 2008). The genetic diversity fostered by millennia of natural selective forces acting on trees in a variety of micro-climates and under shifting climatic regimes results in tree populations that are resilient and robust. As Henry and Quinby (2010) succinctly put it: "the most genetically diverse trees have the greatest likelihood of surviving the myriad of threats in the forest." Most threats to trees now come from outside of the forest, but a gene pool tempered by millennia of merciless selective forces is better suited to face those threats than one that stems from the trees that were too unhealthy or malformed to be logged over the last several centuries. Henry and Quinby (2010) stress the importance of maintaining the genetic reservoirs within old trees so that present day populations inherit their resilience and use it to adapt to a rapidly changing climate and disturbance regime.

In regard to genetic diversity, tree species can be divided into two broad classes—generalists and specialists. Generalists have a relatively uniform genetic makeup throughout their range while specialists have very diverse gene pools throughout their range (Kock, 2008). The seeds from a specialist species collected in one area will be specifically adapted to the conditions in that area, and will not likely thrive in different conditions (Kock, 2008). The seeds of a specialist red maple from North Carolina, for example, will not grow well in Ontario because the genes of that species are finely tuned to daylength (Kock, 2008). Red maple seeds from Wisconsin, however, would likely adapt to southern Ontario as both locations lie at roughly the same latitude. The ecology and tolerances of specialist Carolinian species can thus vary significantly in different environments, enhancing the importance of planting trees from locally-sourced seeds. In some cases, however, due to the uncertainties surrounding the adaptive capabilities of specialist species and the rapidly changing climate, it may be prudent to plant trees from two or three regional seed sources at a given site, especially if the target species is absent from the planting site (Kock, 2008).

Before we can begin to effectively disperse and conserve Carolinian tree species, we must first have seedlings grown from healthy, locally-adapted stock. Most commercial garden centres do not track the seed sources of their trees, and also use seedlings that are mass-produced from cuttings (pieces cut from a plant for propagation) or grafting (joining a bud or branch from one plant (the scion) to the lower part of another plant (the rootstock)), which results in a crop of genetically identical trees, originating from one cloned plant (Kock, 2008). A small number of tree nurseries in Canada now offer source-identified stock, but the prevalence of cloned trees remains high (Kock, 2008). Aside from producing trees that may be poorly suited to a given site, cloning in essence “brings evolution to a grinding halt,” as it does not allow for the mixing of genes between two successful individuals or for the mutations that are the progenitors of genetic diversity (Kock, 2008).

While many of the secondary and tertiary forests of southern Ontario may be lacking in genetic diversity, such forests are not the only repositories of diversity left. Old trees that grow alongside roads were most often planted from locally-sourced seedlings, and can thus represent important seed sources (Kock, 2008). Mature trees growing along roadsides are often genetically fit, as they must withstand a compounded set of stresses relative to forest trees; stresses like high winds, extreme temperature extremes, higher desiccation rates, more extreme droughts, and drier conditions in general (Kock, 2008). Such factors tend to make old roadside trees good seed sources for trees with locally-adapted genetics. Locally-adapted trees are of special importance in a place like southern Ontario where many Carolinian species are at or near the northern limit of their ranges, and individual trees in this area may be particularly well-adapted to the cold and the shorter growing season.

A study conducted by Schaberg et al. (2008) showed clear evidence of lowered genetic diversity amongst tree populations following the selective harvesting of individuals based on physiological traits (either positive—those traits that make trees commercially valuable—or negative). Rich genetic diversity is not only important within tree populations to increase the resilience of forests, but it is also particularly important to trees due to their sessile nature, the long time spans they require to reach reproductive maturity, and the likelihood that they will encounter a great deal of environmental change over the course of their long lives (Schaberg et al., 2008). In an experiment conducted on an eastern hemlock forest in Maine, researchers removed the biggest and best trees from one plot, the smallest and most poorly formed trees from another, and had a control plot with no tree removal (Schaberg et al., 2008). They found that both selectively harvested plots had reduced fitness relative to the control stand and contained less rare alleles and a lower number of possible genotypes than the control (rare alleles are seen as reservoirs of adaptive potential and are essentially the seeds to ensure survival following environmental change) (Schaberg et al. 2008). Such rare alleles are often targeted in breeding programs that aim to improve tree resistance to pathogens or pests.

Selectively harvested stands have also been found to be less able to provide the range and intensity of ecological services that naturally structured stands do (Schaberg et al., 2008). It is therefore important that we do not selectively remove any trees from conservation areas based exclusively on their physiology. In the past we removed the biggest and best, in the present we are removing the smallest and worst, but in order to preserve as much genetic diversity as possible, we need a combination of all possible phenotypes of a given species occurring at the same sites. Schaberg et al. (2008) espouse what they coin "adaptability management" in regard to our forest ecosystems, saying: "*forest landscapes should not only be managed to optimize current fitness and commodity flow, but also to preserve forests as dynamic evolutionary systems where the adaptive potential of populations is safeguarded into the future*." With sound management regimes informed by the latest science, they claim that the genetic diversity, resilience, and ecosystem service provision of forests can be enriched, even in extreme cases like that of southern Ontario's Carolinian forests (Schaberg et al., 2008).

Growing anthropogenic stresses and a changing climate will mean that, in order to not only remain viable but to prosper, many rare tree species will need some human assistance if they are to start rebuilding their once robust and advantageous gene pools. If we are going to undertake reforestation efforts with the best interests of each species concerned in mind, then we are going to need to plant genetically fit individuals with locally-adapted genes. We thus need to conduct activities like the surveying of the "old growth" forests and protected areas of southern Ontario for the few remaining mature descendants of the region's former giants, and we need to disperse their genes in the attempt to partially make up for centuries of selecting against them.

The role of climate change

As mentioned previously, the forests of southern Ontario represent the northernmost range of many Carolinian tree species. Anthropogenic climate change is causing average temperatures in Ontario to increase by 0.5 degrees Celsius per decade (Henry and Quinby, 2008). This temperature increase is causing biomes in the region to extend their northern limits, as more habitat is created with conditions that fall within the ranges of tolerance of a larger number of plant species. It has been estimated that temperate forest biomes are now shifting northwards at a rate of two to ten kilometres per year (CCFM, 2009; Henry and Quinby, 2010; Iverson, Schwartz, and Prasad, 2004). It is thus integral that we preserve Carolinian species in this region, so they are able to progress northwards and bring their northern-adapted gene pools and rich array of ecological services with them. Most tree species can only migrate naturally about 100 to 200 metres per year, which has prompted many experts to consider assisted migration efforts in order to avoid the establishment of dominant invasive species in rapidly fluxing ecosystems (Iverson, Schwartz, and Prasad, 2004). Expediting the northward dispersal of many Carolinian species—especially rare ones—would not only serve to conserve biodiversity and make northern forests more resilient, but would also enhance their ecological service provision. Regardless of whether or not assisted migration will prove to be a viable conservation measure, assisted dispersal to areas where trees will be able to live out their natural lives and reproduce successfully would certainly prove useful to any struggling species.

Climate change is also expected to bring with it an increased frequency and intensity of extreme weather events like droughts, heat waves, storms, and floods. Such conditions can promote further disturbances like forest fires or increased pest activity (Henry and Quinby, 2010). The rapidly changing climate and anthropogenic pollutants are combining to create stresses that weaken tree resistance to pests and diseases that would have been relatively easy to tolerate in less altered environments (Kock, 2008; Puric-Mladenovic et al., 2011). Trees grown in inhospitable environments are often unable to produce adequate quantities of seeds, yet "*the ability of plants to produce seed of good quantity and quality that can be dispersed and enable plant establishment is a critical and probably the most important adaptation strategy to climate change*" (Puric-Mladenovic et al., 2011).

A tree species' range is primarily determined by climate (i.e., prevailing temperature and moisture regimes in a given region), followed by soil type, soil moisture, and seed dispersal mechanisms (Kock, 2008). One might intuit that a warming climate might simply promote the northward expansion of tree ranges, yet a major hindrance to northward expansion in Ontario is the lack of available habitat due to human development (Henry and Quinby, 2010; Kock, 2008). Most tree populations are expected to decline in the southern portions of their ranges due to climate change, but a proportional northward expansion may not be possible for most species (Kock, 2008).

The value of ecological services

Certain ecological processes take centuries to form in temperate forests. Forest structure, for example, can take centuries to develop before reaching the old growth stage. Structure includes factors like canopy cover, number of canopy layers, the presence of multiple age cohorts within tree populations, snags, downed woody debris (large tree trunks can take hundreds of years to fully decompose in temperate climates), the prevalence of pit and mound topography (created when large trees are uprooted), and the presence of shade tolerant versus pioneer species (Henry and Quinby, 2010). Species assemblages are also indicative of a forest's stage of development. The presence of pioneer (as opposed to shade tolerant) species, especially in patches, indicates that a given piece of land has been cleared in recent years or decades, forcing forest succession to begin anew.

Henry and Quinby (2010) attempt to convey the vital importance of old growth forests by stating that: "many forest processes reach a peak of complexity in old-growth forests and can be fully understood only in this context." Old growth forests are thus of incalculable value to those studying forest ecology. Old growth forests are also crucial for the conservation of native biodiversity, as many species have come to depend on the ecological services provided by old growth, and struggle to live outside of these environments. While tree diversity in the Carolinian region actually tends to decline in old growth, understory diversity often flourishes, and complex understory plant communities can take centuries to recover after logging (Henry and Quinby, 2010). Soil insect and microbial communities, whose species richness dwarfs that of plants, are poorly understood in all forest types, but this is especially the case in old growth (Henry and Quinby, 2010).

The ecological services provided by all trees and forests are many, and include: **air and water purification** (trees enhance the air through the addition of oxygen and the removal of greenhouse gases like carbon dioxide, ozone, nitrous oxides, and sulphur oxides through transpiration, while also removing significant amounts of airborne particulate matter through interception), **soil enhancement** (leaf litter and downed woody debris add nutrient-rich organic matter to the soil, improving the soil's retention of precipitation, reducing the impact of precipitation, and preventing topsoil moisture evaporation), **food and habitat provision for wildlife**, **erosion and flood prevention** (erosion and runoff are prevented by the interception of precipitation by trees and their leaf litter, and the creation of soil macro-pores by tree roots, which improves the infiltration of precipitation), **carbon sequestration** (roughly half of the dry mass of trees is comprised of carbon, so the carbon sequestration capacity of various stands and forests can be crudely quantified), **microclimate temperature moderation** (via shade, the alteration of wind speeds, evaporative cooling, and the absorption and reflection of insolation), **aquatic ecosystem protection** (trees contribute vital organic matter to aquatic ecosystems, which is consumed by small and micro organisms at the lowest trophic levels; they also cool water in their vicinity, increasing its oxygen content (Berger, 2008)); **contaminant removal** from soil and groundwater (via phytoremediation); **biodiversity conservation** (which enhances ecosystem resilience in the face of natural and anthropogenic disturbances (Schaberg et al., 2008)), the provision of **opportunities for recreation** (irrespective of the aesthetic value of forests, the air quality improvement and temperature moderation they offer contributes to the physical comfort of those who visit and live near them, and may affect peoples' willingness to be active outdoors (Georgi et al., 2006)), **reductions in energy consumption of**

adjacent buildings, and, of course, the provision of **timber and non-timber forest products** (40% of all pharmaceuticals currently in use, for example, were originally derived from trees (Berger, 2008)) (Nowak and Dwyer, 2007; Millward and Sabir, 2011). An example of a more indirect benefit offered by forested areas is the reduction of healthcare costs through the promotion of healthy lifestyles (Donovan et al., 2013; McCormack et al., 2010). All of these ecosystem services work to improve human health and well-being in ways we have yet to adequately quantify. The rampant deforestation that has taken place in southern Ontario over the last two centuries has crippled the ability of our native forest ecosystems to provide each of the aforementioned services, but it is not too late to make our forests more productive, and our communities more vibrant and healthy.

Though difficult to quantify, it is generally accepted that old growth forests provide a greater array and abundance of ecological services than their secondary counterparts (Berger, 2008). Knowing the particular ecological services that trees provide, it follows logically that large healthy trees provide ecological services in far greater abundance than smaller, less fit specimens (Alexander and McDonald, 2014). Large trees can transpire up to 500 litres of water every day, which greatly helps regulate microclimate temperatures and create habitat in forests (Kock, 2008). Reforestation efforts should thus be focussed on reintroducing trees from the best genetic stock available. Large, healthy specimens would naturally have a huge competitive advantage over their less fit peers, and this advantage should be recognized and emphasized in reforestation efforts. Such specimens also tend to have the highest aesthetic and landscape value, making them the most desirable trees for members of the public to plant.

The ability of trees to sequester carbon is perhaps the single most touted benefit of trees in modern times, and is sometimes used as the sole rationale for reforestation efforts. While I think this often single-minded focus on reforestation is unfortunate and short-sighted, I do feel that the ability of trees to sequester atmospheric carbon solidifies the role of healthy forests as one of the many means by which society can help to mitigate the impacts of climate change.

In regard to the economic value of the ecological services provided by trees and forests, Millward and Sabir (2011) used market values for the mitigation of greenhouse gases like CO_2, methane, ozone, and nitrous and sulphur dioxide, and applied them to the volume of woody material in a given area. Their study found that the average tree in a downtown Toronto park performs roughly $85 worth of ecosystem services each year, while necessitating a mere $25 in maintenance costs, for a net cost-benefit ratio of 1:3.4 (Millward and Sabir, 2011). Such figures, though their accuracy may be subject to debate, nevertheless imply that forested urban parks more than pay for themselves through the provision of ecological services alone. Toronto's Parks, Forest, and Recreation Department found that the city's urban forest sequesters 46,700 tonnes of carbon every year, which has an annual market value of $1.3 million (TPFR, 2010). It is generally known that trees enhance the values of the properties on which they are situated, although methods for quantifying precise values invariably involve a great deal of guess work (and are thus quite unscientific). Such methods primarily make use of existing real estate values, and assume that each mature tree enhances its property's value by roughly 1% (Millward and Sabir, 2011).

A recent study conducted by TB Bank found that the urban forest in the City of Toronto had a net value of $7 billion, or about $700 per tree (Alexander and McDonald, 2014). Toronto's urban forest was found to perform over $80 million in ecological services every year, mostly related to storm water management, air quality enhancements, and lowered energy savings for building due to microclimate temperature moderation (Alexander and McDonald, 2014). These figures were based solely on the quantifiable ecosystem services offered by trees, and did not attempt to account for the qualitative benefits that trees provide (such as aesthetic value, enhanced common spaces, and the provision of a refuge from the hustle and bustle of city life) (Alexander and McDonald, 2014). In short, the study found that the costs associated with maintaining urban forests pale in comparison to the value of the ecological services that such forests provide (Alexander and McDonald, 2014).

Forested areas also serve as educational sites for school children, and this role is likely to become more pronounced as the Toronto District School Board amended its curriculum in 2009 to include more hands-on student involvement and the integration of pressing ecological issues and concepts into lesson plans (OFA, 2011). I do not know of many children who would rather spend a sunny afternoon learning about ecology in a classroom when they could be outside engaging in more tactile and appreciable lessons. Our forests have a lot to offer us, and a lot to teach us—realizing that is the first step in working to help our forests realize their inherent potential, and make southern Ontario a land of forests once again.

Profile of protected areas in southern Ontario

Ontario's Old-Growth Forests (Henry and Quinby, 2010) explores a total of 66 old growth forests in Ontario, 12 of which are patches of Carolinian that remain in the south of the province. Most of southern and central Ontario's old growth forests are not only secondary, but were selectively logged as recently as a decade or so ago (Henry and Quinby, 2010). In several cases, patches of old growth continue to be selectively logged, and many areas continue to have downed trees and branches removed (fallen logs serve as miniature biodiversity hotspots in old growth forests, providing food, water, and habitat to a wide variety of funguses, plants, and animals, as well as providing large amounts of nutrient rich organic matter to forest soils over long time periods) (Henry and Quinby, 2010). Selective logging is practiced in order to realize some direct monetary value from wood as well as to remove potential sources of fuel for forest fires. Indeed, due to major provincial cutbacks to conservation authorities beginning in 1996, many authorities have been forced to use selective logging and woody debris clearance as a means to remain economically viable (Henry and Quinby, 2010). Some of the downed woody debris in the old growth cedar forests of the Niagara Escarpment has been dated to as far back as 1550 BCE, making it an invaluable resource in dendrochronology and local paleoclimatic reconstruction (Henry and Quinby, 2010).

For the purposes of my project, I have aimed to explore some of the lesser-known forests of the Oak Ridges Moraine, in the hope of discovering tree specimens or communities that are as yet unrecognized. Such discoveries could potentially lead to enhanced conservation efforts at under-appreciated sites, or simply bring such sites to the tree-conscious public's attention.

