

Credit Valley Conservation An Invasives Species Strategy



2009 Draft



Executive Summary

Invasive Species have been with us for a long time. Efforts to deal with them have tended to be reactive, costly and often not very often effective. In the last 20 years, attention has shifted from this reactive approach to developing a more strategic approach to dealing with invasive species e.g. the federal strategy, *An Invasive Alien Species Strategy for Canada*. However, these broad based strategies must be translated to a more local and usable scale, where agencies on restricted budgets must make decisions about where to focus resources. Credit Valley Conservation's (CVC) Invasive Species Strategy does just that. It sets goals, objectives and priorities for the organization and provides a framework to begin implementation.

With a mandate to conserve and protect the natural resources of the Credit River Watershed CVC has set the following goals for the management of invasive species in its watershed:

- Maintain healthy ecosystems and native biodiversity.
- Reduce the ecological and economic impacts of invasive species.
- Advance knowledge and societal attitudes about invasive species.
- Provide support and resources for land management, conservation agencies and landowners.
- Assist with and coordinate efforts to manage invasive species both internally and with external groups and at all levels of government.

With objectives set in the fields of land management, science, education, planning and an identified need for partnerships, CVC must ensure it is not duplicating the efforts of other organizations or levels of government. This Strategy identifies possible duplication and where CVC is best poised to fulfil a role and prompt action.

A framework for the implementation of this Strategy is laid out that identifies:

- Initial priorities for areas of the watershed that will be a focus of work.
- Priority invasive species on which to focus efforts.
- Procedures to map, control and monitor invasive species in the watershed.
- Education and outreach opportunities and messaging.
- Areas where advocacy may be required as well as the development of further guidelines or policies.
- A need to further the science of invasive species as implementation proceeds.

At the end of this Strategy, the reader will find numerous valuable resources that provide methods of mapping invasive species, summarized best practices in controlling invasive species, contact information for likeminded agencies and resources for gardening with native plants.

Table of Contents

1.0	Introduction.....	1
1.1	Forward.....	1
1.2	Background.....	3
2.0	What are Invasive and Alien Species?.....	3
3.0	Why should we be concerned?	4
4.0	What is CVC doing?.....	5
4.1	State of the Environment	6
4.2	Guiding Principals: Goals and Objectives for CVC Invasive Species Management.....	13
4.3	A Guide for Implementation.....	20
4.4	A CVC Workplan	24
4.4.1	Developing CVC Priority Invasive Species of Concern.....	24
4.4.2	CVC Priority Areas of Concern.....	27
4.4.3	Control Programs	30
4.4.4	Monitoring	31
4.4.5	Education and Stewardship.....	32
4.4.6	Policy, Guidelines Updates and Advocacy.....	33
4.4.7	Partnerships.....	34
4.4.8	Science/Research	35
5.0	Conclusion	35
	References.....	36

Figures

Figure 1: Distribution of Priority 1, 2 and 3 Invasive Plant Species in the Credit River Watershed	8
Figure 2: Aquatic Invasive (non-plant) Species in the Credit River Watershed.....	11

Tables

Table 1: Existing and Potential Agency Roles in Invasive Species Management.....	16
Table 2: CVC departmental responsibilities in implementation.....	24
Table 3: Priority list of invasive species of concern for the Credit River watershed	25

Appendices

Appendix 1: Invasive Plant Species in the Credit River Watershed.....	39
Appendix 2: Aquatic Invasive Species and Fish Diseases in the Credit River Watershed.....	44
Appendix 3: Forest Pests and Diseases in the Credit River Watershed.....	45
Appendix 4: Guidelines for Implementing Control.....	46
Appendix 5: Select Recommendations on Invasive Species Removal.....	50
Appendix 6: Sources (Nurseries) for Native Plants.....	67
Appendix 7: Partner Organizations in Invasive Species Management.....	69
Appendix 8: Rattray Marsh Invasive Plant Species Management Plan.....	69

1.0 Introduction

1.1 Forward

Credit Valley Conservation's (CVC) Invasive Species Strategy is intended to provide support for CVC land management and planning programs, watershed municipalities, other partner agencies, non-governmental agencies (NGOs) and individuals involved in land management and conservation that face the threat and challenges of invasive species. It is also meant to act as a catalyst for action and discussion, commitment of resources, and development of on-going partnerships. It is also the intent that this Strategy be implemented as a part of CVC's day to day business and that the strategies, tools and guidelines developed are applied in its operations and the management of its lands. Secondly, it is hoped this document will serve as a model to other private and public land holders of what they can do to address the spread of invasive species. CVC will encourage uptake of this Strategy within its current partner base.

This Strategy has been developed over several years and through this process a vast array of information and sources have been accessed and compiled that will continue to be used in the years ahead to clarify goals, set priorities, design and evaluate projects and implement action plans. Within the Appendices you will find detailed information on priority invasive species and their control/management, as well as resources linking to sources for native plant material and other organizations involved locally with the management of invasive species.

This Strategy addresses a number of invasive species taxa: flora, fauna (aquatic and terrestrial) and pests and diseases. It is acknowledged that this Strategy speaks more to plant and aquatic invasives, as these groups represent the majority of invasive species currently present. However, pests and diseases are also considered where action is deemed a priority. Where other agencies are effectively taking the lead on invasive species (e.g. the Canadian Food Inspection Agency's work on the Asian long-horned beetle), CVC will not duplicate efforts but will respect those agencies leading roles and provide support where needed.

This Strategy supports the overall vision laid out for the Credit River Watershed as noted in the CVC Strategic Plan 2006 (CVC, 2007a) of maintaining, "An environmentally healthy Credit River Watershed for the present and future generations". The five main goals set out in CVC's Strategic Plan are as follows:

1. Water Quantity

To manage the hydrological system of the watershed in a manner that emulates natural processes while recognizing human needs.

2. Water Quality

To protect and enhance the quality of surface and subsurface water for environmental and human uses.

3. **Terrestrial and Aquatic Species, Communities and Ecosystems**

To protect, enhance and restore the ecological integrity of the watershed's natural features, functions and systems.

4. **Natural Hazards**

To protect public safety and minimize property damage from natural hazards including flooding, erosion, wetlands and dynamic beaches.

5. **Social and Economic**

To promote the social and economic health of the community through effective watershed management.

A sixth goal, which will be incorporated in an update to CVC's Strategic Plan (2008), is:

6. **Climate Change**

To plan for and mitigate against the anticipated impacts of climate change (extreme weather events, altered precipitation patterns, warmer seasonal temperatures among others) and its effects on human health, public safety and natural systems, features and functions.

The Invasive Species Strategy responds directly to the third objective. It could further be argued that it also directly and indirectly responds to the remaining objectives as both terrestrial, aquatic (water), and human well-being are all intrinsically linked together as a part of the 'living environment'. Climate change will figure in significantly as stressed native communities become vulnerable to invasive species, many of which will thrive under the anticipated changes in climate.

Examples of Invasive Species Impacts related to CVC Strategic Goals

Water quantity: Invasive species can create monoculture communities that can alter natural patterns of run-off e.g. through increased evapotranspiration.

Water quality: Species such as zebra mussel and Cladophora (algae) can greatly reduce near-shore water quality.

Natural Heritage: Invasive species dominate and create monocultures, creating communities of just 1, 2, 3 or 4 dominant species. They directly compete with native species and reduce productivity and native biodiversity.

Natural Hazards: Certain invasive species can create issues with slope stability (those with shallow root systems).

Social/Economic: Direct losses through loss of angling opportunities. Some invasive species release chemicals within the soil that can retard forest productivity (forest products).

Climate Change: While not contributing to climate change invasive species will benefit from these changes, compounding the problems as noted above.