It is sobering to hear forestry experts like the University of Guelph's Doug Larson stress that forest conservation in southern Ontario must be predicated on millennial timescales, rather than the decadal timescales of the forestry industry and the four year timescales of our political paradigms (Henry and Quinby, 2010). Forest ecosystems are much older than the age of their oldest tree or the time since they underwent a major disturbance, as mature ecosystem processes do indeed take millennia to evolve, and are predicated on the complex webs of interaction between a wide array of biotic and abiotic components. Facts like this make the conservation and restoration of forests a challenge beyond the scope of any one person, organization, or generation.

It was further sobering to learn that much of the sight-seeing to be had by tree lovers in southern Ontario's old growth forest stands consists of viewing very impressive stumps of once giant specimens of locally rare species (Henry and Quinby, 2010). It does, however, seem that forest conservation efforts are maturing, and that the conservation areas that exist today will only improve in terms of responsible forest management, and thus that the species which are currently conserved in the remaining patches of forest will most likely continue to be protected in the coming decades and centuries (Henry and Quinby, 2010).

A closer look at the Oak Ridges Moraine

The Oak Ridges Moraine is a large terminal moraine which was deposited by two glaciers during the decline of the Wisconsinan glacial between 14,000 and 12,000 years ago (Christopherson and Byrne, 2009). It spans a 190,000 hectare region between the Niagara Escarpment in the west, and the Trent River in the east (see Figure 8). It is comprised of well-sorted glacial till, mainly consisting of sand, gravel, and rocks deposited by glaciers along a stationary front where the rate of glacial advance equalled the rate of glacial retreat for a prolonged period of time (Cooper, 2009).

The ice of these glaciers was roughly two kilometres thick, and their massive weight compacted and depressed the land beneath them by roughly two-thirds of a kilometre (Cooper, 2009). The compacted land throughout southern Ontario is still undergoing isostatic rebound (rising in elevation by roughly 1 centimetre each year) as a consequence of the weight of the glacial ice (Cooper, 2009). The average daily temperature in the region is roughly 6.6 degrees Celsius, with an average annual precipitation rate of roughly 800 millimetres (McPherson and Timmer, 2002).

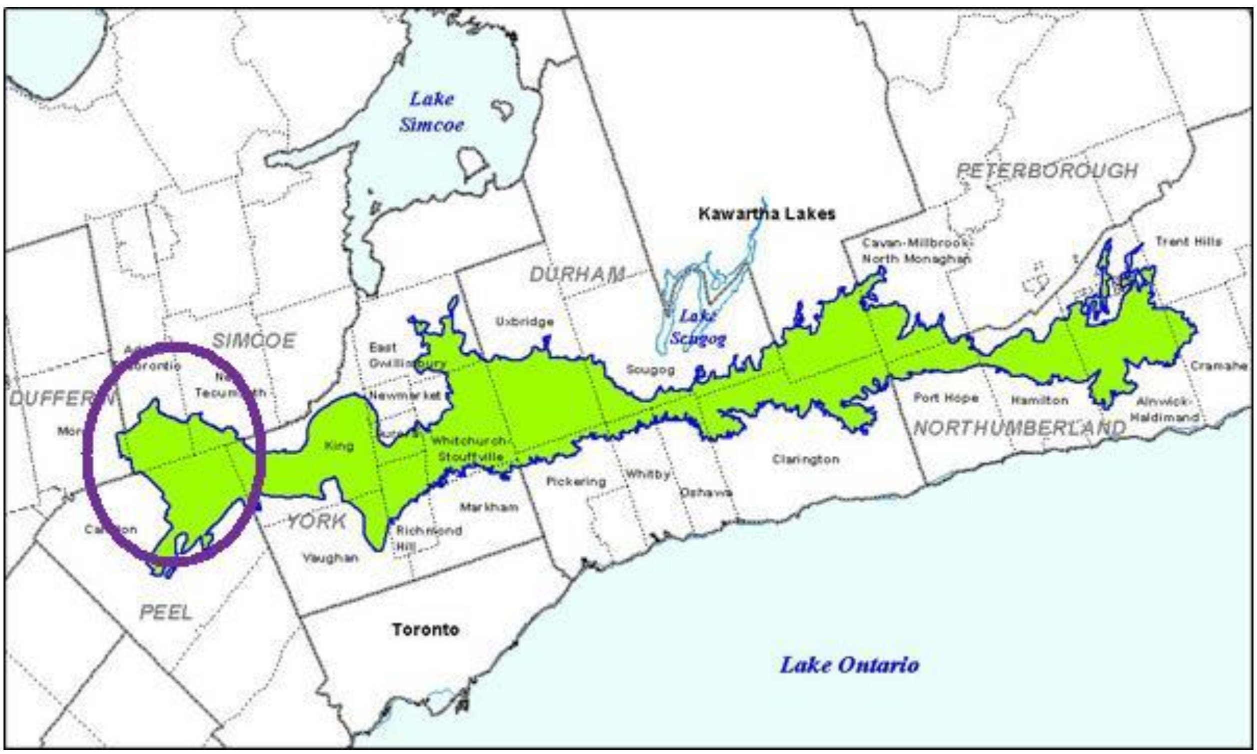


Figure 8: The Oak Ridges Moraine, with study area circled.

Source: http://www.mah.gov.on.ca/Page1744.aspx

Fast-flowing, sediment-rich glacial meltwaters deposited the sand and gravel of the Oak Ridges Moraine in well-sorted clusters of mono-sized particles (Cooper, 2009). The predominant soil texture at the western end of the moraine tends to be that of sandy loam belonging to the great group of Gray Brown Luvisols, which are characterized by a forest mull Ah horizon (a dark-coloured horizon near the soil surface rich in organic matter due to the nutrient cycling of earthworms and other forest microfauna) as well as eluvial and Bt horizons (which are rich in clays due to illuviation from overlying horizons caused by the action of percolating water) (CSSS, n.d.; CSSS(2), n.d.). The soil tends to be rich in carbonates, as a result of the high concentration of sand, and has a high pH value (Cooper, 2009).

The sandy soil which covers much of the moraine does not effectively retain water, nor does it host a significant amount of mineral-rich soil colloids (Brady and Weil, 2010). Thus, the soil requires frequent inputs of precipitation and decomposing organic matter to support a complex array of vegetation. Over 12,000 years of plant community succession, culminating in the species-rich mixed deciduous forests of the Carolinian biome, provided ample organic matter to form a thick layer of highly fertile topsoil throughout the western extent of the moraine. This topsoil, however, can erode away when the protective canopies and root systems of the region's trees are removed, potentially resulting in barren sand dunes where lush forests once stood. Indeed, as will be described later in this section, that is exactly what happened to the moraine roughly a century ago after its forests were cleared and replaced with crops (Cooper, 2009).

The extensive sand and gravel depositions provide an important benefit to the landscape of the western part of the Oak Ridges Moraine—they readily contribute to the formation of aquifers. These aquifers have spawned many natural springs in the area, which in turn feed creeks that enhance groundwater accessibility for local flora and fauna, and eventually flow into the Holland and Humber Rivers (Cooper, 2009). A drawback of these easily accessible aquifers, however, is the fact that they are easily polluted by synthetic fertilizers and anthropogenic effluents. These freshwater aquifers are so susceptible to contamination because they are unconfined, near-surface, and covered by coarse, sandy soils through which water and pollutants percolate easily (Cooper, 2009). When pollutants enter groundwater systems, they are extremely difficult to remove, as groundwater flows at a very slow rate, and can cover vast, unconfined areas (Christopherson and Byrne, 2009). The contamination of the aquifers of the Oak Ridges Moraine means the contamination of all of the rivers that are fed by them. The groundwater from the moraine provides water to many local communities, and is used in households, industry, and agriculture (OMAH, 2001). In short, the coarse soils and hilly topography of the Oak Ridges Moraine create areas for groundwater recharge, and the moraine thus serves as the headwaters region for many of southern Ontario's rivers (OMAH, 2001).

Much of the Oak Ridges Moraine was used extensively for farming throughout the nineteenth century (McPherson and Timmer, 2002). This resulted in the clearance of forests, the erosion of fertile topsoil, the depletion of nitrogen in the soil by crop plants, and the contamination and diminution of local aquifers (Cooper, 2009; McPherson and Timmer, 2002). Other effects on the soils of the Oak Ridges Moraine due to the intensive agriculture in the 19th century included soil compaction by machinery and livestock, and increased soil bulk density (i.e., decreased soil aeration/pore space) associated with the loss of tree root activity (McPherson and Timmer, 2002).

By the early twentieth century, much of the land in the western portion of the moraine was barren and infertile, often reverting back to the sand dune landscape that would have covered the region in the immediate post-glacial era (Kock, 2008; McPherson and Timmer, 2002). Agricultural activity on a given piece of land in the region was most likely brief, probably not exceeding several decades in most cases, before soils became exhausted at the turn of the twentieth century (McPherson and Timmer, 2002). The widespread abandonment of farms in the Oak Ridges region ensued.

Most of the abandoned farms that did not revert to desert ecosystems began to revert to grasslands, which helped to stabilize soil nutrient levels at a point that would allow for the growth of some tree species (McPherson and Timmer, 2002). Total soil nitrogen decreased from the pre-settlement forest stage to the abandonment stage by roughly 60%, while soil phosphorus decreased by up to 90% (see Figure 9) (McPherson and Timmer, 2002). Potassium levels, however, remained relatively consistent throughout the fluctuations in soil fertility due to the high mineral content of the region's sandy soils (McPherson and Timmer, 2002).

These developments catalyzed afforestation efforts on the part of locals and the Government of Ontario beginning in the 1920s, efforts which were in large part spearheaded by a single person—pioneering forest restorationist Dr. Edmund Zavitz (Kock, 2008; McPherson and Timmer, 2002). These efforts began with the widespread planting of red pine trees—a hardy generalist pioneer species which flourished in the parched, nutrient-deprived soil to which it was well-suited (Cooper, 2009; McPherson and Timmer, 2002).

The planting of red pine seedlings on abandoned lands in the Oak Ridges Moraine initiated the first major stage of site recovery. The young red pines served to shelter the region's soils from further erosion by wind and precipitation, added much-needed inputs of organic matter to the topsoil, promoted increased faunal activity, and generally kick-started the process of pedogenesis on planted sites (McPherson and Timmer, 2002). On average it took roughly 30 years for nutrient rich organic layers of topsoil to begin forming following reforestation efforts, with the production of organic topsoil accelerating between 30 and 60 years following tree planting (McPherson and Timmer, 2002). Researchers found that with tree planting followed by natural regeneration, soils could be brought close to pre-settlement fertility levels in as fast as 75 years, providing a foundation for more complex forest ecosystems to become established (McPherson and Timmer, 2002).

Traditionally, red pines have been used in the restoration of calcareous sandy sites in Ontario because of their relative tolerance to dry and nutrient poor conditions (McPherson and Timmer, 2002). Red pines are also known for having wide-reaching root systems that stabilize soils and help in the distribution of soil nutrients (by taking nutrients from deep soil horizons that are inaccessible to most plants and eventually depositing these nutrients on the forest floor as organic matter—a process known as "nutrient pumping") (McPherson and Timmer, 2002). The early red pine plantations were largely successful in terms of reducing soil erosion, replenishing organic matter in the topsoil, and providing food and habitat for local wildlife, which initiated increases in regional biodiversity (Cooper, 2009). The history of intensive land use and development has shown that the moraine is a relatively fragile landform, in large part due to the sensitivity of its glacial till soils to disturbance (McPherson and Timmer, 2002). The sound management of such a fragile landform, in an area of such importance to local human populations, is thus integral to ensure the continued health of Oak Ridges Moraine ecosystems.

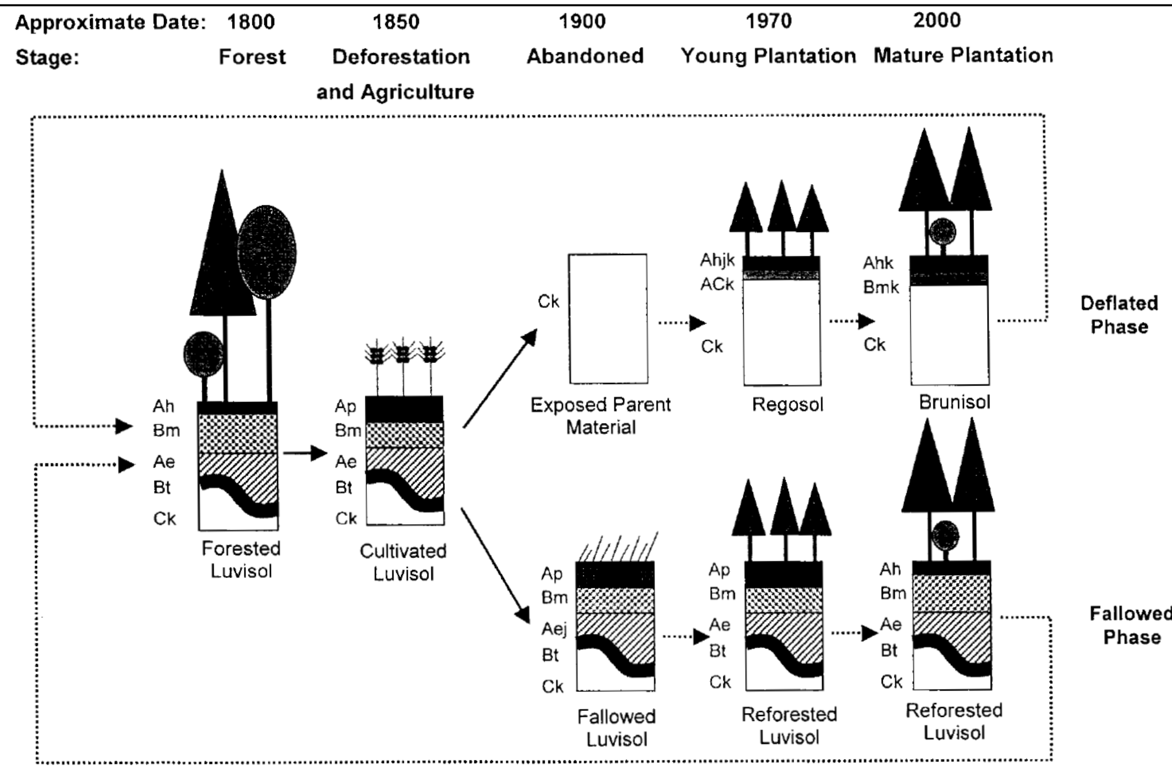


Fig. 2. Conceptual chronosequence of soil degradation and restoration on the Oak Ridges Moraine induced by pre-settlement deforestation, followed by exploitive pioneer agriculture, land abandonment and fallowing and/or deflation (solid arrows). Soil restoration (dotted arrows) was initiated by reforestation with red pine that will likely progress towards the Forest stage (Luvisol) assuming environmental constancy and the absence of further disturbance. Dominant coniferous and deciduous vegetation are illustrated by triangular and elliptical crowns; crops and grasses usually occurred on Ap horizons.

Figure 9: A sample chronosequence illustrating fluctuations in soil fertility associated with forest clearance, land cultivation, and land abandonment on the Oak Ridges Moraine.

In 2001, the Government of Ontario composed the Oak Ridges Moraine Conservation Plan to ensure that all future development on the moraine was “smart,” or sustainable (OMAH, 2001). This plan first entailed the division of the moraine into four distinct land use designations: natural core areas, natural linkage areas, countryside areas, and settlement areas (see Figure 10) (OMAH, 2001). Different regulatory guidelines were then established to govern development in each type of area, with natural core areas receiving the highest level of protection (OMAH, 2001). Although the moraine is rich in limestone and gravel, the Conservation Plan states that “no new aggregate resource extraction is permitted in Natural Core Areas" (OMAH, 2001). Natural core areas and natural linkage areas are also protected from the development of new transportation or utility corridors, unless such corridors are deemed necessary “and there is no reasonable alternative" (OMAH, 2001). New recreational developments such as golf courses are only permitted in countryside areas, and must meet “stringent review and approval standards,” although such standards are not laid out in the Conservation Plan or the Oak Ridges Moraine Conservation Act, 2001 (OMAH, 2001). The Conservation Plan states that “rural settlements” are exceptions to its guidelines, leaving the question of responsible development activities in and around them up in the air (OMAH, 2001).

The Conservation Plan was intended to provide municipalities with “direction... on how to protect the Moraine's ecological and hydrological features and functions" (OMAH, 2001). Most of the planning, enforcement, and practice of the Conservation Plan was left in the hands of local municipalities, whose governments can be and have been swayed into unsustainable forms of development by the interests of local industry and business leaders (Cooper, 2009; OMAH, 2001). The language of the Conservation Plan is decidedly weak, frequently stating the need for “stringent review and approval standards” in regard to development projects, without ever so much as stating what exactly those standards are or how stringently they should be adhered to (OMAH, 2001).