CVC staff will be responsible for future coordination and monitoring of implementation over time. It is hoped that this strategic plan will be widely endorsed, supported and

implemented, and that many partners will come forward to participate in this endeavour. It is recognized that this document will need to be dynamic and adaptive over time as new trends, science and strategies develop for invasive species.

1.2 Background

The rapid spread of invasive alien species has become a major concern among ecologists, naturalists, biologists and land managers worldwide. From an ecological perspective, the concern centres on the displacement of diverse native species, the impacts on interrelated fauna species (those that rely on native plants for food or other values), and reduced genetic diversity. In fact, invasives are now considered one of the most serious threats to global biodiversity. Further, invasives can, either directly or indirectly, contribute to increased erosion, spread of disease, flooding, and other ecological ailments. Invasives present major challenges and lead to significant costs for the agricultural, fishing and forestry industries.

The issues involved in managing invasives are complex. The past century of human activity has resulted in increased environmental degradation and species migration, both of which have created ideal conditions for invasions. Clearly, managing invasives necessitates improved land care and environmental practices, as well as effective strategies to minimize introductions through transport. Some invasives have become culturally valued and widely planted, pointing to the need for a shift in thinking and industry practices. All of these changes will require long-term, multi-faceted efforts.

Even where direct immediate control is necessary, there are many challenges. The scope of the problem is often far greater than available resources. Staff and budgets within many agencies are already strained and volunteers cannot carry the full responsibility. There is a need for clear priorities and knowledge about the most effective approaches to managing invasions. Further, agencies must be prepared to respond to considerable controversy over various techniques, such as cutting mature trees and the use of pesticides (Havinga *et al*, 2000).

2.0 What are Invasive and Alien Species?

There are many non-native species that do not pose a harm or threat to either ecological or human health. Some of these species are restricted to low numbers and may not survive because of foreign conditions they have not adapted to (e.g. winter temperatures, lack of suitable food items). Some require human help and maintenance such as many garden plants and may still provide some basic ecological functions such as air quality and water quality/regulation or wildlife cover. However, those species that are adaptable and

Native: A species that has existed in a given area prior to European settlement.

Alien (non-native): A species that has been introduced from another geographic region to an area outside its natural range.

Invasive: Usually a non-native species whose introduction does or is likely to cause economic or environmental harm or harm to human health. An invasive species is a species that moves into a habitat and ultimately displaces some or most of the original components of the community (White *et al*, 1993).

even flourish because of the lack of native limitations, and become invasive. Non-native invasives tend to out-compete native species for resources and dominate space. They may directly kill others (predate or release toxins) or introduce disease and/or hybridize (genetic contamination). Typically, non-native invasives prefer disturbed habitats, are aggressive, have high reproductive rates, travel easily and far by human, wildlife, wind, water and lack natural predators.

A very few native species can also become invasive in some circumstances due to the impacts or influences of human disturbance and the overall degradation of environmental conditions. Such native species would have historically been constrained by the conditions of a naturalized landscape, but can be 'released' by the aforementioned impacts and influences to become an invasive species.

Other Animal Pests and Diseases

Pests are species that are judged by humans to be undesirable and cause negative aesthetic, ecological, social and economic impacts. This term can be applied to both native and non-native fauna species that are generalist in nature and will respond to human changes to habitat e.g. rodents, raccoon, skunk, deer, geese, coyote, gypsy moth etc. Dense populations can lead to parasites and disease. Society must then replace natural predators that would normally hold populations in check with the use of pesticides, hunting/trapping and other commercial services.

Diseases are microscopic in nature and have ecological functions similar to predators and parasites. Given that they are unseen and transmitted before symptoms develop they are often feared, especially when diseases of non-native origin or have evolved into more adaptive and invasive strains. Sources of disease can include mites, nematodes, fungi, bacteria and viruses.

Many diseases relate to human diets, activities, environmental contaminants and communicable disease rates related to population densities. These are addressed by Health Units and other government programs. Sicknesses related to water borne bacteria, parasites or algae are addressed in the CVC Water Quality Strategy (CVC, 2003). Other diseases such as Dutch elm disease, butternut canker, and beech bark disease, among others are within the scope of this Strategy, but are also a much larger problem than can be dealt with at a local scale. CVC will provide local support and cooperation with those provincial and federal agencies that are managing and researching these diseases.

In this document the word invasive may be used to include any native or non-native plant, pest or disease requiring management to maintain native biodiversity.

3.0 Why should we be concerned?

Invasive species are of concern to all of us. They impact native biodiversity directly, yet the impacts don't stop there. In a spiral of diminishing returns, ecological goods and

services are reduced at multiple scales. Ecological goods and services provided by natural ecosystems include the creation, regulation and purification of air, water and soil that sustains all life. The human health benefits and savings associated with healthy ecosystems are well known. Furthermore, biodiversity provides important genetic resources for food, medical and economic products valued by society. There are many other cultural and recreational values associated with natural ecosystems.

“Non-native species introductions and the degradation of the environment are related to increasing population (agriculture and urbanization), travel, cultural diversity and climate change. [Some] introduced plants, animals, and pathogens often pose an initially hidden but eventually monumental problem.... Their harmful effects are often subtle and surreptitious, but the eventual impacts on the economy or natural environment are no less real, and [are] often disastrous and even irreversible” (Simberloff, 1996).

The Province of Ontario has released a Biodiversity Strategy supported by CVC that identifies the need to control invasive species (Government of Ontario, 2005). The Ministry of Natural Resources (MNR) considers the threat of invasive species second only to habitat losses. Invasive species are a serious threat to global biodiversity by competing with and preying on native species which have co-evolved productive relationships with other native species over eons. This further impacts the habitats and natural areas we all depend on.

At the federal level, the Government of Canada notes that “Invasive alien species can alter habitats and essential ecosystem functions, including hydrology, nutrient cycling, contaminant adsorption, natural fire regimes and energy flows and cycles. Essential ecosystem functions can be placed at risk, including greenhouse gas absorption by forests, pest control by native species, water filtration by wetlands and the use of native biodiversity for the bio-based economy (including pharmaceuticals and other biotechnology)” (Government of Canada, 2004).

Referring to Zebra and Quagga mussels, the nutrient rich feces of these species have benefited the native algae *Cladophora*. This algae has reached nuisance biomass levels not seen in the Great Lakes since before the Clean Water Act, and it washes up on shorelines in decaying mats that foul beaches and support fecal indicator bacteria. Furthermore, food web changes directly resulting from these mussels and the Round Goby are implicated in annual type E botulism events that have killed thousands of fish and waterfowl in the lower Great Lakes (Lafrancois et al, 2007).

The economic costs of invasive species can be severe. Some estimated costs of invasives for 16 species have been between \$13.3 and \$34.5 billion; damage on agriculture crops and forestry is \$7.5 billion annually; zebra mussels range from \$3 to \$7.5 billion for the Great Lakes, with Ontario Hydro at \$20 million to date with annual operating costs of \$1 million. Annual sea lamprey control costs are over \$21 million shared with the United States (Government of Canada, 2004).

4.0 What is CVC doing?

4.1 State of the Environment

Canada

The World Conservation Union's list of the 100 worst invaders include local species such as Dutch Elm Disease, Japanese knotweed, purple loosestrife, spiny water flea, gypsy moth, carp, rainbow trout, starling, rats and domestic/feral cats. In Canada alien species represent 27% of all vascular plants, 181 insects that feed on woody plants, and 55 freshwater fish. In 2002, 24% or 90 Species at Risk were threatened by invasive species (Government of Canada, 2004).

The Great Lakes

The Great Lakes currently harbour 180 non-native species (Government of Canada, 2004) with "a new aquatic species entering the Great Lakes approximately every six to nine months (many being invertebrates). Some of the invaders become established and change the ecology of the lakes by disrupting food webs, displacing native species, altering energy pathways, and affecting water clarity in near-shore zones. They not only lead to ecological changes but can also alter cycling of chemical contaminants and nutrients and impact infrastructure operational costs and beaches. Both Canada and Ontario recognize the threat of aquatic invasive species to the health of the Great lakes and will work cooperatively to implement a national plan in the Great Lakes region (Government of Canada, 1999). The Lakewide Management Plan for Lake Ontario (Environment Canada *et al*, 1998) defines a number of objectives to improve the condition of the lake that cannot be met unless the issue with invasive species within the Great Lakes itself are dealt with.

Credit River Watershed

The MNR considers the threat of invasive species to biodiversity as second only to habitat losses. In this sense the Credit River Watershed is typical of southern Ontario and the Great Lakes Region where urban development still remains the major driver in the loss of native biodiversity. However, it could be argued that areas of the CVC Watershed that have already experienced this 'habitat loss' due to urbanization (e.g. Brampton, Mississauga) could then consider invasive species as the number one threat to the remaining biodiversity within their local contexts.

Even when considering the new emerging "smart growth" and environmental (e.g. Green Belt Act) policies in the province, habitat loss in near urban and rural areas will continue to be the number one threat. What must also be considered is that increasing urbanization and population growth will have the following additional impacts:

- More growth means a greater diversity of cultures, which may increase the importations of non-native species which may have social or cultural significance, some of these species in turn could be invasive.

- More development, which means more impacts to natural areas, alteration of local environmental conditions, stress, and increased usage of natural areas. Essentially more disturbance, which means more invasive species concerns.
- More development equals more homes with gardens (including water gardens), which means more potential for the introduction of non-native species through this avenue.

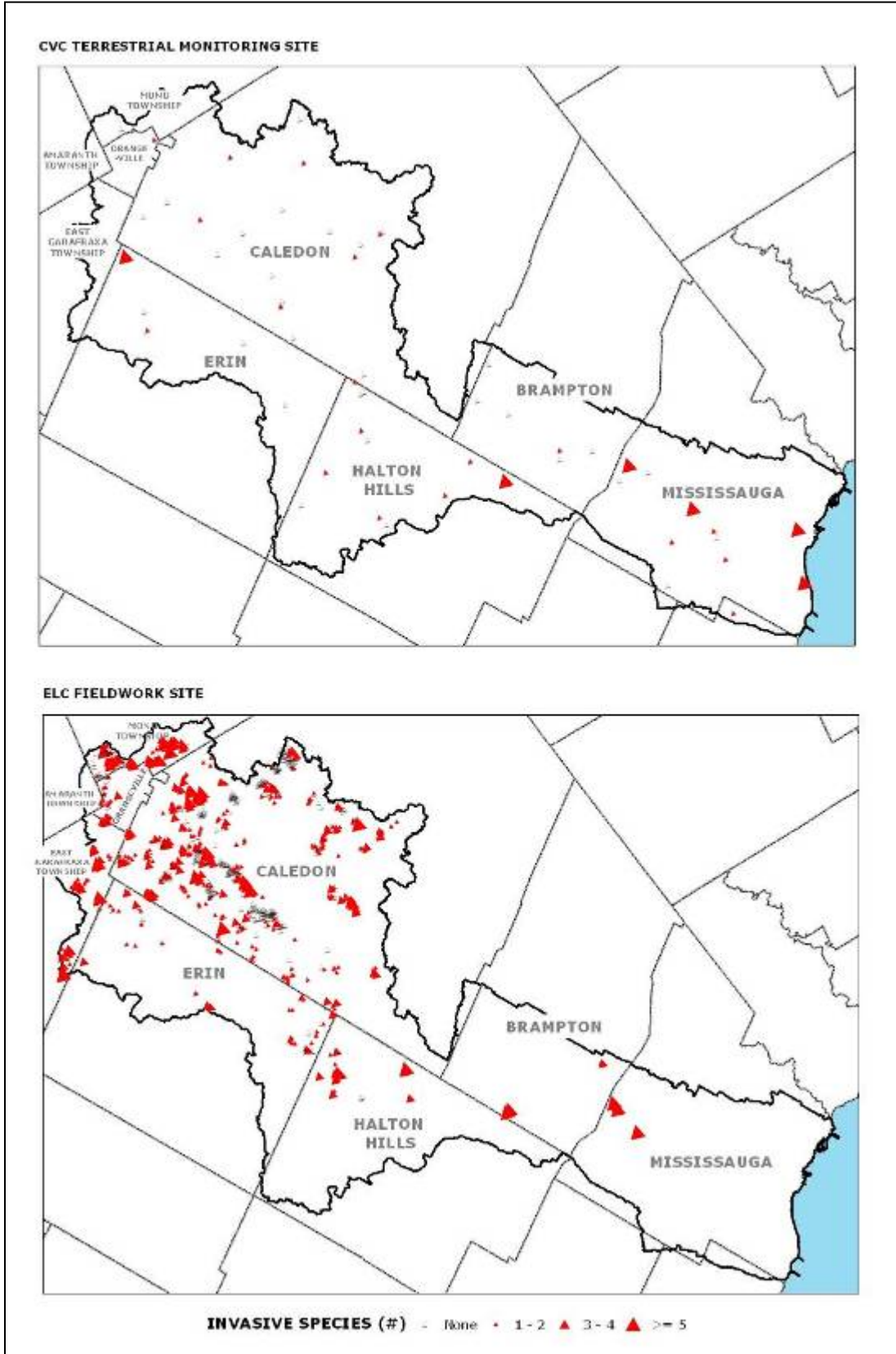
Considering this all with climate change, invasive species will follow very close behind habitat loss as a major negative impact on biodiversity.

Terrestrial Invasives- Flora

Natural habitats represent only 20% of the land use in the Credit Watershed. Non-native species represent 35% of all plant species recorded in the watershed (Kaiser, 2001).

CVC terrestrial forest and wetland monitoring plots provide the only objective and quantitative information available to date for the watershed. **Figure 1** (top) shows the locations of the 45 monitoring plots in the CVC watershed and those plots that have recorded the presence of invasive plant species considered the most of concern (Priority 1-3, see section 4.4.1). Of these 45 plots, nearly half (20) have recorded an invasive plant species with 15 plots recording at least one priority 1 invasive plant specie (an invasive species considered the most severe in its impacts/behaviour). As would be expected plots located in the more urban areas of the jurisdiction have a greater abundance of invasive plant species recorded in these plots e.g. of the 6 plots with greater than 5 invasive plant species, 5 are located in Brampton and Mississauga. Even plots located in what would be considered as ‘pristine’ wilderness areas are not exempt from these statistics. **Figure 1** (bottom) shows the locations of areas in the watershed that have had vegetation community mapping completed for them (Ecological Land Classification: Harold Lee *et al*, 1998)). While these surveys are not evenly distributed across the watershed, being more concentrated in the northern sections, it does provide an illustrative look at what surveys and sampling are detecting in the watershed regardless of distribution. Of the 1052 polygons (areas) surveyed, over half (562) have recorded invasive plant species, with about one quarter (280) recording at least one priority 1 (the most invasive) invasive plant specie.

Figure 1: Distribution of Priority 1, 2 and 3 Invasive Plant Species in the Credit River Watershed



Aquatic Invasives – Fauna

Of all fish species documented in the Credit 8 of 48 species (17 %) are non-native. In Ontario 28 of 182 (15 %) fish species are non-native.