“The Plan’s water resource policies require municipalities to prepare watershed plans, water budgets and water conservation plans to incorporate into their official plans within specified time periods. Restrictions on large scale development are imposed if this work is not completed" (OMAH, 2001, p. 5). What the Conservation Plan did not require, however, was that the official plans of municipalities be legally binding. If municipalities are not legally bound to operate within the parameters that they set for themselves, how can one expect them to make those parameters as realistic as possible, as opposed to simply telling the Government of Ontario what they want to hear? In this light, it seems that the Government of Ontario is essentially handing off a difficult responsibility to municipalities that can profit in the short-term by shrugging off difficult, long-term, responsibilities.

The Ontario Ministry of the Environment, rather than the Ministry of Municipal Affairs and Housing, is best positioned to spearhead efforts to preserve the Oak Ridges Moraine. Certainly the communities on and around the moraine are entitled to the same level of autonomy that all municipalities enjoy, but if the Government of Ontario is unwilling to set binding, definitive regulations on the development of the moraine, and treat it like the special case that it purportedly is, then the government’s willingness to protect the moraine from future human abuse must be called into question. Thankfully, the environmental awareness of citizens of the Oak Ridges Moraine seems to be on the rise, as can be demonstrated by extensive grassroots organizing against intensive resource extraction and other forms of development, and strong voter support for local Green Party candidates. Perhaps many locals have learned from the historical mistakes in the region, and perhaps many more are simply proud of the natural heritage that surrounds them.

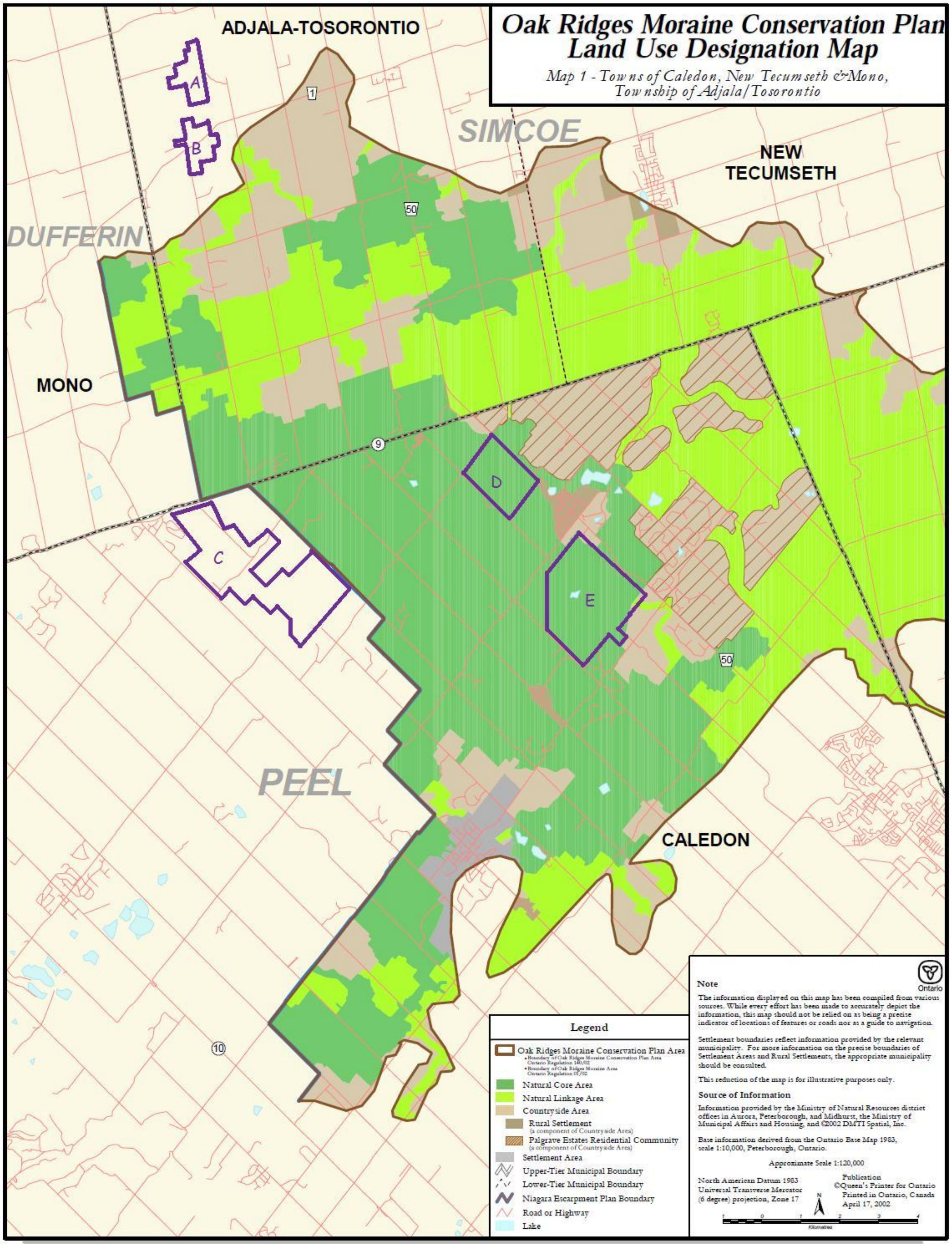


Figure 10: The western end of the Oak Ridges Moraine, with surveyed areas outlined in purple (A: Mono Cliffs Provincial Park; B: Hockley Valley Provincial Nature Reserve; C: Glen Haffy Conservation Area; D: Palgrave Conservation Area; E: Albion Hills Conservation Area).

Source: http://www.mah.gov.on.ca/Asset1869.aspx

Methodology

To begin setting the stage for my field work, I first selected a group of trees to be the focal point of my research. This group was subdivided into two categories, an "A-list" of at risk species that I did not expect to find in large numbers, if at all, in my field studies, and a “B-list” of less rare but locally important trees to look for as a contingency plan in case my hunt for rare trees proved less than fruitful. A-list trees included the following species: American chestnut (*Castanea dentata)*, red mulberry (*Morus rubra*), paw-paw (*Asimina triloba*), cucumber tree (*Magnolia acuminata)*, Kentucky coffee tree (*Gymnocladus dioicus*), and butternut (*Juglans cinerea*), all of which are officially at risk in Ontario. B-list trees included: white pine (*Pinus strobus)*, tulip tree (*Liriodendron tulipifera*), Ohio buck-eye (*Aesculus glabra*), white, red, and rock elm (*Ulmus americana, U. rubra, U. thomasii*), white oak (*Quercus alba*), shagbark hickory (*Carya ovata*), yellow birch (*Betula alleghaniensis*), American beech (*Fagus grandifolia*) and black cherry (*Prunus serotina*).

The next stage in preparation for my field work was to select a cluster of protected areas in the western Oak Ridges Moraine region to survey. I chose to cluster my survey in five protected areas that are within close proximity of each other for several reasons. First, such clustering will give those interested in collecting seeds for restoration efforts some options in terms of where to collect from and will allow them to easily collect seeds from several individuals of their target species spread over different, yet similar, locations. Such options will essentially make these people masters of seed dispersal, as their selective seed gathering from the fittest trees will mimic, yet magnify and expedite, natural processes. Secondly, starting this work in a cluster of protected areas will illustrate to those interested what a methodical survey for accessible natural heritage trees in a given area can look like, which will hopefully inspire others to adopt a similar survey methodology in their own areas of choice. The area in which I have focussed my surveys is located in the headwaters region of the Humber and Holland Rivers, at the western end of the Oak Ridges Moraine (see Figure 8). The protected areas that I selected to serve as survey sites were: Palgrave Conservation Area, Albion Hills Conservation Area, Glen Haffy Conservation Area, Hockley Valley Provincial Nature Reserve, and Mono Cliffs Provincial Park.

Once on the ground in my chosen protected areas, I walked all of the major (and some minor) trails that cut through sections of the forest showing few signs of recent disturbance, and a somewhat natural assemblage of tree species and forest structure. Prior to visiting each park, I would scan satellite images for deciduous, or otherwise natural, forest stands, and prioritize the trails that ran through them (it is quite easy to see where planted, mono-culture stands are located from satellite imagery). Due to the aforementioned history of the Oak Ridges Moraine, many highly degraded sites were reforested using only one or two species (most often red pine, but occasionally Scots pine, white pine, or cedar) that were well adapted to nutrient-deprived sandy soils (McPherson and Timmer, 2002). Such secondary forests are invariably easy to identify, and not simply due to their monoculture nature, but due to the fact that trees were often planted neatly in rows, and large numbers were planted simultaneously, creating even canopy levels throughout such stands.

I limited my surveying to those areas within 10 metres or so of trails, so as to ensure that the trees catalogued are easily accessible, and to avoid as much off-trail disturbance as possible during seed collection. In each park I spent two days surveying the trees, spending anywhere from 12 to 18 hours on the ground at each location.

I carefully noted all of the exemplary specimens of the trees on my A-list and B-list that I encountered. I calculated the approximate height of each recorded tree using a smart phone application called Smart Measure, version 1.5.8, developed by Smart Tools Co. With this application, one can simply stand at an appropriate distance from the tree and point the crosshairs on the screen at the tree's base. One then clicks the start button and gets a measurement for their distance from the base of the tree. One then points the crosshairs at the top of the tree, and receives a measurement of the tree height to one tenth of a metre. At times using this method was difficult, as being in crowded forests often meant that I lacked a clear line of site to a tree's base and top.

After finding noteworthy trees I also measured their diameter at breast height (DBH - roughly 1.3 metres above the ground) using a tape measure. This commonly-used forestry metric allows people to crudely estimate a tree's age, but also allows one to track the growth of a tree year after year.

When taking measurements I also noted the GPS coordinates, in decimal degrees, of each specimen using the smart phone application Latitude & Longitude, version 3.0.8.2.1, developed by Kaiwidment. This application usually gave readings accurate to within 25 metres, which served my purposes well-enough as I also provided manual directions to the location of each tree in my site summaries. I was also sure to take a picture of each notable tree that I found to further facilitate their identification by seed collectors.

During my surveys I always had on hand two tree identification reference books—Farrar's *Trees in Canada* (1995), and Kershaw's *Trees of Ontario* (2001)—just in case I came across, say, a juvenile beech with leaf morphology that closely resembled that of American chestnuts (I did, several times).

My criteria for selecting natural heritage trees was both relative and subjective. A century or two ago, a “natural heritage” tree would stand at twice the height of a relatively exemplary specimen of its descendants today (Henry and Quinby, 2010). I simply looked for specimens who were above average in height and/or girth and age. There are several ways by which to approximate the age of a given tree. Strangely shaped crowns, often with dead branches and branches perpendicular to the trunk or bent at 90 degree angles are indicative of old trees (Henry and Quinby, 2010). The bark morphology of old trees is often characterized by deep ridges, distinct plating, and/or balding (whereas young bark tends to be smooth and relatively uniform) (Henry and Quinby, 2010). Old trees often have a distinct lean due to shifting soil, and they often develop buttress roots for added support (Henry and Quinby, 2010). Many old trees support complex communities of mosses and lichens, which can take decades to develop (Henry and Quinby, 2010). The only way to be certain about a tree’s age, however, is by using a tree corer to take a small cross-sectional sample the length of the radius of the tree trunk and counting the annual growth rings on the sample. I chose not to use a tree corer to evaluate the age of exemplary trees I found, as I felt that the potential harm that could come to trees via bore holes (mainly by providing a passage through a tree's protective bark for insects and pathogens to access and potentially infect the sapwood) did not justify the need to arrive at an exact figure for a tree's age. Growth rings, caused by the difference between the relatively rapid growth of trees in the warm, moist spring and summer months, and the slow or stagnant growth of trees during winter months in temperate (or seasonal) climates, are highly accurate indications of tree age, and can even be used to model the climates of centuries past (a process known as dendrochronology). Trees grow faster in particularly warm and/or moist years, leaving behind broader spaces between the narrow dark-coloured concentric lines that indicate greatly reduced growth in the winter. The wood from trees growing in most tropical or non-seasonal climates has no rings at all, making accurately dating trees in such regions extremely difficult.

While height and form can be used to crudely approximate a tree's age, both measures are highly correlated with site conditions, and are thus quite unreliable indicators (Henry and Quinby, 2010). Trees that are growing on marginal sites with thin or poorly drained soil (as is the case with most of southern Ontario's old growth forests) may grow in small annual increments, and could grow as much in a century as a tree of the same species could grow in a single year if grown on an ideal site (Henry and Quinby, 2010). Southern Ontario's oldest known trees are eastern white cedars growing on rocky outcrops of the Niagara Escarpment, which have been aged at over 1500 years yet only attain heights of several metres in many cases (Henry and Quinby, 2010).

After surveying my five target protected areas in this manner, I compiled my data in a spreadsheet, and then uploaded it into an interactive mapping/geocoding and database management tool known as a Google Fusion Table. The resulting table and map (see Figure 11), complete with coordinates, size measurements, pictures, and seed dispersal periods for each natural heritage tree catalogued, can be accessed at:
https://www.google.com/fusiontables/DataSource?docid=1A4GfCqGxfmJ2XUA8kbAHMG9_BxWNGBCz_G__0d_A. Access to my heritage tree data and map is open to the public. In addition to using the Twitter account I created at the outset of my final project work (CarolinianSeedPrject @ CarolinianSeeds) to inform a select few about the results of my surveying, I also reached out to a variety of Ontario-based tree conservation organizations in the hope that they might help me disseminate my work. I have remained in contact with four organizations—Carolinian Canada Coalition, Ontario Forest Research Institute, Ontario Forestry Association, and Trees Ontario—who expressed interest in my work. When finalized, I will share my results and Final Project Paper with them in the hope that they might make these resources available to their tree-loving audiences. Ideally, I hope that some of those who come across my work will appreciate the pragmatic nature of my approach to finding and cataloguing natural heritage trees, and will use my work as a starting point from which to conduct their own surveys of protected areas in Ontario's Carolinian forests.

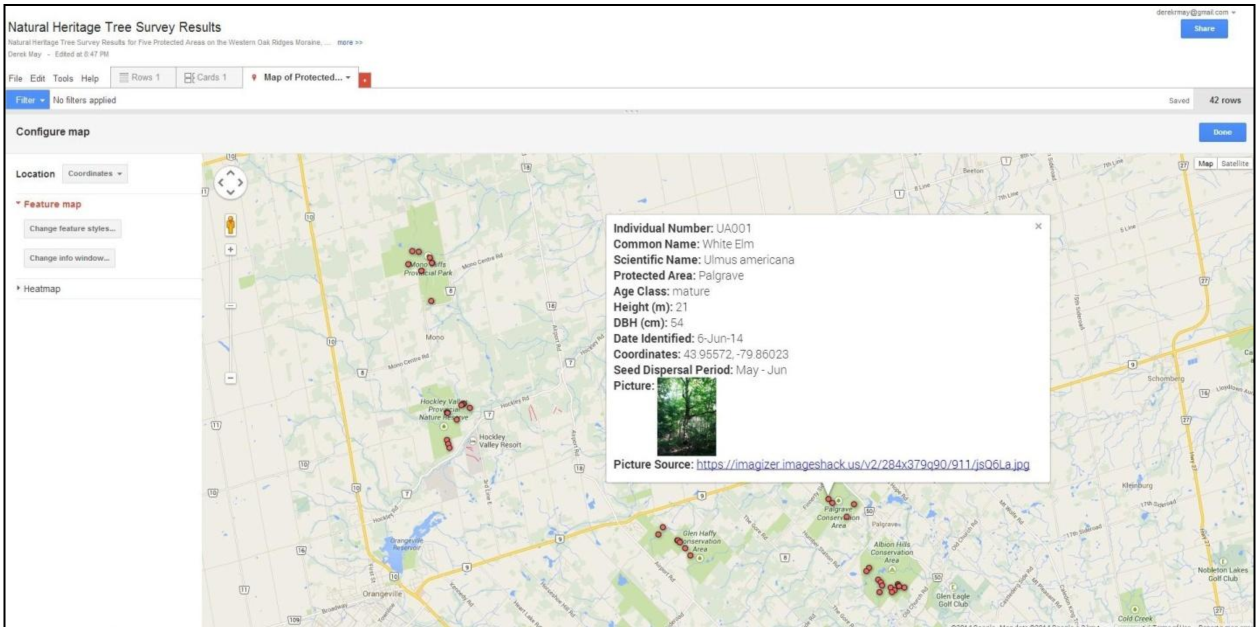


Figure 11: A screenshot of my fusion table map. Each red dot indicates a natural heritage tree. When clicked on, information about that tree will be displayed.

Source: https://www.google.com/fusiontables/DataSource?docid=1A4GfCqGxfmJ2XUA8kbAHMG9_BxWNGBCz_G__0d_A

I should note that in most cases I did not expect to find any exemplary members of my A-list species at the protected areas I surveyed. Cataloguing my B-list species thus proved useful, not only due to available data but the fact that there are already several ongoing, capital-intensive restoration projects involving tree species that are officially recognized as at risk. The B-listers are in a slightly less desperate state, but could still use some help in terms of dispersal and selection for beneficial traits given the fractured, tiny, and degraded landscapes we have set aside for them.