Figure 2 shows a number of aquatic (fauna) invasive species present in the Credit River Watershed. This map provides a quick snap-shot of where invasive species have been detected, and the locations of major fish barriers that may restrict further upstream colonization. The term barrier can be applied differently for each species because of their differing physiology and other movement characteristics e.g. what may be a barrier for goldfish such as a fast moving stream, may not be one for a species that is able to cling to the stream substrate like rusty crayfish. The barriers shown on **Figure 2** are ones regarded as active barriers or dams that may restrict the movement of a majority of the aquatic species present. More detailed analysis of fish data, barrier assessments and risk parameters is available (e.g. lamprey and rainbow trout) and will also need to be undertaken as implementation proceeds. As can be seen from the series of key maps, most invasive species are restricted to the southern half of the watershed below the Niagara Escarpment which serves as a significant natural barrier to upstream colonization. There are exceptions such as carp and goldfish; which likely were introduced above this natural barrier by people.

Referring to **Figure 2**:

- Common Carp- In the lower Credit (A) may extend as far north as the Norval Dam. Also found In Fairy Lake (B).
- Rosy Red Fathead Minnow- In the lower Credit (A), may extend as far north as the Norval Dam. Also occurring in SWM pond with a buried outlet in northwest Brampton (B).
- Goldfish- Recorded observations mostly in the lower Credit, Experience though reveals them to be widely dispersed throughout the watershed,
- Round Goby- - In the lower Credit (A), may extend as far north as the Streetsville Dam.
- Rusty Crayfish- Found in the Credit as far north as Mayfield Road (A). The Escarpment may remain as the last major barrier to colonization of the headwaters areas on the main Credit River, although smaller tributaries along the escarpment may be passable by this species.
- Sea Lamprey- Found at Meadowvale (A). Likely represents some 'leakage' at the Streetsville dam barrier. Norval dam the next major barrier upstream. However, planned lampricide controls should continue to keep them below the Streetsville barrier.

Artificial barriers created by humans (e.g. dams) have generally been portrayed as having negative impacts on native fish populations are in fact in many cases protecting them from invasion by non-native species. Even barriers assumed to contain certain species can be circumvented, especially where uninformed individuals may transfer these species through bait dumping, relocation and water transfers. Also to consider is the introduction of native Ontario 'sport' fishing species to new areas of the watershed, such as northern

pike and non-native sport fish like brown trout. Where brook trout have been extirpated and restoration is not an option brown trout may fill their role and the absent ecological niche, but care must be taken to protect those natural populations of brook trout that still persist. The issues with northern pike are somewhat different. Likely introduced above the escarpment by landowners and anglers, fishing derbies have been attempted (with mixed success) to reduce their populations and impacts on the brook trout population. Considering climate change and its potential impacts on cool and cold water streams this strategy may need rethinking.

While not yet identified in the Credit River watershed, the algae rock snot (*Didymosphenia geminata*) has been found in Quebec. Cladophora while native often becomes a nuisance in the summer along the Lake Ontario shoreline and in stretches of the river. This particular species is illustrative of how a seemingly harmless native species can become invasive when environmental conditions degrade and natural processes break down creating a problem that has economic, ecological and human health impacts.

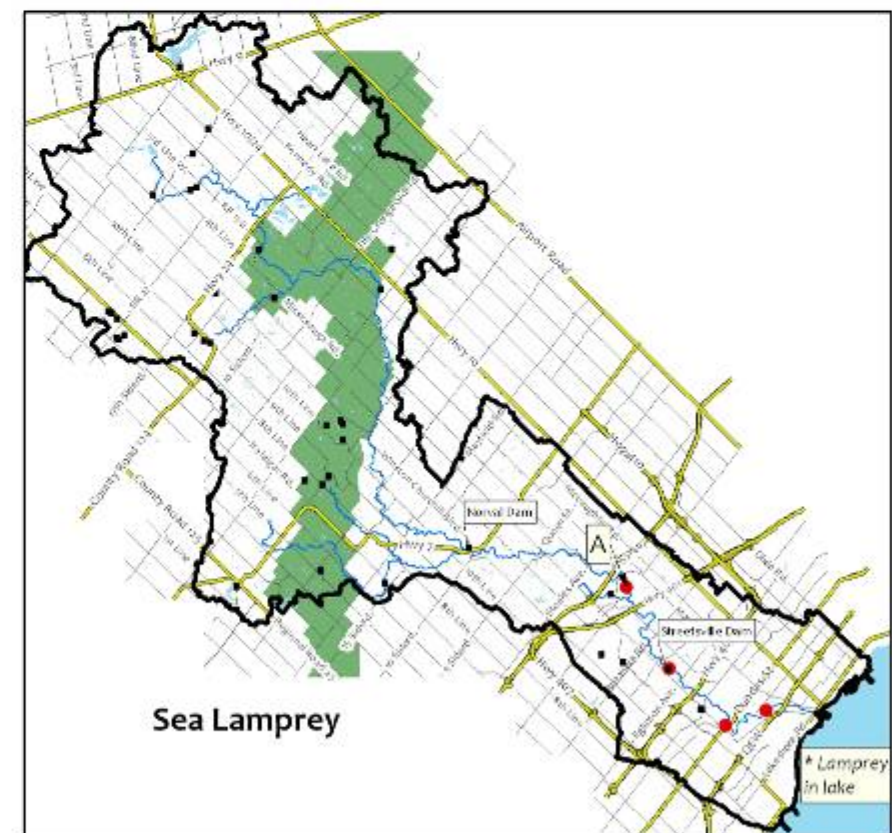
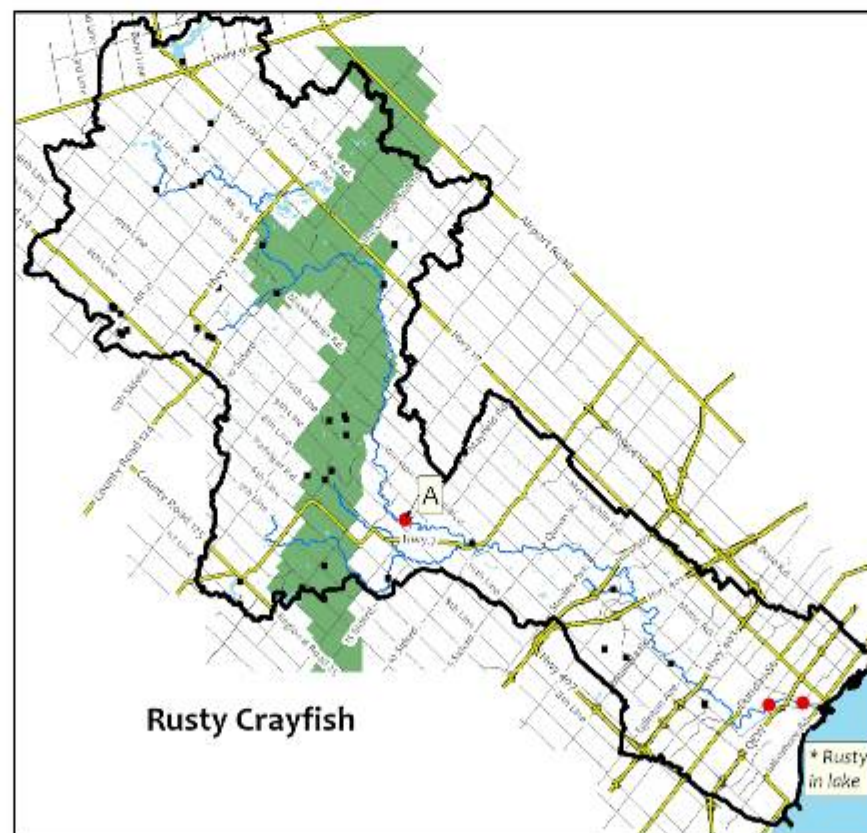
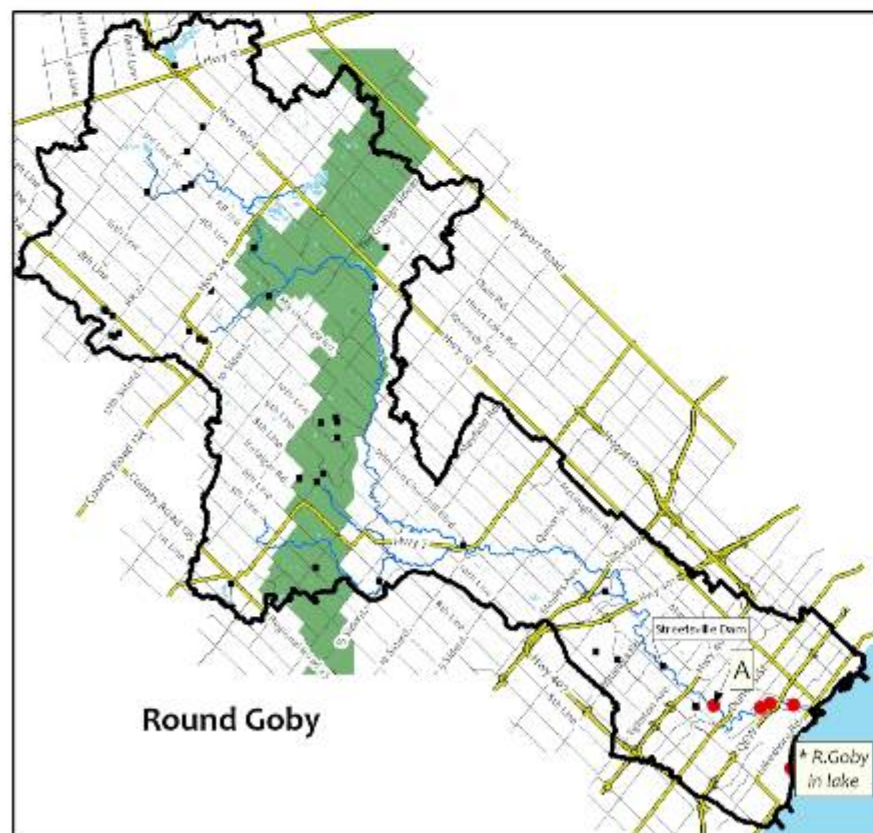
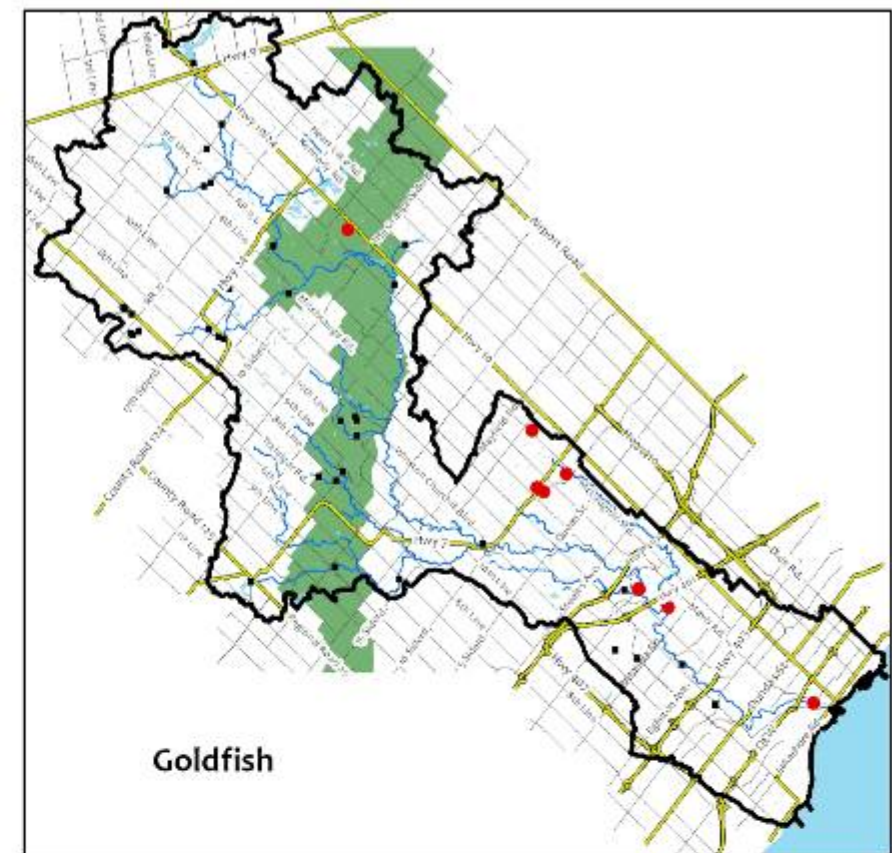
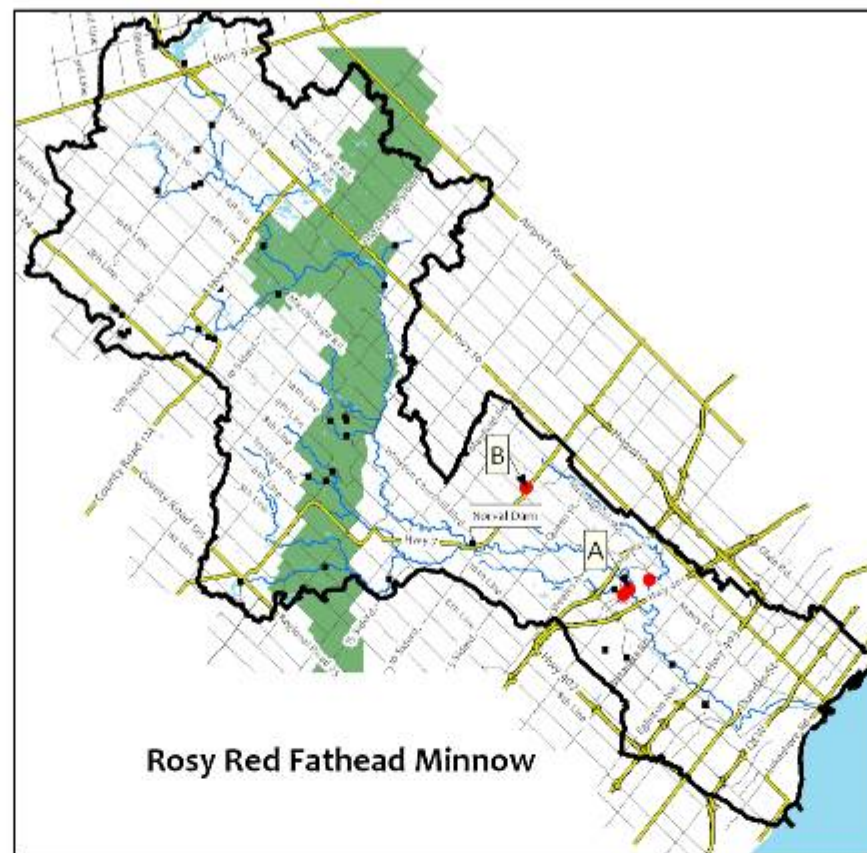
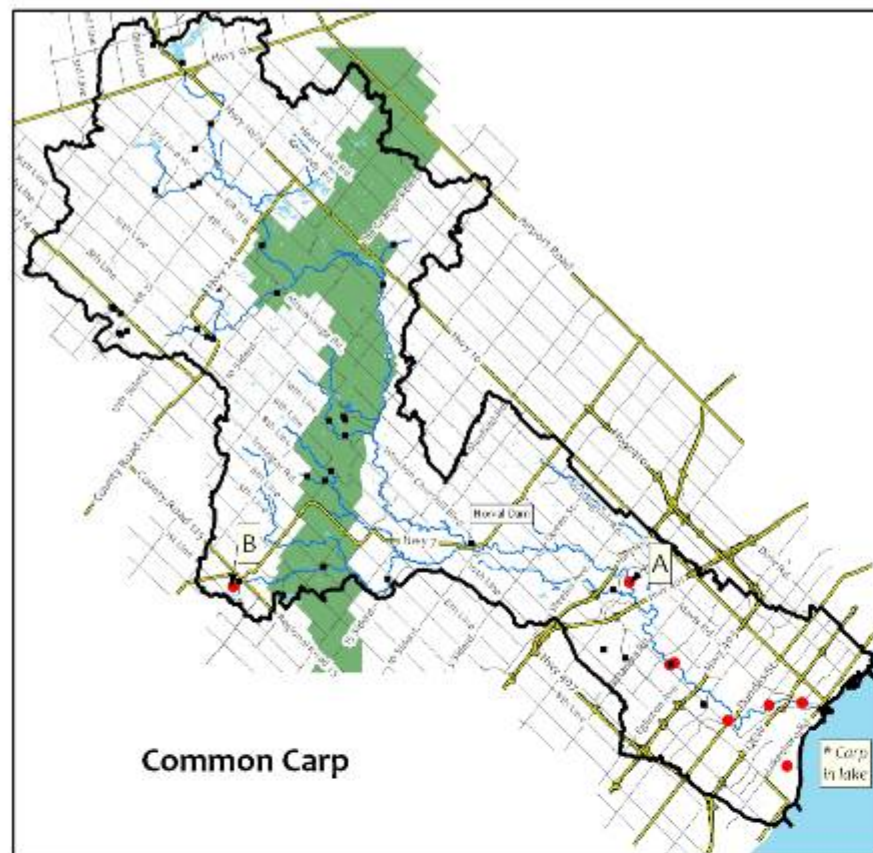