Over the course of conducting my surveys, I realized I would have to amend my working definition of "natural heritage tree" to include any at risk or locally rare tree that I found, not simply exemplary specimens of such trees. My hope is that due to continued conservation and forest management efforts, the sapling and juvenile at risk trees of today are simply exemplary specimens waiting to happen.

Part of the reason for my somewhat casual methodological approach to finding and classifying natural heritage trees is that I did not want to recreate data like that which came about from one of the only local protected area tree species surveys that I came across while conducting background research. The survey used a strict, randomized statistical approach to gauging tree diversity in protected areas, exclusively sampling a 25m x 25m plot of forest in each target conservation area. This methodology led to the massive underrepresentation (or overrepresentation) of certain tree species in the data, with one protected area (Mono Cliffs Provincial Park—which I too surveyed) being recorded as containing only *one* species of tree (Medeiros, 2009).

Results by survey site

Palgrave Conservation Area

Palgrave Conservation Area, also known as Palgrave Forest and Wildlife Area, is located on Highway 50 just north of the town of Palgrave, and just south of Highway 9. This protected area is roughly 225 hectares in size, and sits at an elevation of roughly 300 metres. The area consists of planted stands of conifers and naturally-regenerating hardwood forests, divided by moist lowland areas hosting creeks, marshes, and ponds. The planted conifer stands are all at a mature stage, and consist mainly of red pine, but the area also has large stands of planted white pine that are in good health (and are already producing an understory layer of juvenile white pines and white ash), and also stands of cedar and white spruce. Many of the white pines have already reached heights of 25 metres, with an average diameter at breast height (DBH) of 55 centimetres.

There are two major trails spanning the conservation area; the Bruce Trail (shown in blue in Figure 12), and the Oak Ridges Trail (shown in red). These trails intersect with many smaller walking and mountain biking trails, some of which are indicated on the trail map in green. All the trails on the map are well-marked with numbered sign posts at major intersections, so navigating one's way through this forest is a breeze.

The Bruce Trail and the area to the south of sign posts 6 and 7 contain some very large and healthy basswoods, some reaching as high as 30 metres with DBHs of 60 centimetres or more. Some of the most impressive trees I saw in Palgrave were basswoods, and many of the largest specimens are growing in small clusters close to trails, making the collection of their seeds an easy task. The southern corner of Palgrave (south of sign posts 6 and 7) also contains the area's largest sugar maples, as well as its most extensive stands of black cherry. Along with the park's basswoods, I was most impressed by the towering black cherries that are amongst the most common trees in several places, some of which reached heights of 30 metres (see Figure 13). Palgrave's "southern corner" is perhaps its best example of a mature hardwood stand, being dominated by sugar maple, black cherry, white ash, basswood, and white pine, with ironwood being a prominent understory tree.

The native invasive climbing vine known as riverbank grape is a major problem in the southern portion of Palgrave (see Figure 14). This plant is particularly harmful to juvenile trees, as it quickly enshrouds their canopies in a dense layer of leaves, blocking out the sun and making survival impossible. There are many cases in Palgrave where riverbank grape has even killed mature trees. If walking here, I would recommend bringing some pruning shears or a knife to sever the sinuous vines of riverbank grapes that have begun to overtake the lower branches of trees.

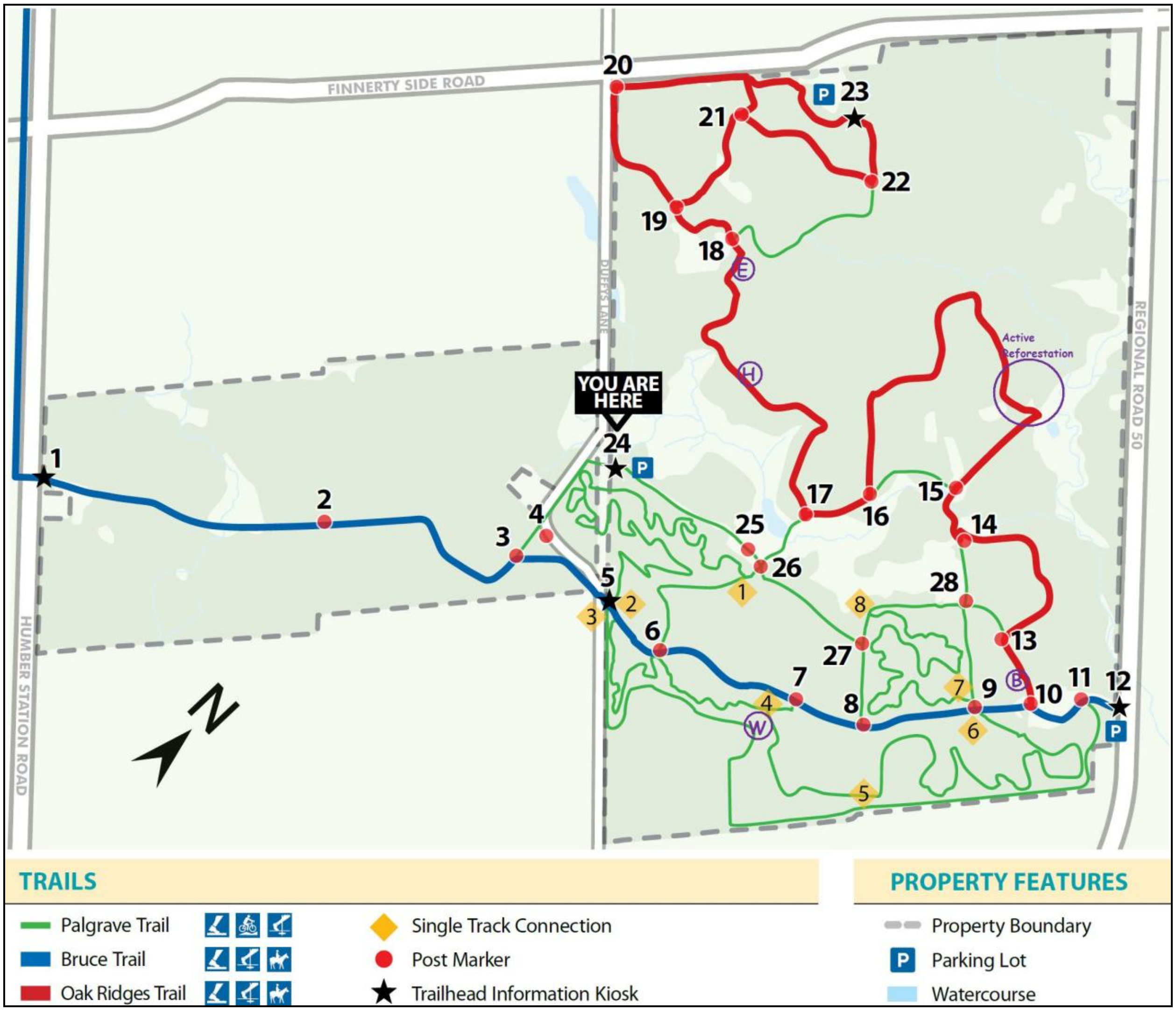


Figure 12: Palgrave Conservation Area Trail Map. Notable trees are marked with circled letters. See Table 1 for a guide to map symbols.

Source: http://www.palgravetraining.com/uploads/1/2/9/7/12974699/palgrave_trail_map.pdf

The most common deciduous tree throughout the park is the versatile white ash. The mid-successional nature of this tree means that it can grow in partially shaded areas or in full sunlight, in a wide range of soil types. I observed many white ash growing among stands of cedar and white pine, as well as in deciduous stands.

The Bruce Trail between sign posts 9 and 6 is lined in several places by serviceberry trees. In June and July these trees produce delicious and nutritious berries that are relished by humans and wildlife alike. Palgrave does seem to have all the right conditions to support healthy populations of local wildlife, including deer, coyotes, foxes, raccoons, rabbits, squirrels, chipmunks, ducks, geese, and songbirds. In my time there I saw several deer and raccoons, as well as many red squirrels, who seem to covet white pine seeds.

Figure 13: A towering black cherry tree in Palgrave Conservation Area

The "W" on the trail map, just south of sign post 4, indicates what could be the oldest tree in the park—a gnarly old white pine that is clearly at least a generation older than any of the planted white pines (see Figure 15). It was not as tall as some of the other pines, but could well be twice as old as any of them, representing an important seed source.

On the Oak Ridges Trail between sign posts 17 and 18, the "H" on the trail map indicates five shagbark hickory saplings. I recorded the measurements of the largest tree in this young cluster (see Figure 16), but all are growing within several metres of one another. They are all moderately shaded, being surrounded by tall white spruces growing at the edge of a marsh. Shagbark hickories are now locally rare, but were once an important food source to local indigenous groups who traded their seeds and planted specimens well outside of the species' natural range (Kershaw, 2001).

Near sign post 18, the "E" on the trail map indicates what was easily the oldest white elm I saw in Palgrave. Despite sporting a large, festering canker about 5 metres up its trunk (a tell-tale sign of the omnipresent Dutch elm disease), this elm had an extremely lush and broad canopy, indicating good health (see Figure 17). While many juvenile elms line the major trails in Palgrave, this was the only fully mature elm I saw in the park. It is possible that this individual has a high level of resistance to Dutch elm disease, making it a potentially important seed source.

Figure 14: Riverbank grape is climbing its way ever further up the spruce on the left. The spruce on the right was recently saved from further grape damage.

On the Oak Ridges Trail, about 150 metres past sign post 10 on the way to sign post 13, on the left side just past a red maple hanging low over the trail, I found the only at risk tree I was to come across in Palgrave—a juvenile butternut (see Figure 18). While it is hard to estimate the age of trees growing in a forest understory due to the fact that many shade tolerant species can remain more or less dormant for decades while they wait for a canopy gap to appear before growing tall in earnest, I would safely age this tree at between 5 and ten years of age. This is unfortunate, as butternuts do not tend to produce significant volumes of seed until reaching the age of 20 or so. Nonetheless, this tree will likely still be around in several years when it will begin to mature. At that time seed collectors will be free to race the local squirrel population for one of this tree's highly coveted nuts.

The purple circle on the trail map indicates an area that is undergoing active reforestation efforts by local conservation authorities. The area is primarily open, and borders extensive marsh lands. It has been planted with several hundred trees comprised of balsam poplar, large-toothed aspen, trembling aspen, silver maple, white spruce, red osier dogwood, basswood, and cedar. All of these plantings are in the juvenile stage of growth, and all are doing well except for the cedars. Many of the deciduous plantings are being browsed quite heavily by deer, but it appears that browsing levels will not prove fatal.

Perhaps the most interesting area in Palgrave to me was the trail between sign posts 26 and 27. This section of the forest has some towering specimens of basswood, black cherry, white ash (the biggest in the park), sugar maple, trembling aspen, white spruce, white pine, and by far the biggest white birches in Palgrave. The rugged topography in this area may have protected some of these veteran trees from harvesting, and the land in general from development, in decades past.

Figure 15: The white pine pictured is the oldest that I saw in Palgrave. It certainly stands out in a crowd.

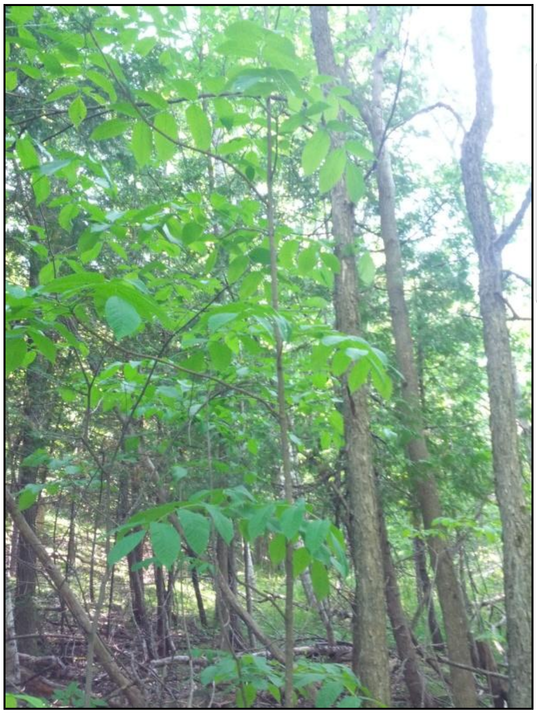


Figure 16:

A shagbark hickory sapling

Figure 17: The elm pictured above is the oldest one I found in Palgrave CA

Figure 18: The distinctive leaf and bark of the butternut

TABLE 1: Natural Heritage Tree Data for Palgrave Conservation Area

Individual Number	Common Name	Scientific Name	Map Symbol	Age Class	Height (m)	DBH (cm)	Date Identified	Coordinates	Seed Dispersal Period
PS001	White Pine	*Pinus strobus*	W	veteran	24	120	6-Jun-14	43.94919, -79.85086	Aug - Sep
CO001	Shagbark Hickory	*Carya ovata*	H	sapling	4	1.5	6-Jun-14	43.95437, -79.85833	Sep - Oct
UA001	White Elm	*Ulmus americana*	E	mature	21	54	6-Jun-14	43.95572, -79.86023	May - Jun
JC001	Butternut	*Juglans cinerea*	B	sapling	5	4	7-Jun-14	43.95387, -79.84678	Sep - Oct

Albion Hills Conservation Area

Albion Hills Conservation Area comprises 446 hectares of rolling, sandy hills and young forest stands (Conservation Ontario, 2012). Some large sections of Albion Hills were planted in recent decades with red pine, with other smaller sections being planted with white pine or white spruce. Extensive, naturally-occurring cedar groves cover many of the moist, low-lying slopes in the conservation area, the younger generations of which were likely derived from the handful of veteran cedars that are scattered throughout the park (the biggest of which measured 145 centimetres DBH and 17 metres tall). The park is located on Highway 50, just south of the town of Palgrave, and about 2 kilometres south of Palgrave Conservation Area. Albion Hills is a well-known hotspot for mountain-bikers, hosting several major

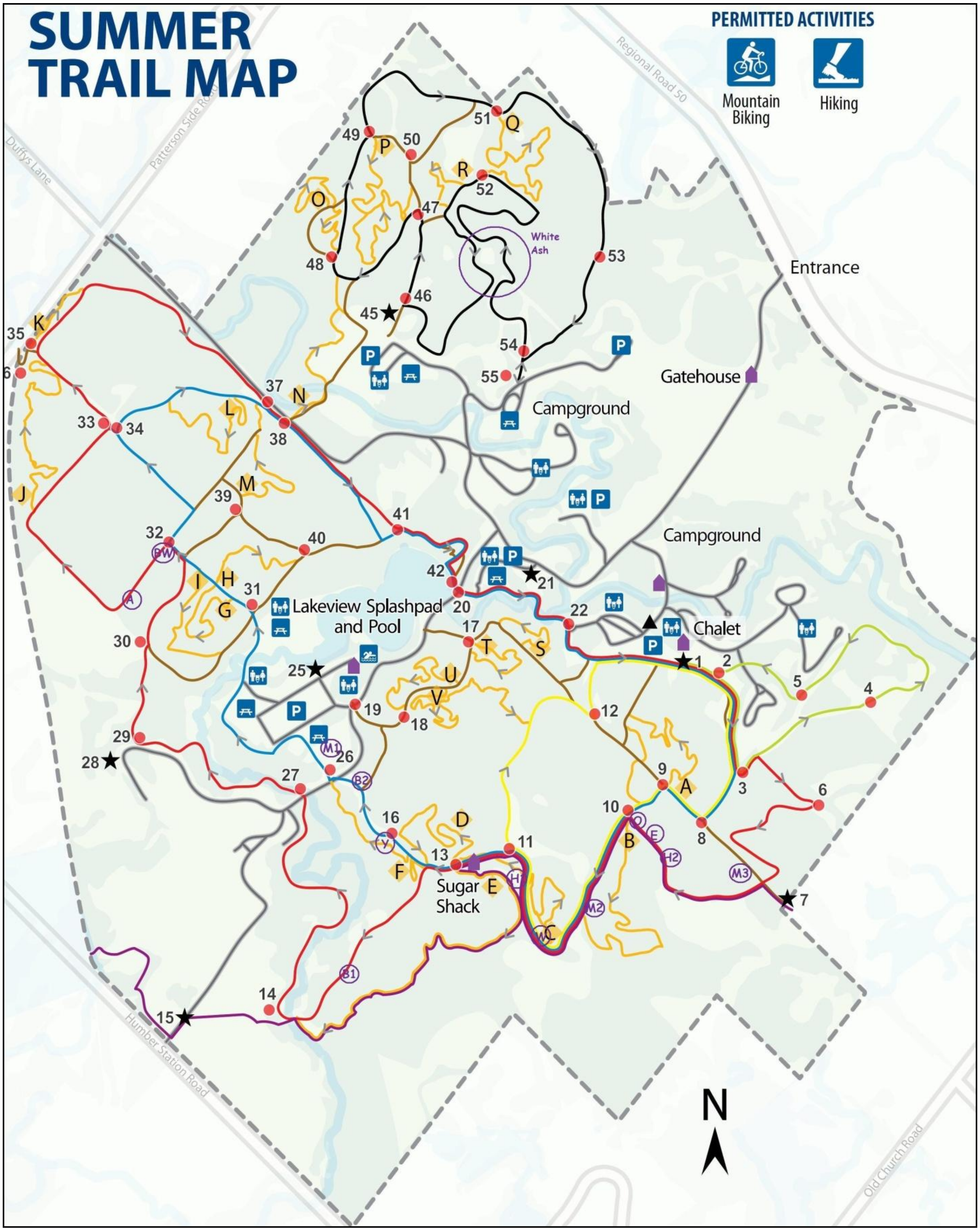


Figure 19: Albion Hills Conservation Area Trail Map. See Table 2 for a guide to map symbols.

Source: http://www.trca.on.ca/trca-user-uploads/trailMap-AlbionHills-Summer.pdf events and races each year, and the mountain biking trail infrastructure is extensive, well-marked, and well-used. The biking trails are marked in yellow on the trail map (see Figure 19), and should not be considered off-limits to hikers, as some of them offer the best views to be had in the conservation area. Many of the hiking trails in the park are poorly maintained (having uneven, partially-eroded surfaces with frequent sections covered by loose rocks, which can make hiking difficult), and some trails are poorly marked—so be sure to have a trail map on-hand if you decide to visit. A good habit to get into when visiting such parks with a digital camera is to take a high-resolution photo of one of the trail maps provided at major intersections and trail-heads. Even if you think you know where you are going, it never hurts to have a map on-hand, and having a map can embolden hikers to explore intriguing-looking side-trails that they might otherwise bypass.

Heading south from the main parking lot (which is adjacent to trail marker 25 on the map), one will be immediately reminded of which tree species dominates this park and region—sugar maple. Only 30 to 40 metres south of the parking lot, just to the left of the blue trail, is a massive old sugar maple (see Figure 20) with a DBH of 170 centimetres and a height of 22 metres. Many of the oldest trees in the conservation areas I surveyed have attained massive girths while reaching fairly modest heights, and this results from the fact that they grew in the open for long periods of time, with the forests around them cleared for agriculture, lumber, and other forms of development. In the dense forests which would naturally occur on these sites, even juvenile trees would stand taller than some of the old giants that I found, as their race for the light in the forest canopy would lead them to prioritize height over girth. This sugar maple was the first of three giants that I found in Albion Hills (marked M1, M2, and M3 on the map), all of which are likely in the range of 300 years of age. Other veteran sugar maples can be found frequently along old fence lines which once divided properties and agricultural plots. As Kock (2008) mentioned, such fence lines in the region almost always contain trees grown from locally-adapted genetic stock, and can represent excellent seed sources.

Figure 20: A giant sugar maple at Albion Hills (marked M1 on the map and individual number AS001 in Table 2).

The first giant sugar maple (M1) appeared to be in excellent health despite its age, and likely still produces prodigious volumes of seed every year. A second sugar maple of comparable age and form (M2) can be found on the red trail between sign posts 11 and 10. It is growing roughly 10 metres away from the trail in a young sugar maple-dominated stand, but it cannot be missed (see Figure 21). It has a DBH of 140 centimetres and a height of 23 metres. While this tree's two main trunks appear healthy and productive, it is showing many signs of old age, with large rifts and hollows in its stems where once large branches have fallen away and the heartwood has begun to rot. The third ancient sugar maple to be found at Albion Hills was perhaps the healthiest of the three, and can be found on the brown trail between sign posts 7 and 8 (see Figure 22), in an area with many large, mature sugar maples, as well as some mature beech and black cherry. Where sugar maple and beech dominate, little else will grow in the understory, and although this results in species-poor stands, sugar maple and beech forests represent the most common climax forest type in the region.

Figure 21: A second giant sugar maple at Albion Hills (marked M2 on the trail map and AS002 in Table 2).

The blue trail between sign posts 26 and 13 is a great example of a young mixed deciduous forest, featuring pioneer species like trembling aspen, mid-successional species like white ash, red maple, and white pine, as well as juvenile shade tolerants like sugar maple, beech, hemlock, and yellow birch. A rare example of a veteran yellow birch (the only veteran of this species I found at Albion Hills) can be found just south of sign post 16, about 8 metres into the woods (see Figure 23). This specimen has a DBH of 70 centimetres and a humble height of 20 metres (again, this indicates that it grew in the open for most of its life).

Walking along the red trail from sign post 13 to 14, just after a cleared area and before a dense cedar grove, to the left of the trail, is a young butternut close to reaching the juvenile stage of growth (see Figer 23). It stands a humble 4.2 metres and has a DBH of 8 centimetres, but could start producing seeds, in small quantities at first, within the next few years. Past this butternut, growing along the trail

Figure 22: The third giant sugar maple of Albion Hills (marked M3 on the map and AS003 in Table 2).

Figure 23: A veteran yellow birch at Albion Hills (marked Y on the map and BA001 in Table 2).

amongst the cedars, can be found many mature speckled alders—a rare sight this far south (see Figure 25). Alders play an integral role in forest establishment on heavily disturbed sights, as they are one of only two native tree species that are nitrogen-fixers, having roots with nodules containing symbiotic bacteria that are able to convert atmospheric nitrogen (N_2) into organic forms that can be taken up by plants. Due to this rare characteristic, alders were the first tree species to widely colonize southern Ontario after glaciers began to recede from the region roughly 12,000 years ago (Tarrant and Trappe, 1971). Their presence added much-needed nitrogen to the then infertile soils, and they also built the soil up with organic matter from leaf litter and downed woody debris, laying the groundwork for the establishment of other tree species (Tarrant and Trappe, 1971). Their presence on degraded sites should thus always be seen as a positive sign, as it indicates that the site's soils are on the mend.

Figure 24: The form and bark of a butternut sapling at Albion Hills (marked B1 on the map and JC002 in Table 2).

A second butternut, this one a juvenile, can be found on the red trail just 30 metres past sign post 26, at the edge of a sumach grove. This tree stands 6.5 metres with a DBH of 13 centimetres. A third, smaller butternut sapling can be found roughly 25 metres past this juvenile on the eastern side of the blue trail, again enshrouded by a grove of young sumachs.

Figure 25: A characteristic clump of speckled alders in Albion Hills, along with an alder leaf.

I found only two hickories in Albion Hills, both shagbark hickory saplings growing to heights of roughly 3 metres. The first specimen of this locally-rare tree can be found on the red trail between two small marshes, about 200 metres south of sign post 11, right after biking trail C crosses the red trail (see Figure 26). Although it is still a sapling, this shade tolerant tree looks to be roughly 5 years old, and is eagerly awaiting a gap to appear in the canopy which would let enough light through to facilitate more rapid growth. Another shagbark hickory sapling can be found about half-way between sign posts 10 and 7 on the red trail, growing amongst a stand of white pine.

Figure 26: The shagbark hickory sapling on the left is individual CO002 in Table 2 and "H1" on the trail map. The sapling to the right is CO003 and "H2." A characteristic shagbark hickory leaf is below.

Where the red trail first comes to the shore of a large pond between sign posts 11 and 10 there is a veteran white pine—the only true veteran I saw at Albion Hills—growing just to the east of the trail (see Figure 27). This specimen, which measures 32 metres tall with a DBH of 90 centimetres, is a generation older than any other white pine that I came across in the park, and has excellent form and health, making it a great candidate for seed collection. This area of the park is home to many juvenile and a handful of mature yellow birches—a rare sight in young forests and a good indicator of forest health.



Figure 27: The base, trunk, and crown of veteran white pine (PS002, or "W" on map) at Albion Hills.

The forest surrounding sign post 10 is the only area of the park that is home to mature red oaks, which reach up to 25 metres tall and 50 centimetres DBH. Just 10 metres past sign post 10 moving towards sign post 7, just to the left of the trail, is the only white oak I found in any of the areas I surveyed. While frequently planted in urban settings, naturally-occurring white oaks are quite rare in the Oak Ridges Moraine region, which is near the northern extent of this species' range. This juvenile white oak (see Figure 28) was 18 metres in height with a DBH of 14 centimetres. Just 50 metres past this white oak, on the same side of the trail, is a large white elm, the biggest that I saw in Albion Hills, measuring 24 metres tall with a 42 centimetre DBH. This stretch of the trail also features some unusually large tamaracks, up to 26 metres tall with DBHs of 45 centimetres or more.


Figure 28: The rounded leaves and pale, scaly bark of the white oak. Pictured here is the juvenile at Albion Hills ("O" on the trail map).

The forests in the northern portions of the park tend to be much younger than those in the south. Planted red pine stands dominate the northwest quadrant of the park, and trails tend to be lined with young basswoods, white elms, and old apple trees whose presence speaks to the area's agricultural past. Just to the south of sign post 32 is an old cluster of basswoods, with four main stems up to 43 centimetres DBH and 21 metres tall (see Figure 29). As the ground below this broadly-crowned cluster is relatively open and bare, this would be an ideal place for basswood seed collection. Just before this stretch of trail makes a sharp turn to the northwest, a very old apple tree can be found growing just a few metres off to the left. This specimen was the biggest of the countless apple trees I came across at all of the parks I surveyed. One of its two main stems measured 45 centimetres DBH and 16 metres in height—massive dimensions for this usually small orchard tree.

Figure 29: Basswood cluster at Albion Hills ("BW" on the map, and TA001 in Table 2).

The northeast quadrant of the park features young sugar maple-dominated stands, with average DBHs of 35 centimetres and heights of up to 30 metres. These younger stands allow more light to reach the forest floor than more mature sugar maple stands, which allows for diverse and lush understory communities featuring white ash, alternate-leaf dogwood, yellow birch, ironwood, and white elm. There are some towering white ash in this section of the park (see the circle beside "White Ash" on the trail map), up to 55 centimetres DBH and 27 metres tall. Curiously, I did not notice any signs of the emerald ash borer in Albion Hills, with all of the ashes seeming to be in excellent health.

TABLE 2: Natural Heritage Tree Data for Albion Hills Conservation Area									
Individual Number	**Common Name**	**Scientific Name**	**Map Symbol**	**Age Class**	**Height (m)**	**DBH (cm)**	**Date Identified**	**Coordinates**	**Seed Dispersal Period**
AS001	Sugar Maple	*Acer saccharum*	M1	veteran	22	170	27-Jun-14	43.92526, -79.83427	Oct
BA001	Yellow Birch	*Betula alleghaniensis*	Y	veteran	20	72	27-Jun-14	43.92313, -79.83199	Sep - Feb
JC002	Butternut	*Juglans cinerea*	B1	juvenile	4	8	27-Jun-14	43.92070, -79.83342	Sep - Oct
JC003	Butternut	*Juglans cinerea*	B2	juvenile	7	13	27-Jun-14	43.92440, -79.83283	Sep - Oct
CO002	Shagbark Hickory	*Carya ovata*	H1	sapling	3	2	27-Jun-14	43.92229, -79.82763	Sep - Oct
PS002	White Pine	*Pinus strobus*	W	veteran	32	90	27-Jun-14	43.92066, -79.82693	Aug - Sep
AS002	Sugar Maple	*Acer saccharum*	M2	veteran	23	140	27-Jun-14	43.92141, -79.82565	Oct
QA001	White Oak	*Quercus alba*	O	juvenile	18	14	27-Jun-14	43.92353, -79.82400	Sep - Oct
UA002	White Elm	*Ulmus americana*	E	mature	24	42	27-Jun-14	43.92306, -79.82346	May - Jun
CO003	Shagbark Hickory	*Carya ovata*	H2	sapling	3	1	27-Jun-14	43.92282, -79.82324	Sep - Oct
AS003	Sugar Maple	*Acer saccharum*	M3	veteran	27	145	27-Jun-14	43.92229, -79.82042	Oct
TA001	Basswood	*Tilia americana*	BW	veteran	21	43	28-Jun-14	43.92981, -79.83891	Sep - Dec
MS001	Apple	*Malus sylvestris*	A	veteran	16	45	28-Jun-14	43.92847, -79.84042	Sep - Oct

Mono Cliffs Provincial Park

Located on Mono Centre Road (County Road 8) between Highway 10 and Airport Road, Mono Cliffs Provincial Park is a 737 hectare section of the Niagara Escarpment at the northern limit of the Oak Ridges Moraine (Town of Mono, 2009). Within the park, erosion-resistant sections of the escarpment's capstone (which is comprised of dolomitic limestone) stand out from the surrounding landscape in features that look very much like steep-sloped drumlins. The cliffs of these features give the park its name, and have also created small, inaccessible refuges for isolated stands of trees. The old-growth cedar forests which cling to the cliff faces of the park (see Figure 30) contain some of the oldest cedars in eastern North America, with recorded ages up to 700 years (Toronto Hiking, 2012). Some of these ancient cedars may be no more than a metre or two tall, their growth stunted throughout their lives due to a lack of soil and water on the seemingly inhospitable cliff faces (Henry and Quinby, 2010).

Figure 30: The roots of these ancient cedars hug the cliffs while the stems wind their way towards the sun.

Over 450 plant species have been identified in Mono Cliffs, and the area is in an important transition zone between the species-rich Carolinian forest to the south, and the Great Lakes-St. Lawrence forest to the north. Many Carolinian species reach the northern limit of their ranges here, and many GLSL species here are further south than their ranges would normally accommodate. Climate change will soon place Mono Cliffs squarely in the Carolinian zone, meaning that it could now be, or will soon be, hospitable to tree species that have not occupied its valleys since pre-Pleistocene times. The natural northwards migration of most of those species, however, will take hundreds if not thousands of years (Puric-Mladenovic et al., 2011), so Mono Cliffs might soon find itself on the frontlines of assisted tree migration efforts. There are several expansive, open fields within the confines of the park, as well as a large abandoned apple orchard, and such sites could become home to a wide array of at risk and rare Carolinian trees.

Starting on the park's trail systems from the main parking lot on the eastern border (along 3rd Line EHS), one will walk past a broad open meadow to the south, with a good view of the major rock outcrop that comprises the most distinctive geographical feature in the southern portion of the park. Just past this meadow, roughly 25 metres before reaching the yellow trail (see Figure 31) and just three metres to the north of the trail, I found a very healthy specimen of the endangered blue ash. Officially designated as a Species of Special Concern by the Ontario Ministry of Natural Resources, there are only 56 known occurrences of blue ash in all of Canada (OMNR, 2013(1)). There are no recorded instances of the tree occurring as far north as Mono Cliffs, although its favoured habitat does include the limestone outcrops of the Niagara Escarpment (OMNR, 2013(1)). This specimen is a juvenile on the cusp of reaching maturity, but is likely already producing significant volumes of seed. It stands 13 metres tall, has a DBH of 9 centimetres, and appears to be in excellent health (see Figure 32).

The yellow trail, which winds its way up the northern edge of the rock outcrop in the southeast of the park, can be hard to locate as it works its way through ancient cedar groves on the slopes of the outcrop. The distinctive karst landscapes throughout the park, but especially on and surrounding the limestone outcrops, mean that the soils of Mono Cliffs tend to be thin and acidic, in many cases not allowing for the growth of diverse mixed forests. In some areas, however, the cedar forests have healthy understories of robust shade tolerants like ironwood, hemlock, and yellow birch. Just to the east of the northernmost trail junction on top of the outcrop stands a very old beech that is large despite the fact that it has spent its life in thin and generally marginal soils. This specimen stands 26 metres and has a DBH of 56 centimetres.

The soils on the top of the southeastern rock outcrop are thicker and more fertile than those on the periphery, and the area is home to many mature and healthy beeches, making it a fantastic spot to collect beech nuts. Aside from beech, these forests are home to trees like sugar maple, ironwood, and hemlock, along with the pioneering white birch, red maple, and large-toothed aspen in younger stands. Some hemlocks on the outcrop have reached sizes of 60 centimetres DBH and 27 metres tall, while the ubiquitous sugar maples grow up to 70 centimetres DBH and 31 metres tall.