Figure 2: Aquatic Invasive (non-plant) Species in the Credit River Watershed

Other confirmed species in Lake Ontario include spiny-hook waterflea, cladophora, VHS, columnaris, zebra & quagga mussel, and rudd.

Pests and Diseases

Species such as Canada goose are problematic along the waterfront while others such as feral cats and dogs are most problematic in and adjacent to areas of human settlement. Brown-headed cowbird, considered a brood parasite of native song birds can be considered problematic across the watershed especially in those areas that have seen extensive clearing of forest, which this species has particularly benefited from. Other species such as mute swan; which are more or less restricted to the waterfront can have significant effects e.g. one breeding pair in a wetland can have enormous impacts on other breeding native avifauna present in the wetland (Paul Prior, fauna biologist, Toronto and Region Conservation; pers. comm.).

Forest pests such as gypsy moth have been cyclical in occurrence in the watershed with damage being limited in large part due to a successful control program using BtK spray (a spray containing a bacterium that targets caterpillar larvae) on localized eruptions of this pest. Of more concern are pests such as Asian long-horned beetle and emerald ash borer which have appeared rapidly in the Toronto region and surrounding area with devastating results. While Asian long-horned beetle has occurred at our doorstep, continued vigilance will be necessary to ensure it does not erupt once again from the Canadian Food Inspection Agency quarantine zone. Emerald ash borer is now known within our watershed and, without feasible options for control, the impacts to urban forests alone will be enormous. It may be that we have no choice but to observe the expectedly severe impacts of this species as it moves through our forests devastating ash tree populations. In many cases entire forests will be destroyed, in others 25% to 75% of the trees could be lost if and when viable bio-controls are discovered. Other pests such as the Sirex wood wasp which attacks pine trees are not here as yet, but linger in Eastern Ontario, where government authorities monitor their expanding range. Diseases such as Dutch elm, beech bark, butternut canker and white pine blister rust occur across the watershed, while the continuing drought over the last decade has amplified the impacts of these diseases.

Diseases affecting humans such as Lyme disease and West Nile Virus (WNV) have been sporadic in the watershed and cyclic in nature. In the case of WNV, control programs have largely been successful, but it is too early to tell what long term patterns may be revealed over time. Lyme disease may become more prevalent in the future as our climate warms and creates a more suitable living environment for this pathogen.

Diseases affecting fish have not arisen in the watershed as yet. Eruptions of Columnaris such as that occurring in the Kawartha Lakes district a number of years ago and the frequent occurrences of Viral Hemorrhagic Septicaemia (VHS) associated with Lake Ontario suggest this is an ever present threat that CVC must monitor and prepare for should cases become known.

Climate Change

With climate change, increasing temperatures will allow more invasive species to survive through our winters and establish populations. Illustrating this point has been some recent research completed in the United States, showing that Kudzu (*Pueraria montana*),

referred to as the ‘vine that ate the south’ has been expanding its range as the -20°Celsius winter isotherm has steadily retreated northwards. Projections show that in the next 10-15 years this species could reach the Credit River watershed (Sage *et al*, 2007). Changes in precipitation patterns may also contribute to the spread of invasives. As native species adapted to our current climate become stressed and extirpated from local habitats, in many situations invasive species that are more aggressive in behaviour will fill the niches left behind. CVC is currently developing its strategy to respond to climate change and will be creating programs and adapting existing ones to address this issue and its linkages to invasive species. One of the solutions to both issues is to restore natural areas and functions which will increase the resiliency of habitats to future impacts.

CVC may also need to examine the use of Ontario native species non-endemic to the watershed that may be better adapted to the changing climate. In theory, making the decision on what will replace certain species in our watershed when the habitat conditions become unsuitable for it, rather than allowing an invasive species to make that choice for us.

4.2 Guiding Principals: Goals and Objectives for CVC Invasive Species Management

Managing invasive species is complex and will require long-term multi-faceted efforts. Prevention of ongoing introductions will require an awareness strategy, improved land use and land care practices, improved and targeted monitoring at a watershed scale, as well as effective ways to minimize transport. Where situations arise immediate control and a quick response to new invasive species occurrences will be necessary. Land management agencies also need to establish clear priorities for control and adopt the most effective methods in order to focus resources that are often limited. Agencies must also be prepared to respond to controversy over some control methods, such as cutting mature trees and the use of pesticides (Havinga *et al*, 2000).

Strategic plans for managing/addressing invasive species have been completed by a number of agencies, such as the Ontario chapter of the Society for Ecological Restoration’s Strategy, “A Strategic Plan for Managing Invasive Plants in Southern Ontario” (Havinga *et al*, 2000); which has been primarily referred to in formulating this CVC strategy. Many other strategies are underway, most notably from the MNR which will be the most relevant and perhaps binding. It is expected to build on the existing MNR Biodiversity Strategy. The principles and approaches defined in the federal strategy, “An Invasive Alien Species Strategy for Canada” (Government of Canada, 2004) has also been considered in formulating CVC’s strategy.

The following main goals and objectives of this CVC Invasive Species Strategy build upon many of the suggested principles of the SER and federal strategies.

Goals

The overall goals of an invasive species management strategy for CVC are:

- To maintain healthy ecosystems and native biodiversity.
- To reduce the ecological and economic impacts of invasive species.
- To advance knowledge and societal attitudes about invasive species.
- To provide support and resources for land management, conservation agencies and landowners.
- To assist with and coordinate efforts to manage invasive species both internally and with external groups and at all levels of government.