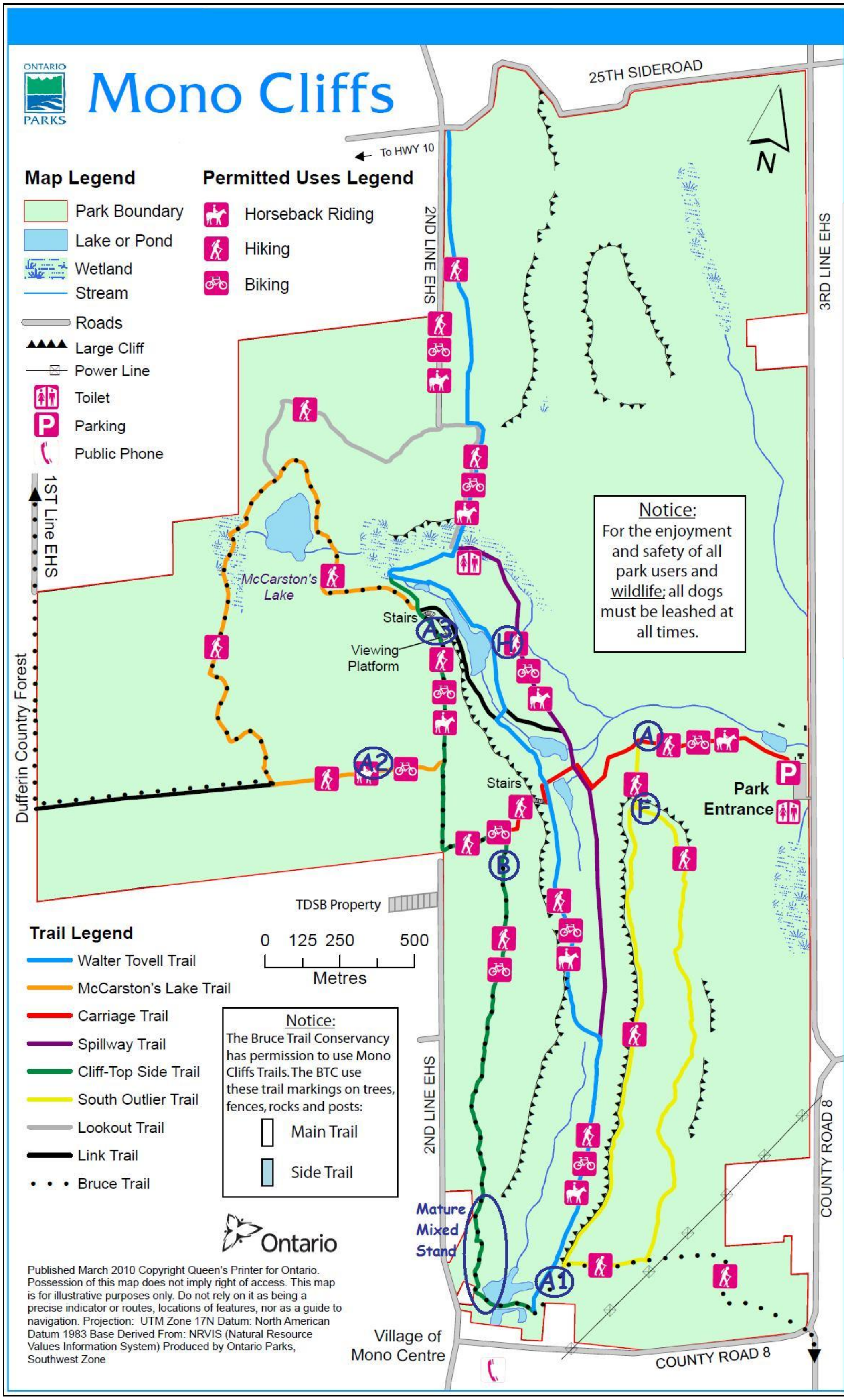


Figure 31: Mono Cliffs Trail Map

A = Blue Ash

A1, A2, A3 = White Ash

B = Butternut saplings

F = Beech

H = Dotted Hawthorn

Source: http://headwaterscommunities.org/wp-content/uploads/2012/02/Mono_Cliffs_Trails1.pdf

As one descends into the fertile valleys of Mono Cliffs Provincial Park, the assemblages of trees change noticeably, as does their size and form. A towering and healthy white ash measuring 72 centimetres DBH and 30 metres tall stands 5 metres to the west of the yellow trail just before it joins the blue trail. The low-lying regions of the park also support the growth of large white pines, many of which can be found along the southern limits of the green trail. As the green trail passes by a large pond and turns north, there is an excellent stand hosting a diverse array of mature trees including sugar maple, beech, red oak, cedar, hemlock, white spruce, yellow birch, and black cherry (see "Mature Mixed Stand" in Figure 31). This stand appears to have remained undisturbed for a long time, and will increasingly begin to take on the characteristics of an old growth forest if left undisturbed in the decades ahead.

Figure 32: The blue ash at Mono Cliffs—bark, trunk, and leaf.

As one walks north on the green trail, it passes through a very large and long-abandoned apple orchard which is slowly being colonized by native tree species. Many open, grassy areas dot this abandoned orchard, and there are lots of opportunities here for the planting of native species, many of which are struggling to establish seedlings here amidst the dense network of grasses and forbs. Just as the orchard ends and begins to transition back to a closed-canopy forest, a young butternut can be found leaning over the trail, surrounded by a young stand of trembling aspen. This butternut measures 4 centimetres DBH and 3.8 metres tall. Just ten metres down the trail, three more butternut saplings can be found, the largest of which is 4 centimetres DBH and 5.5 metres tall (see Figure 33). Although butternuts tend not to start producing significant volumes of seed until they reach roughly 20 years of age, far younger specimens will produce small quantities of seeds, and two of these individuals look to be close to reaching that stage. These butternuts lie approximately 150 metres south of the red trail.

Along the purple trail north of the red trail, the forests are just beginning to overtake the grasslands that overtook the area after the original forests were cleared by settlers. This area comprises a good example of an early-successional forest, with its open canopies and pioneer tree species like white ash, sumach, trembling aspen, and hawthorn. Dotted hawthorn, a very small tree growing at the northern extent of its range in the Mono Cliffs region, can grow to large heights here. The largest specimen I found was 8.2 metres tall with a DBH of 18 centimetres—a towering specimen relative to other members of its species.

Figure 33: Two butternut saplings growing in an aspen grove at Mono Cliffs.

The blue trail linking the purple and green trails north of the viewing platform passes through another Mono Cliffs stand on the cusp of achieving old-growth status. Hemlocks in this area can reach heights of up to 32 metres, with DBHs up to 80 centimetres. This stand also contains large sugar maples, cedars, white birch, and black cherries, with younger beech and basswoods popping up in the understory. On disturbed sites, beech trees take a long time before they can naturally re-establish themselves, and require a dense canopy cover to do so, so the presence of beech saplings can be viewed as a clear sign of a forest on the mend (USFS, 1990).

The northern sections of McCarston's Lake Trail (orange on the map) pass through mature sugar maple-dominated woodlands, with huge sugar maples growing on slopes that were perhaps never cleared by settlers. These sugar maples can reach sizes of 100 centimetres DBH and 32 metres tall. On the northwestern portion of McCarston's Lake Trail, black cherries dominate alongside sugar maples, and can reach sizes of 33 metres and 63 centimetres DBH. This area, however, mostly contains young sugar maple-beech forests, with some of the biggest and oldest trees in the area being ironwoods, which grew up to 30 centimetres DBH and 21 metres tall. Containing the hardest and densest wood of any tree in Canada, ironwoods would have been prized in this region for applications requiring extremely tough wood, such as the construction of tool handles (Farrar, 1995).

The southern stretch of McCarston's Lake Trail contains some very large sugar maples, black cherries, and white ashes growing along old fence lines. One white ash along this stretch ("A2" on the trail map) stands at 32 metres tall, with a DBH of 95 centimetres. It appears to be very healthy, showing no signs of ill-health at the hands of the emerald ash borer. The biggest white ash I came across at Mono Cliffs is located just to the east of the green trail, roughly 25 metres north of the viewing platform. It has attained a height of 26 metres and a DBH of 108 centimetres, and like the other ashes in the park, appears to be in excellent health.

TABLE 3: Natural Heritage Tree Data for Mono Cliffs Provincial Park									
Individual Number	Common Name	Scientific Name	Map Symbol	Age Class	Height (m)	DBH (cm)	Date Identified	Coordinates	Seed Dispersal Period
FQ001	Blue Ash	*Fraxinus quadrangulata*	A	juvenile	13	9	5-Jul-14	44.04659, -80.06931	Sep - Feb
FG001	Beech	*Fagus grandifolia*	F	veteran	26	56	5-Jul-14	44.04468, -80.06836	Sep - Oct
JC004	Butternut	*Juglans cinerea*	B	sapling	4	4	5-Jul-14	44.04180, -80.07379	Sep - Oct
JC005	Butternut	*Juglans cinerea*	B	sapling	6	4	5-Jul-14	44.04181, -80.07377	Sep - Oct
FA001	White Ash	*Fraxinus americana*	A1	veteran	30	72	5-Jul-14	44.03033, -80.06879	Sep - Feb
CP001	Dotted Hawthorn	*Crataegus punctata*	H	veteran	8	18	6-Jul-14	44.04882, -80.07515	Sep - Oct
FA002	White Ash	*Fraxinus americana*	A2	veteran	32	95	6-Jul-14	44.04428, -80.08057	Sep - Feb
FA003	White Ash	*Fraxinus americana*	A3	veteran	26	108	6-Jul-14	44.04922, -80.07877	Sep - Feb

Glen Haffy Conservation Area

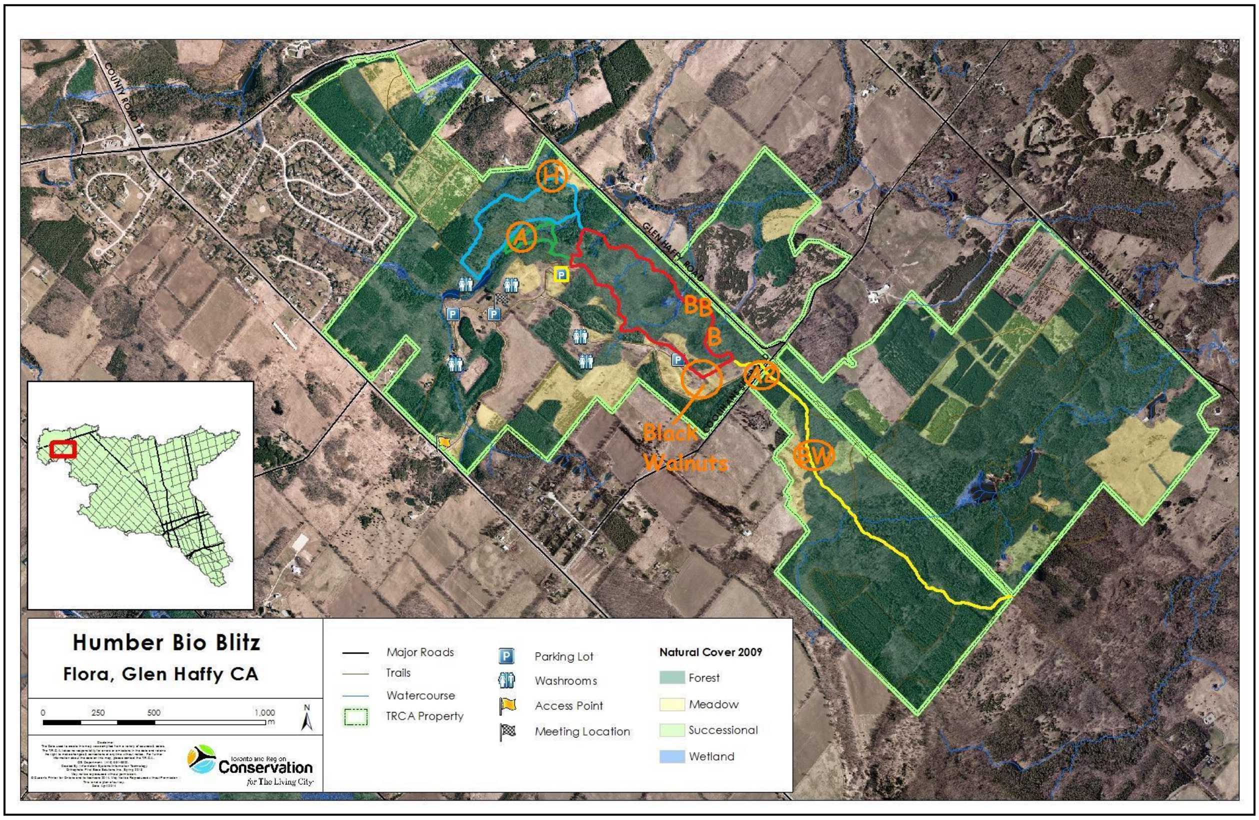
Glen Haffy Conservation Area is a 426 hectare property owned and operated by the Toronto and Region Conservation Authority (TRCA) (NEC, 2005). Located along the initial stretches of the Humber River, this park can be accessed at 19245 Airport Road, in Caledon Township. It is a multi-use conservation area, with cleared and well-maintained picnic areas, trails for hiking, cross-country skiing, and, unfortunately, off-road recreational vehicles, as well as a rainbow trout hatchery which supplies trout for stocked ponds within the park as well as nearby conservation areas (NEC, 2005). The soils here are much siltier and more fertile than the sandy soils of Palgrave CA, Albion Hills CA, and Mono Cliffs PP, and although the mature forest stands here are small and predominantly confined to rugged riparian zones, they offer some excellent examples of the mixed deciduous forests which once blanketed the entire region.

The park is divided into two main northern and southern sections by Coolihan's Sideroad. Almost all of the park's natural, mixed forests are located in the northern section, and are accessible by three main trails. The soils in the northern section are highly fertile, ostensibly due to the fact that development here was kept in check due to the prevalent rugged topography. The southern section of Glen Haffy consists almost entirely of planted monoculture stands of conifers, predominantly red pine but also white pine and white spruce in smaller sections. These planted areas contain mature trees (the red pine stands have average heights of 22 metres and DBHs of 25 centimetres), but their understories tend to be species-poor and sparse, which speaks to the nutrient-poor soils resulting from the intensive agriculture that the area underwent in centuries past.

Unfortunately, no digital trails maps of Glen Haffy are currently available, so hikers will be limited to referencing the trail map posted at the main trail head near Lookout Point (see Figure 35), along with satellite imagery provided by the TRCA, courtesy of Google Earth (see Figure 34).

Figure 34: Glen Haffy trail map. This custom map shows the Bruce Trail in yellow. See Table 4 for map symbol key.

Source: http://2014.ontariobioblitz.ca/wp/wp-content/uploads/2014/05/Glen-Haffy_General.jpg



It is best to access the hiking trails in the park via the trail head near the Lookout Point parking lot. A large sign labelled "Nature Trails" will guide hikers away from the manicured portions of the park and into the oldest stands of forest. As the red trail begins, hikers will move from mature stands of sugar maple, black cherry (up to 50 centimetres DBH and 24 metres tall), and basswood into a young sugar maple-dominated forest in which trees reach average sizes of 22 metres tall and 35 centimetres DBH. White elm, alternate-leaf dogwood, and ironwood are common in the understories of these young forests, as the sugar maples have yet to attain sizes and crown diameters that will eventually block the sun from reaching the understory almost entirely. Occasionally, in relatively undisturbed sections of forest, beech and hemlock saplings are common—a positive sign for the future. Stand composition in the northern portion of Glen Haffy tends to change very rapidly, with small areas dominated by a few tree species, and larger areas dominated by sugar maples. Mature sugar maple stands are punctuated by the occasional large white ash, which appear to be healthy throughout the park and can reach sizes in excess of 30 metres tall and 55 centimetres DBH.

As I would come to realize while surveying Hockley Valley, such mature, super-canopy white ash very likely pre-date the surrounding sugar maples, and would have created the conditions long ago for the establishment of the shade tolerant sugar maples. Curiously, while most of the veteran white ashes I observed at Glen Haffy showed no signs of emerald ash borer infestation, many juvenile and just-mature white ashes have been infected and killed by the fungus carried by this introduced and invasive insect. It is possible that the borer has already infected some of the veteran white ash in the park, and that they are simply not yet showing signs of infection (which include sections of peeled-back, or light-coloured flaking bark with meandering bore-trails of the borer larvae visible in the sapwood, as well as dead, bark-less branches, especially near the tree's uppermost limits). Another curious observation was that I did not notice any white ash growing on the periphery of forest stands as I did in all other surveyed areas. In Glen Haffy, the only ashes to be found were growing as isolated individuals in forest interiors.

Figure 35: This no nonsense signage at Lookout Point sketches the three main trails. The access point to these trails is indicated on Figure 33 by the parking lot outlined in yellow.

Roughly 30 metres past the third creek crossed by the red trail (which is spanned by a 2 metre wide bridge roughly 15 metres long), is the first truly veteran beech I found in the park (see Figure 36). This specimen, logged as FG002, measured 58 centimetres DBH and 29 metres tall, and is located directly beside the trail (it even has a trail marker posted on it). Several other veteran beeches are located nearby, with a very nice specimen (55 centimetres DBH and 26 metres tall—FG003) located just 20 metres down the trail. A third veteran beech (FG004), measuring 54 centimetres DBH and 23 metres, can be found 100 metres down the trail from the second (these three beeches are each marked with a "B" on the trail map). Veteran hemlocks also line this trail, reaching 25 metres in height, with DBHs of 60 centimetres. The presence of veteran beech and hemlock together at the same site was particularly exciting for me, as beech, hemlock, and yellow birch have all declined dramatically in their natural ranges in southern Ontario, where once they were common (Henry and Quinby, 2010).

Figure 36: These three veteran beeches are among the many to be found in Glen Haffy's northern section. On the far left is individual number FG002, in the middle is FG003, and on the right is FG004.

Where the red trail reaches its southern limit, it intersects with a clearing in which several dozen mature black walnuts are thriving (see Figure 34). The average dimensions of these trees is 28 centimetres DBH and 20 metres tall. As the red trail bends to head back north, it is bordered by mature black walnut stands that appear to have been planted along an older trail or road that once cut through the park. Needless to say, this would be an ideal area from which to collect black walnuts, which have a wide variety of dietary and medicinal uses, in addition to having a high germination rate.

The green and blue trails span the northernmost section of the park, and showcase young sugar maple-beech-hemlock forests which are characteristic of this region. These are the three most shade tolerant species native to southern Ontario, and because the region has such moderate disturbance regimes (with very few incidences of fire, for example), shade tolerants naturally dominate here.

At its easternmost limit, the blue trail runs parallel with Glen Haffy Road for a short time, and passes through a large clearing. Just 20 metres beyond this clearing, directly beside the trail stands an impressive veteran hemlock, 24 metres in height with a DBH of 81 centimetres (see Figure 37). The hemlock is only several metres away from an equally impressive sugar maple which is 28 metres tall and 93 centimetres in DBH. This patch of forest is also home to veteran white ashes and black cherries. Indeed, between this clearing and the trout ponds to the west, several patches of sugar maple-dominated forest look as though they are close to achieving old growth status (perhaps being 40 or 50 years away). The area even features some mature white pines, up to 29 metres tall and 58 centimetres DBH. The forests in this region of the park have canopies comprised roughly of 90% sugar maple and 5 to 10% white ash. Where the green trail runs along either side of a small creek, the white ashes are perhaps the tallest trees in the park, with the biggest one measured being 31 metres tall with a DBH of 66 centimetres.

Figure 37: The veteran hemlock on the left can also be seen in the photo on the right, with a veteran sugar maple in the foreground.

In general I noticed three types of climax forests emerging in the northern portion of Glen Haffy: sugar maple-white ash, sugar maple-beech-hemlock, and sugar maple-white ash-black cherry-basswood. The few natural stands that exist in the southern portion of the park tend to be very young, and were probably seeded by the scattered veterans that exist along trails, especially the section of the Bruce Trail which runs parallel to Glen Haffy Road. On the Bruce Trail, about 300 metres south of Coolihan's Sideroad, I found what was easily the biggest basswood I saw in Glen Haffy, measuring 28 metres tall and 55 centimetres DBH (see Figure 38). A 60 centimetre DBH, 30 metre tall white ash lies just 10 metres further down the trail from this basswood. Travelling down the trail another 150 metres, at the top of a short incline, I came across a very old white ash dying of senescence which measured 22 metres tall and 81 centimetres in DBH.

The fact that just a handful of veteran trees can seed entire stands of forest speaks to the importance of leaving several veterans or mature individuals on every hectare of land cleared during any kind of development. We are often inclined to view various types of development as permanent fixtures on the landscape, but in reality all development is transitory while ecology prevails. The veteran trees that remain at Glen Haffy and in other protected areas would have borne witness to multiple land uses in their vicinity over the course of their lives. They would have witnessed homesteads, even entire towns, being constructed, would have witnessed them flourish and grow, and eventually, fall into decline, disrepair, and abandonment.

Along the Bruce Trail to the southern edge of the park can be found scattered mature sugar maples, beeches, hemlocks, white ashes, and cedars, which are busily supplying the forest floor with an abundance of seeds from which the next generation of forests in the park will grow. Interestingly, the single biggest, and likely the oldest, white ash I found at Glen Haffy was growing directly beside Coolihan's Sideroad, about 25 metres west of where the Bruce Trail crosses it (see Figure 39). It was 23 metres tall and a whopping 210 centimetres DBH—wider than my measuring tape was long.

Figure 38: An old basswood on the Bruce Trail in Glen Haffy Conservation Area (individual number TA002).

Figure 39: Though low-branching, this white ash (FA005) is singled-stemmed, and at 210cm DBH is greater in girth than any other tree measured. Growing only a few metres from Coolihan's Sideroad, it seems very healthy despite its age.

TABLE 4: Natural Heritage Tree Data for Glen Haffy Conservation Area									
Individual Number	**Common Name**	**Scientific Name**	**Map Symbol**	**Age Class**	**Height (m)**	**DBH (cm)**	**Date Identified**	**Coordinates**	**Seed Dispersal Period**
FG002	Beech	*Fagus grandifolia*	B	veteran	29	58	10-Jul-14	43.94025, -79.93945	Sep - Oct
FG003	Beech	*Fagus grandifolia*	B	veteran	26	55	10-Jul-14	43.94022, -79.93918	Sep - Oct
FG004	Beech	*Fagus grandifolia*	B	veteran	23	54	10-Jul-14	43.93947, -79.93822	Sep - Oct
TC001	Hemlock	*Tsuga canadensis*	H	veteran	24	81	11-Jul-14	43.94514, -79.94721	Oct - Dec
FA004	White Ash	*Fraxinus americana*	A	veteran	31	66	11-Jul-14	43.94235, -79.94966	Sep - Feb
TA002	Basswood	*Tilia americana*	BW	veteran	28	55	11-Jul-14	43.93451, -79.93289	Sep - Dec
FA005	White Ash	*Fraxinus americana*	A2	veteran	23	210	11-Jul-14	43.93713, -79.93556	Sep - Feb

Hockley Valley Provincial Nature Reserve

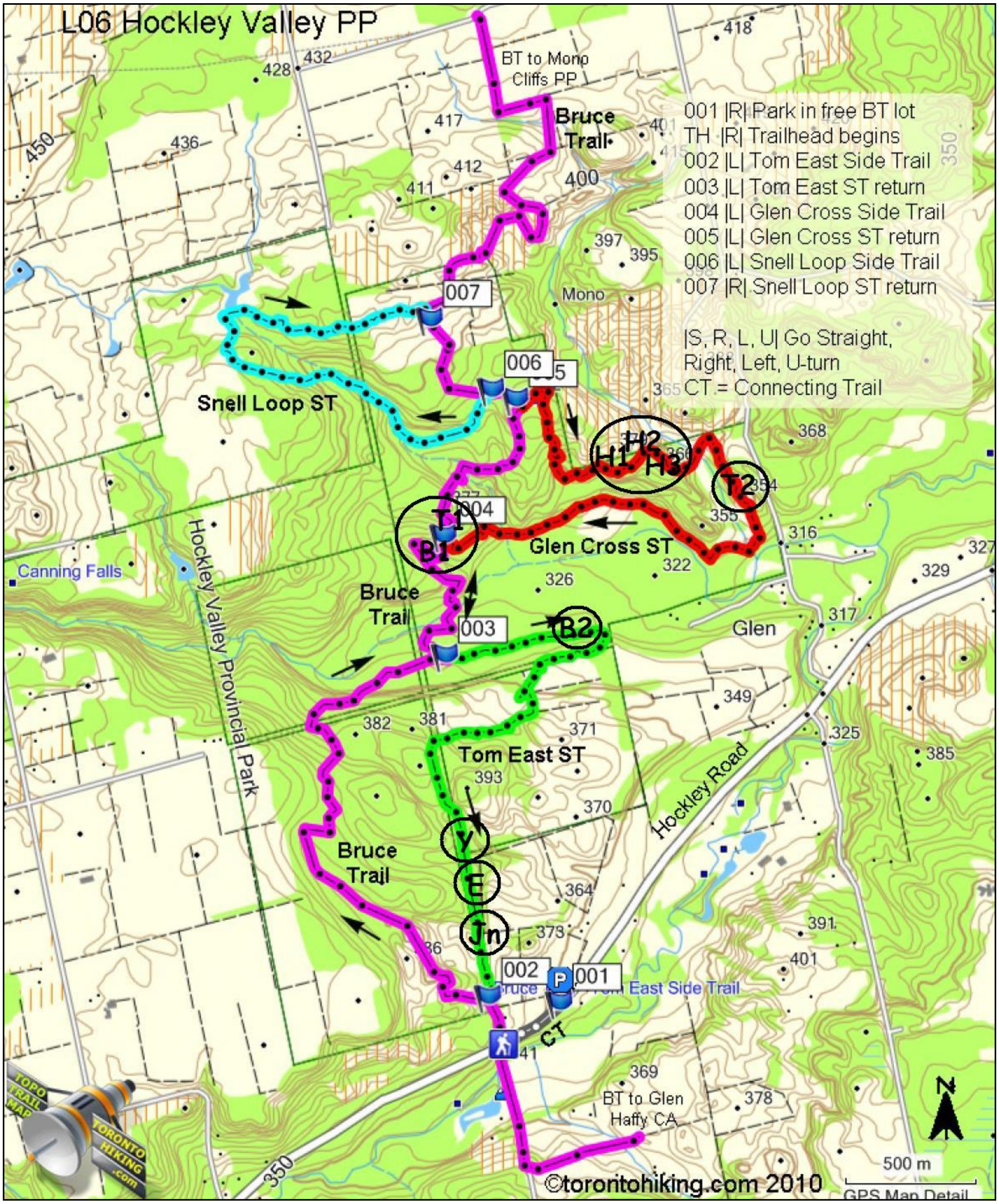
Hockley Valley Provincial Nature Reserve is a 505 hectare piece of land at the northern edge of the Oak Ridges Moraine, located on Hockley Road (County Road 7) between Highway 10 and Airport Road (NEC, 2005). It lies roughly half way between Glen Haffy CA to the south and Mono Cliffs PP to the north. The reserve can be accessed directly from Hockley Road via the Bruce Trail, with a small parking lot for park users located about 100 metres west of the Bruce Trail access point—a small, nondescript wooden staircase leading into the forest. There are three major side trails in Hockley Valley, all of which form loops which start and end on the Bruce Trail (see Figure 40). The soils here are typical of the region, with sandy loams in upland areas and fertile, silty soils in low-lying areas.

The first 500 metre section of the Bruce Trail is surrounded by young pioneer and mid-successional forests with species like cedar, red pine, trembling aspen, white ash, and white elm. I was also surprised to find in this area a good number of jack pines, which are typically a Boreal forest species and rarely occur so far south. Some southern sections of the park are also home to young (i.e., 10 to 20 year old) Scots pine stands, which appear to have been planted to prevent erosion. Beyond this initial section of the Bruce Trail, the forest quickly transitions to medium-aged sugar maple stands, with average heights of 26 metres and DBHs of 40 centimetres. In these sugar maple stands, the trails tend to be lined with mid-successional species like white elm (up to 16 metres tall and 20 centimetres DBH) and white ash. Towering veteran white ashes occur throughout the sugar maple dominated forests of Hockley Valley. Most of these veteran ashes are super-canopy trees, rising above the sugar maple canopies, often reaching heights in excess of 30 metres.

Further along the Bruce Trail there are also scattered veteran beech (up to 24 metres tall and 52 centimetres DBH), black cherry (up to 26 metres tall and 42 centimetres DBH), and hemlock (up to 23 metres tall and 43 centimetres DBH). Many of the sugar maple-white ash stands have an abundance of beech saplings in the understory, as well as hemlock, ironwood, and yellow birch.

Figure 40: Hockley Valley Trail Map. See Table 5 for a guide to map symbols.

Source: http://www.torontohiking.com/TMpdf/L06TM.pdf#zoom=75



There are many river crossings in the central part of the park, and the slopes leading down to the rivers, as well as the lowland regions surrounding the rivers, tend to be dominated by mature cedar groves. The riverbanks themselves are often home to basswoods (up to 27 metres tall and 46 centimetres DBH) and red ash (up to 21 metres tall and 40 centimetres DBH) along with cedars. All of the creeks and small rivers in the central portion of the park drain into the Nottawasaga River, which eventually runs to Georgian Bay. The creeks of Hockley Valley tend to be shallow, rocky, and fast-moving, and the bridges along all of the trails are very well-maintained.

Shortly before the Bruce Trail reaches sign post 004, to the east of the trail by about 8 metres, is a very conspicuous veteran beech. Most of its upper branches are now dead, but based on the number of old beech nuts and husks I found at its base, it is still in its reproductive years. It now stands a humble 19 metres tall, but has a DBH of 74 centimetres. It is growing on a slope, but has a nice flat 2 by 4 metre platform at its base that would make an ideal beech nut collection hotspot. Just 25 metres past this beech, on the same side of the trail, is a veteran ironwood standing 19 metres tall and with a DBH of 29 centimetres (see Figure 41). I was immediately struck by the unusual form of this ironwood—a form that I would see repeated throughout Hockley Valley—which had low, relatively wide-reaching branches rather than the usual straight, branch-less trunks. This could indicate that these ironwoods once grew out in the open, but ironwoods are a short-lived tree and most of the specimens like this one were growing amidst trees that were almost certainly older than they. Regardless, Hockley Valley had many very impressive ironwoods in the uplands of its central region, with some reaching as high as 22 metres.

Figure 41: This ironwood in Hockley Valley has a form rarely seen, yet one that is common in the area.

I should note at this point, that compared to the other four parks I surveyed, Hockley Valley is on a different scale altogether. The individual trees there are taller, the forests are older and more mature, and the understories are lusher and more diverse. Some of the exemplary trees I found at other sites would hardly stand out at all at Hockley Valley.

Just 25 metres past the 19 metre tall ironwood, I found a very impressive basswood, which was 65 centimetres DBH and 30 metres in height. I assumed at the time that it would be the most impressive basswood I would see in Hockley Valley, but I was very much mistaken.

The Bruce Trail between the two access points to the Glen Cross Trail passes through some very impressive sugar maple-beech forest, with many veteran beech reaching heights of 25 metres and diameters of 57 centimetres DBH. Given the past co-dominance of beech trees in the region's forests, it was very refreshing to see so many healthy old specimens in one place.

I started surveying the Snell Loop Trail from sign post 007—the northern-most access point. From there, the trail cuts through a small abandoned apple orchard which is now being colonized by juvenile white ashes, white elms, and invasive European buckthorns. Riverbank grape is a major problem in this area, like most open areas in southern Ontario undergoing natural regeneration. It has long baffled my mind why no Canadian conservation authorities at any level of government recognize riverbank grape, *Vitis riparia*, as a problematic invasive. Sure it is a native species, but so is the mountain pine beetle. I have seen a great deal of evidence at a wide variety of conservation areas and green spaces in southern Ontario which shows that some people are attempting to control this troublesome plant, but whether these are officially sanctioned actions or simply the actions of concerned, tree-loving individuals I do not know.

The southern portion of the Snell Loop Trail is dominated by mature sugar maple stands (with individuals up to 30 metres tall and 63 centimetres DBH). White ash and white elm are common along the trail, with red ash and yellow birch (up to 24 metres tall and 45 centimetres DBH) common in the moist, low-lying creek valleys.

The Glen Cross Trail, starting from sign post 005, winds through yet another mature sugar maple forest (with average heights of 25 metres and DBHs of 30 centimetres), dotted with mature basswood, beech, and black cherry. As the trail progresses, towering white ashes (some exceeding 30 metres in height and 60 centimetres in DBH) begin to appear amongst the smaller maples.

About one kilometre along the Glen Cross Trail, right at the base of the first staircase that hikers descend, I found the only mature hickory I was to see at any of the surveyed sites (see Figure 42). This specimen, a bitternut hickory, looks to be in the prime of life and in peak fitness, standing 29 metres tall and having a DBH of 46 centimetres. Slightly downhill from this mature specimen, along the trail, approximately 12 bitternut hickory saplings can be found (see Figure 43). These saplings are up to 3 metres tall with DBHs up to 2 centimetres. Roughly 250 metres further down the trail, after several twists and turns, there is a juvenile bitternut hickory 4 metres to the north of the trail. This juvenile stands 10.5 metres tall with a DBH of 6 centimetres. Roughly 150 metres past this juvenile hickory, near the top of a wide staircase leading up a ridge (0.5 metres away from the second-to-last step), stands another juvenile bitternut hickory. This second juvenile is 9 metres tall with a DBH of 4 centimetres.

The eastern stretch of the Glen Cross Trail[1] passes through sections of mature planted red pine, with diverse and healthy understories and scattered mature white pine, white ash, and sugar maples. The trail passes through several clearings amongst the red pines, all of which contain sapling, juvenile, and mature black walnuts. The largest black walnut on this section of the trail measures 35 centimetres DBH and 24 metres in height. There are also scattered black walnut saplings growing in the understory of the red pine forests.

[1] Note: The eastern and southern stretches of the Glen Cross Side Trail were recently renamed the Isabel East Side Trail. No major changes to the trail have taken place, however.

Figure 42: The location, bark, and form of a mature bitternut hickory (CC001) in Hockley Valley.

After passing through three small clearings, the trail winds through another stand of red pines, and amongst this stand, directly beside the trail, is an impossible to ignore veteran basswood (see Figure 44). By far the biggest and most impressive basswood I found on my surveys, this specimen stood 25 metres tall with a DBH of 120 centimetres. As basswood seeds normally undergo double dormancy, requiring two winters' worth of cold stratification before they will germinate, I could not resist the urge to poke around in the leaves at the base of this giant and collect a handful of its seeds.