Objectives

Specific objectives include (not necessarily in order of priority):

Management and Science

- To prevent further introductions of invasive species, including rapid response mechanisms
- To prevent further expansions of invasive species populations into natural habitats.
- To identify priority invasive species for control.
- To determine the most effective methods for managing specific invasive species.
- To identify priority geographic areas for invasive species management.
- To monitor and document the state of invasive species in the watershed and the effects on natural habitats.

Education

- To support and disseminate research about the ecology and most effective methods of controlling the most problematic invasive plants in the Credit Watershed.
- To create tools for advocacy and education about invasive species and their management.
- To support, encourage and facilitate direct action towards managing invasive species.
- To contribute to improved land management practices in general (e.g. use of native species in plantings, forestry practices, movement of waste material amongst other practices).

Partnerships

- To promote partnerships that allow for information sharing and pooling of resources for more effective management of invasive species.
- To encourage discussion and address unresolved issues and challenges regarding invasive species.

Planning

- To work with municipal, provincial and federal partners to influence planning and other public policy to prevent the spread of invasive species and to facilitate their management.

- To provide sound scientific recommendations relative to invasive species to development proponents through the review of planning applications.

As noted at the beginning of this document, CVC will apply the above noted approach to its own lands first and the way in which it manages and operates on those same lands. Following that, CVC will, through its existing partnership base and its Education and Stewardship Outreach programs, seek uptake of this Strategy by other private and public landowners

Many existing strategies, programs and agencies focus on a specific group of invasive species, which pertain to a particular discipline or department such as plants, wildlife, disease, agriculture, forestry or aquatic species. This leads to a disjointed approach with no one agency having a complete picture of the overall efforts or guiding an overall strategy. These agencies need to share and integrate approaches and priorities. CVC, given its structure, jurisdiction and integration of programs is best situated for dealing with this environmental and socio-economic challenge at a local scale. Consider the following as examples of the complex and innovative approach needed to address the issue of invasive species:

Case Study 1: The Nature Conservancy partners with big box retailer

In response to invasives in the United States one big-box retailer has already removed Norway maple and Lombardy poplar from its stores in 5 states. They also tag native plants in nurseries recommended by the Nature Conservancy. Three states have banned dozens of plants including Norway maple, Japanese barberry and burning bush (Associated Press 2007).

Case Study 2: City of Mississauga

The City of Mississauga forestry department restricts the planting of certain invasive species within 100 metres of natural areas.

Considering this, nesting all available strategies and programs together with CVC’s will require ongoing cooperation and diligence. In many cases CVC will not duplicate efforts and will respect primary roles of other lead agencies and assume the position of a supporter and partner. This includes respecting changes in federal and provincial legislation and enforcement actions related to agriculture, imports and transportation, market controls on goods and services and many aspects of fish and wildlife management. As well, many local municipal governments have related bylaws (either existing or forthcoming) that could address invasives species and options for control. **Table 1** illustrates some of the other main agencies involved in invasive species management, relevant regulations and Acts they administer/enforce and the expected and observed roles they assume at each jurisdictional level. This table aids in the identification of CVC’s role vis-à-vis the roles of other agencies and partners.

Table 1: Existing and Potential Agency Roles in Invasive Species Management

Legend: (P) Primary (S) Supportive Role (N) No Specific Role (U) Role Unknown (!) Role shown is expected but not currently observed to be fulfilled

Jurisdiction	Specific Roles								
	Strategies	Import Controls	Funding	Research/ Science/Monitor	Education	Coordination	Enforcement/ Regulation†	Site level control projects	Lobbying
Federal									
<i>Environment Canada</i> Administers the Canadian Environmental Protection Act, Species at Risk Act, Canada Wildlife Act, Wild Animal & Plant Protection & Regulation of International & Interprovincial Trade Act	P	N	P	P	P	P!	P!	N	
<i>Department of Fisheries and Oceans</i> Administers the Fisheries Act, Species at Risk Act	N	N	P	P	N	N!	S!	S	
Canadian Food Inspection Agency Plant Protection Act, Seeds Act	N	P	P	P	P	P	P	S	
Provincial									
<i>MNR</i> Administers the Species at Risk Act, Fish & Wildlife Conservation Act	P!	N	P	P	P	P!	P!	P	S!
<i>Ontario Ministry of Agriculture, Food and Rural Affairs</i> Administers the Provincial Weeds Act, but this is also downloaded to municipalities	N	N	N	S	N	N	S!	S!	S!
<i>OFAH (NGO)</i>	N	N	N	P	P	S	N	N	P
Regional									
<i>CVC</i> Administers the Conservation Authorities Act, also responsible for administering legislation through other Acts and regulations' e.g. Niagara Escarpment Act, Fisheries Act and others.	P	N	S	P	P	P	S!	P	S
Regional government	U	N	N	N	U	U	U	U	S!
Local									
<i>Municipalities</i> Administers the Local by-laws, Provincial Weeds Act (does not include urban municipalities), Property Standards Act	P	N	N!	S	P!	N	P!	P	S!
<i>Local NGO's</i> e.g. local stewardship councils, naturalist groups, Evergreen	N	N	N	S	S	N	N	S	P
<i>Public/Landowners</i>	N	N	N	S	N	N	N	P	P!

† Very few Acts, regulations or bylaws address invasive species directly, but through the administration of these documents there may be an allowance for the management of invasive species either directly or indirectly. Refer to Section 4.4.6 in the workplan, where there is a need identified to review the relevant legislation and determine its use and applicability for the management of invasive species and the administering agencies willingness to apply it. This column reflects the expected role in enforcement in an ideal situation where agencies use all regulatory tools available to them.

As shown in **Table 1**, there are many stakeholders in invasive species management and various tools are available to both encourage and enforce action. Wherever a ‘P’ or ‘S’ are replicated in the same column, there is a risk for duplication, but also an opportunity for partnering. In these cases coordination is the rule and clarity in roles must be defined. Roles at the federal and provincial level tend to be ones of broader coordination, policy development, and enforcement of related acts and regulations, as well as broader scale strategies. Local/Regional roles tend to be more implementation focused, which is where overlap can become the greater risk and partnering can have the greatest benefit (e.g. How can CVC and municipal governments coordinate their messaging, could the city address property standards and CVC focus more on natural areas and broader public education?). While many agencies have an option within their mandate to act on invasive species, many have not done so. Clarification and initiative from the various stakeholders is required.

A quick summary is provided below by breaking down the table by role:

Strategies

Federal and Provincial strategies provide broad sweeping guidance and a framework for jurisdictional actions. Locally these strategies are adopted in principle and translated into the local context in more detailed and action oriented strategies and plans. At a local/regional level CVC and local municipalities must coordinate approaches and priorities.

Import Controls

This is clearly a federal concern where international import and export are involved, but questions linger over who leads or what precautions are taken over inter-provincial trade.

Funding

Funding is generally provided at the provincial and federal level and linked to their strategies. DFO provides funding to CAs. CVC provides funds indirectly through in-kind contributions to private landowners.

Research/Science and Monitoring

This is a shared responsibility among agencies in which research is undertaken, and where gaps are identified. Duplication of activities should be avoided. Monitoring should be standardized so that all parties are using the same indicators and thresholds. Agencies such as OMAFRA generally limit research topics to agricultural pests and diseases. CVC’s role is related to monitoring rather than primary research, which mainly occurs at provincial and federal levels. Local NGOs and landowners generally provide support to local programs related to monitoring.

Education

There are many players and programs in Education, and duplication often occurs. More coordination is required and roles and audiences need to be clarified. Federal/provincial programs are generic in form and broad based. Directed efforts happen at a more local level (CVC and municipalities). Efforts at the local level must be coordinated to meet shared objectives. Certain NGOs may assist with the delivery of messaging.

Coordination

Coordination can happen at varying scales. For example, Federal agencies coordinate provincial efforts, while the Province coordinates regional efforts and so forth.