The initial stretch of the Tom East Trail is dominated by mature stands of cedar, punctuated by veteran sugar maples, basswoods, ironwoods, and trembling aspen. Roughly 600 metres down the trail, which is very straight in this area and runs parallel to a charming little stream, stands a veteran beech. Not only does this beech stand out because of its size, but it appeared to be the healthiest of all the veteran beeches I came across in my surveys. Situated only 1 metre to the north of the trail, this beech stands 29 metres tall and has a DBH of 66 centimetres.

Figure 43: The leaves of a bitternut hickory sapling and the bark of two juveniles.

Figure 44: Basswood TA004 in Hockley Valley, by far the biggest basswood I found during my surveys.

After meandering through mature stands of sugar maple, black cherry, white ash, and hemlock, the trail straightens and heads straight back towards Hockley Road. Soon after the trail straightens, it begins to pass through stands featuring mature yellow birch, and eventually comes to the only veteran yellow birch I found at Hockley Valley. Roughly 3 metres to the east of the trail, this specimen is 32 metres in height with a DBH of 54 centimetres (see Figure 45). Roughly 150 metres down the trail from this yellow birch I found an excellent mature specimen of a white elm (see Figure 46). Just 0.5 metres to the east of the trail, this elm is at the base of a small decline where the trail bends to the east. It stands 31 metres in height with a DBH of 39 centimetres, making it a less-than-exceptional specimen, but it was still the largest healthy white elm I found in all of my surveys. This area also features large red ash, up to 35 centimetres DBH and 24 metres tall.

Figure 45: This was the only veteran yellow birch I found at Hockley Valley. It may look somewhat spindly, but its wood is the second hardest in North America.

Figure 46: One could likely find mature white elms of this size on busy urban streets, but to see one of this size in the wild is rare.

Not far from Hockley Road at the base of the Tom East Side Trail, where the trail first begins to run alongside open, privately-owned fields to the east, I found a decidedly veteran black walnut growing at the forest's edge. Growing amongst several other mature and juvenile black walnuts several metres to the east of the trail, this individual stands only 18 metres tall but has a DBH of 110 centimetres (see Figure 47). The presence of this centuries-old specimen solidified the lower portion of the Tom East

Trail, as well as the eastern stretch of the Glen Cross trail, as ideal spots from which to gather black walnuts derived from locally-adapted individuals.

Figure 47: A veteran black walnut at Hockley Valley. How many of the mature black walnuts in the park and its vicinity could have come from this one individual?

TABLE 5: Natural Heritage Tree Data for Hockley Valley Provincial Nature Reserve

Individual Number	Common Name	Scientific Name	Map Symbol	Age Class	Height (m)	DBH (cm)	Date Identified	Coordinates	Seed Dispersal Period
FG005	Beech	*Fagus grandifolia*	B1	veteran	19	74	12-Jul-14	43.98835, -80.06041	Sep - Oct
TA003	Basswood	*Tilia americana*	T1	veteran	30	65	12-Jul-14	43.98803, -80.06006	Sep - Dec
CC001	Bitternut Hickory	*Carya cordiformis*	H1	mature	29	46	13-Jul-14	43.99108, -80.05305	Sep - Oct
CC002	Bitternut Hickory	*Carya cordiformis*	H2	juvenile	11	6	13-Jul-14	43.99132, -80.05231	Sep - Oct
CC003	Bitternut Hickory	*Carya cordiformis*	H3	juvenile	9	4	13-Jul-14	43.99153, -80.05167	Sep - Oct
TA004	Basswood	*Tilia americana*	T2	veteran	25	120	13-Jul-14	43.99004, -80.04843	Sep - Dec
FG006	Beech	*Fagus grandifolia*	B2	veteran	29	66	13-Jul-14	43.98559, -80.05535	Sep - Oct
BA002	Yellow Birch	*Betula alleghaniensis*	Y	veteran	32	54	13-Jul-14	43.97788, -80.06051	Sep - Feb
UA003	White Elm	*Ulmus americana*	E	mature	31	39	13-Jul-14	43.97660, -80.05974	May - Jun
JN001	Black Walnut	*Juglans nigra*	Jn	veteran	18	110	13-Jul-14	43.97508, -80.05925	Sep - Oct

Cultivation tips

Seed Storage and Cleaning

The most fundamental rule associated with seed storage is that seeds always be kept at cool temperatures. As a general rule, seeds that come from fleshy and moist fruit should be kept moist and seeds that are dry on the tree prior to dispersal should be kept dry. Seeds can generally be stored in a refrigerator for up to two years without a significant decline in viability. It is crucial that all collected seeds be labelled, identifying both the species and the collection site (Kock, 2008).

Some general guidelines for seed cleaning and preparation are: in the case of samaras (seeds that are winged for dispersal by wind), the wings should not be removed from the seed; capsuled seeds surrounded by fine fibrous material to aid in wind dispersal can be stored and sown with the fibrous material attached; and husked seeds must have their husks removed prior to storage (Kock, 2008).

More specifically, the following storage tips should be adhered to for particular species. The dry fruits of maple, ash, elm, tulip tree, ironwood should be kept in closed, labelled paper bags. The dry seeds from the catkins of birch, poplar and alder are best kept in labelled paper envelopes. Cones should be kept in labelled paper bags or left out to dry. Nuts of buckeye, hickory, hazel, and walnut should be kept dry, in open containers for up to a week. Acorns, chestnuts, and beech nuts are short-lived and cannot be allowed to dry out for more than a few days. Fleshy fruits from trees like juniper, dogwood, viburnum, cherry, serviceberry, hackberry, etc., should be left in open containers to ripen, and can then be refrigerated for several weeks before seeds should be removed. Some berries can be dried prior to storage. Dry pods from trees like honey locust, redbud, and Kentucky coffee tree can be left out for weeks on end (Kock, 2008).

Frugivorous and granivorous birds are excellent natural seed cleaners, as during digestion, the fruit encapsulating the seeds is macerated and the seed coats become scarified (scratched), making it easier for embryos to escape their often rigid seed coats. This process can be mimicked by placing fruit or seeds in a bag with sand, forcing the air out of the bag, and then grinding the sand and fruit/seeds together in a kneading fashion. Seeds can be separated by rinsing this mixture in water—the pulp and non-viable seeds will rise to the top and float while the good seeds will sink and come to rest on top of the sand. Pulp can be screened off the top and the seeds can be separated from the sand with a sieve (Kock, 2008).

Seed Dormancy

All temperate plants go into dormancy every winter as they have hormones that prevent buds from leafing out during warm periods between September and March (Kock, 2008). In order to break this dormancy, plants must go through a cold temperature period between 0 and 5 degrees Celsius. The length of this period is dictated by the plant's genetic adaptation to the local climate. *"Cold temperatures trigger the enzyme-controlled slow breakdown of the growth-inhibiting hormones within* *the winter buds. A similar chemical reaction occurs inside the seed of many species... seed that is dispersed later in the summer and into the fall must remain dormant to prevent it from germinating during an autumn warm spell and then being destroyed by the first frost. These seeds have a dormant embryo that must experience cold, moist conditions before the shoot and radicle* [i.e., the seed root] *will push out of the seed"* (Kock, 2008, p. 32).

Seed dormancy can be broken using stratification, a method that involves keeping seeds cold and moist for a period ranging from two to four months (red oak and sugar maple, for example, require 90 to 120 days of cold or else they will not germinate). In order to stratify seeds, it is best to place them in a plastic freezer bag with a 50/50 mix of sand and peat moss, and some air should be left in the bag so seeds can breathe. The moisture content of the bag should be checked monthly, and the dampness should be comparable to that of a freshly wrung out sponge (Kock, 2008).

Certain tree species produce a proportion of seeds that undergo double dormancy, that is, they require a cold period (winter) followed by a warm period (summer), followed by another cold period before germination will occur. Carolinian species with seeds that can follow this pathway include tulip tree, ash, hawthorn, basswood, hop tree, and dogwoods (Kock, 2008).

Seed Cultivation

Most seeds that have been dried and stored need to be soaked for a day or so prior to planting in order to draw out some of the germination-inhibiting chemicals in the seed coat. Seeds with very hard seed coats like basswood, bladdernut, black locust, and hawthorn can have their seed coats softened by being placed in water at a full boil, and then left to soak in that water for a day. If the seed coat has broken down enough to allow for germination, the seeds will swell to two or three times their normal size. They should then be planted right away (Kock, 2008).

Seed beds should be well-drained yet moist, and well-cultivated. Seeds should be covered with soil at a depth of roughly twice their smallest width, and sowing too shallow is always better than too deep. Covering sown seeds with a thin layer of mulch is ideal, as is ensuring the seeds and seedlings are not exposed to excessive sunlight (about 50% shade is good for most species), especially on hot days. It is ideal to sow seeds in pots with mixtures of 50% potting soil or compost, 25% sand, and 25% peat moss. The peat moss helps to acidify the potted soil somewhat, which is desirable as most Carolinian trees grow best in slightly acidic soils. To prevent a common fungal disease referred to as "damping off," seedlings should be watered thoroughly and then given two or three days for the top layer of soil to dry out (Kock, 2008).

Prior to planting, seedling roots should be pruned to a length of roughly 10 centimetres. When seedlings are transported or stored temporarily they should be placed in plastic bags so their roots do not dry out. Certain species (like willows and poplars) can reproduce clonally from cuttings (severed twigs and small branches), which can be grown in pure sand, a 50/50 peat moss and perlite mix, or a sand and peat mix. Evergreen cuttings should be five to ten centimetres long, with three or four nodes (budding sites) and two centimetres of bottom bark removed. It can take anywhere from two weeks to three months for cuttings from various tree species to begin rooting (Kock, 2008).

Seed Collection

Growing Trees from Seed (Kock, 2008) outlines many of the best practices associated with seed collection for the purposes of conservation and restoration. Some of these practices are counter-intuitive, like the fact that many old trees growing by roadsides represent important seed sources as they were most often obtained from local woodlands and withstood harsh localized conditions for decades or even centuries. Kock (2008) stresses that seed collectors should be sure to note the moisture level at each collection site, and match collection site moisture levels with those of the planting site. He notes however, that given the increases in extreme weather events—especially droughts—due to climate change, the seeds of healthy trees growing on dry sites should be given priority over the same species of tree growing on moist sites due to their greater drought tolerance. In general, it is always a good idea to collect seeds from multiple individuals within each target species at each site (Kock, 2008).

It is recommended that collectors avoid collecting seeds from trees that are the only members of their species in a given locality, as these trees may self-pollinate and their offspring could thus be lacking in genetic diversity. Kock stresses that we should always note the seed source of the trees we plant, as even if the seeds are not locally derived, as their success or failure might shed some light on where best to source seeds from in the future, as well as the areas in which a given species has genetic stock which is most resilient to climate change (Kock, 2008).

Nut-bearing trees like oaks and hickories often have their seeds devoured by weevils or larger animals, so the time of collection should be as close to the time of peak seedfall as possible. If many of a tree's seeds have matured but have yet to fall, a good technique is to throw a rope over a heavily-laden branch and pull on both ends to shake the branch and liberate some seeds. Seed collectors are, however, strongly encouraged to leave a large percentage of a tree's seed crop alone for natural dispersal (Kock, 2008).

It is important to note that many trees do not produce seeds until they are 30 or 40 years old. Some species only produce abundant seed crops in annual intervals of anywhere from two to seven years—thus the relative number of seeds produced by each species should be recorded each year (Kock, 2008).

Recommendations and a discussion on ongoing conservation and restoration efforts

Although I did not find the treasure-trove of rare gems that I was hoping to, overall I was extremely encouraged and pleasantly surprised by the state and health of the forests that I surveyed, as well as the management practices that seemed to be in place. All of the protected areas I surveyed, for example, contained significant volumes of downed woody debris on forest floors—an integral component of natural soil-building processes which was too often removed by forest managers in the past. Some surveyed areas had temporary trail closures or permanent re-routing to allow for natural regeneration in sensitive areas. Several of the parks had well-placed artificial animal habitat to attract the seed dispersers and pollinators that once occupied southern Ontario's forests in prolific numbers. All the protected areas had signage asking people to stay on the trails, and otherwise respect the fragile ecological integrity of forest stands. The planting of native species was a positive sign in Palgrave CA—a sign I would have liked to see more of in other parks (see Figure 48). All surveyed protected areas contained some scattered veteran trees which became the progenitors of today's forests, which showed that the scale of forest clearance and degradation in southern Ontario, though expansive, was not absolute. Most encouraging, however, was the presence of isolated forest stands in every park that are on the cusp of achieving old-growth traits. It appears that nothing can stop these stands now, and that in the future they will only become healthier and more resilient.

Figure 48: A section of Palgrave CA planted with a diverse array of native tree species.

Such encouraging signs, however, should not promote complacency. Modern-day restorationists should aim to efficiently re-create conditions that are common in healthy Carolinian forests. For example, restorationists working on levelled fields should restore the landscape’s natural rugged topography prior to planting, as pits and mounds create habitat for different types of trees and animals alike, and pits can also serve as miniature water reservoirs, attracting amphibians and seed dispersers of all types. Squirrels bury nuts on the mounds and birds perch on mounds, depositing seeds in their droppings. Sites prepared in such a manner will regenerate rapidly even without planting regimens in place, given the presence of an adjacent stand of trees as a seed source (Kock, 2008). Diseases which are being introduced to our forests at unprecedented rates are best thwarted simply by sustaining and enhancing genetic diversity and species richness (Kock, 2008). The removal of healthy individuals of a pathogen-plagued species to help prevent the spread of insect pests and diseases (once a common practise which had disastrous effects on genetic diversity) hinders the buildup of natural predators and also removes trees that may have strong natural resistance to pests and diseases (Kock, 2008).

The recreational and educational benefits of forests are palpable if not quantifiable, and once restored, they can in turn have a restorative effect on those who venture into them. Healthy, vibrant stands of remnant forests should be used as models in our efforts to restore ecosystems in the same biome (Berger, 2008). As many mast trees in the Carolinian are rare, it would make sense to ensure that existing stands of native trees and reforested sites have viable populations of squirrels and birds present wherever possible. Squirrels and birds are much more effective forest restorationists than most "expert" human forest restorationists, and their skills should be utilized on reforestation sites to lessen the cost and effort of reforestation.

In some cases, simply protecting forests from human development and encroachment can be enough to ensure their restoration (Berger, 2008). When forests are highly altered, however, restorationists will need to introduce rare or threatened tree species with slow seed dispersal rates (like hickories and beech) (Berger, 2008). Ultimately the goal is to create self-sustaining ecosystems by ensuring adequate habitat, genetic diversity, and wildlife.

Berger (2008) defines comprehensive forest restoration as that which fulfills the following criteria: 1. Re-establishing native forest species in their natural distributions and abundances; 2. Re-establishing natural forest structure (such as mixed-level canopies, vibrant understories, good drainage, and fertile, stable soils); and 3. Re-establishing natural forest processes like succession, natural selection, nutrient cycling, and localized disturbance regimes. He clarifies, however, that any intervention that brings about or moves towards any of these ends is considered restorative. Human intervention is mostly concerned with the first step, as nature will do most of the restorative work after that so long as it is given free rein to do so (Berger, 2008).

Restoration efforts should begin with an ecological inventory, the mapping of site conditions, a survey of local ecological degradation, and the setting of goals, objectives, and management practices (Berger, 2008). Subsequent efforts may need to involve the following activities: fencing off particularly vulnerable areas (riparian zones or wetlands, steep slopes, planting sites), noxious weed and invasive species control, road and trail removal or minimization, fuel abatement via controlled burns, the establishment of native plant nurseries, and the collection and introduction of wild, locally-adapted plants and animals (Berger, 2008). In order to ensure their effectiveness, restoration efforts must also make allowances for proper monitoring, evaluation, and adaptive management.

In our efforts to re-establish the diverse Carolinian forest of Southern Ontario, it is not enough to simply focus on cultivating as many rare trees as possible. We should be focussing, rather, on cultivating the offspring of the best remaining wild, locally-sourced specimens of rare trees together on the same site to strengthen the genetic diversity of remnant populations. Furthermore, we should plant offspring of these specimens in areas where they can multiply and disperse naturally, or at least where their seeds could be easily gathered for further dispersal by humans or wildlife. While the re-establishment of massive swathes of old growth Carolinian forest may now be next to impossible due to extensive development throughout the region, the least that can be done is to ensure that the species richness of the Carolinian is preserved. The forests of Southern Ontario may never again be considered "natural," but at least they can be managed in order to be more biodiverse, resilient, and beneficial to all forms of life. As Schmitt and Suffling (2006) put it: ""*If we recognize that we should be both creating a new ecological landscape and preserving altered fragments of an old one, then we shall have more success than is possible merely by scrambling to preserve fragments of the old system*."

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