Oftentimes expected roles are not fulfilled, leading to a breakdown in the chain and the confusion of roles as other agencies take up ‘un-assumed’ roles. CVC’s role is to coordinate local efforts downwards to the municipal level and with NGOs as well as upwards to the Provincial levels to ensure a consistent provincial approach.

Enforcement and Regulation

Who will enforce the management or control of invasive species? This is a difficult topic. As current legislation is applied, very little is employed directly to prohibit or control invasive species. Clearly there is a need to identify what legislation can be used to prohibit or control invasive species and if CVC can apply this or the responsible agency can apply or is even willing to apply. There are, however, other acts that do provide very clear regulations for control, such as:

- Weeds Act: Some agricultural weeds are identified. This act however is downloaded to municipalities and is rarely enforced.
- Plant Protection Act: Controls on import and export of plant pests (e.g. ALHB)
- Local bylaws: Many local municipalities have the ability to draft local bylaws to regulate the use of invasive species, or by application of the Property Standards Act (e.g. See Case Study 2, pg. 15 and Mississauga’s restrictions on the planting of a group of invasive plant species)

Site level Control Projects

Where agencies have land ownership the role/responsibility for managing invasive species on those lands is clear. Where projects involve aquatic habitats of lakes or watercourses, jurisdictions may overlap and coordination is required. CVC will look first to its own lands and share the responsibility with MNR and DFO over lakes and watercourses. MNR has generally focused on fish and wildlife, and DFO has focused on issues linked to Great Lakes and international waters. Local NGOs and landowners may participate in projects either as volunteers/partners or on lands in their ownership.

Lobbying

Lobbying governments to improve legislation or to enact local bylaws is generally a bottom up approach. The most power lies with local NGOs and the public to facilitate change from the local to federal level.

Summary of Expected Roles

After considering the above, it becomes clear that CVC’s role includes the following:

- Communications/Outreach/Advocacy. CVC also maintains academic/research partnerships with educational institutions including the Universities of Toronto and Guelph as well as the Royal Ontario Museum and Royal Botanical Gardens that can be further developed.

- CVC regulations and administration as related to environmental protection, conservation of lands and input to development standards.
- Implementation on CA lands (Site Plans).
- Research/Monitoring- Where data gaps exist.
- Education- regional delivery.
- Coordination of local efforts e.g. Education.
- Local Strategies.

Municipal roles might include:

- Municipal bylaws.
- Implementation on municipal lands.
- Education- local delivery.

Provincial roles:

- Provincial Strategies.
- Improved funding.
- Improved coordination.
- Education (include invasive plants), and widen audience.
- Enforce existing legislation.
- Lobbying for improvements to existing legislation/ new legislation.

Federal roles:

- Follow up on existing Strategies.
- Improved funding.
- Improved coordination.
- Improve educational outreach.
- Enforce existing legislation.
- Improve existing legislation/ new legislation.

NGO roles:

- Lobby government agencies for improved funding, enforcement and regulations.
- Partnering with lead agencies on site level control projects.
- Add invasive species to educational programs. Coordinate with local stakeholders.
- Include invasive species as a part of monitoring or participate in local monitoring efforts.

Public/Landowner roles:

- Lobby government agencies for improved funding, enforcement and regulations.
- Participation in local site level control projects or initiate own.
- Participate in local monitoring efforts.

Stakeholders actively working with CVC with a specific interest in invasives include many local fishing and naturalist clubs and other environmental organizations (listed in **Appendix 7**).

In 2007, concerned individuals and organizational representatives met to assess opportunities to develop a more effective response to the growing threat of invasive terrestrial plant species within Ontario. As a result, the Ontario Terrestrial Invasive Plant Council was formed to further coordinate and develop integrated plans for Southern Ontario. As new strategies are adopted by this group they will be integrated into CVC's current strategy as a part of the program to address the terrestrial plant component of the invasive species strategy. It is hoped that this group will identify and address many of the gaps indicated in **Table 1** and the accompanying text.

4.3 A Guide for Implementation

Pulling together the broader goals and objectives of this Strategy the following is a guidance and planning framework that will direct the more detailed development of a workplan (presented in section 4.5) for CVC that addresses the challenges presented by invasive species from the program development stage, to specific projects and their evaluation.

Program Themes

Common themes across many strategies and existing programs that can be endorsed/implemented by CVC in the development of its own programs include:

- Identifying priority geographic areas for management and prevent further introductions.
 - Protect most natural areas from invasion first (prevention before control).
 - Realize it is impossible to eradicate invasive species where human activity is high; therefore this will necessitate active management.
 - Target early invasions. Minimize transport, screen, monitor and educate.
 - Control methods will not be successful unless the source problem/area is reasonably addressed including travel pathways.
 - Invasive species arrive from a source area via a number of 'pathways' (e.g. roads) or other land uses adjacent to natural areas. The method of travel can also be different from natural modes (e.g. wildlife, water vs. hikers, dog walkers, vehicles, water diversions).
 - Inventory manicured properties and road allowances in public ownership.

- Adopting preventative land care and land use practices. For example:
 - Minimize disturbance in natural areas.
 - Restore areas that are already damaged.
 - Replant and/or re-seed as soon as possible after removal to avoid further invasions.
 - Exercise caution when moving fill from one site to another.
 - Cleaning equipment (e.g. waders, boots, vehicle tires) when moving between sites whether aquatic or terrestrial.
 - Plan trails appropriately considering pathways of invasion e.g. Consider strategic introduction of boot wipers (to reduce weed seed introduction) at main entrances with signage and develop trail planning guidelines.

- Adjust forestry practices to consider the ecology and vectors of invasive species spread and proliferation e.g. release of suppressed invasive species through selective harvesting that confound forest management objectives or create new source areas of invasives.
- Promote soil stockpiling, so native seed sources are available post development for native community restoration.
- Develop appropriate plant lists that serve as restoration guidelines.
- Provide demonstration sites for developers, landscape industry and the nursery trade showing the benefits and cost effectiveness of landscaping with native and non-invasive alternatives.

This may necessitate the development of guidelines and best management practices documents, or it may be compiling existing ones to make available to landowners, development practitioners and other organizations and individuals that CVC works with.

- Conducting research and disseminate results.
 - Continue ongoing relevant research and monitoring (species and community inventories, monitoring plots, climate change, and socio-economic cost-benefits).
 - Use best available control methods, but have to be adaptive or experimental based on monitoring results.
 - Standardize and integrate databases with other agencies/institutions.
 - Integrate with other CVC programs such as Climate Change Strategy and Impact Monitoring.
 - Create an annotated bibliography/database of research and resources, including educational and other resources, relevant to southern Ontario.
 - Make this information easily accessible to public and stakeholders.
- Promoting partnerships.
 - Liaise with MNR, Fisheries and Oceans Canada, Environment Canada and other relevant regulatory agencies.
 - Work with the local nursery/landscaping industry/garden centre industries and Ministry of Transportation to phase out priority invasive species or to mitigate impacts. Other industries may include hatcheries/baitfish and the pond/aquarium trade.
 - Support and coordinate efforts and programs with the Ontario Invasive Plant Council.
 - Regional and municipal partnerships should be the focus of CVC. Begin with cooperation in municipal planting programs.
 - Continue to encourage participation by NGOs and their influence on parent provincial or federal organizations.
 - Work with other individuals and community groups.
- Policy and regulation development.
 - Provide input and support to federal/provincial policies (e.g. noxious weeds, food inspection, fish transfers, and navigation laws). .

- Educate or lobby local decision makers re; land use regulations to reduce disturbances and remove invasives (topsoil bylaws, wider corridors and buffers, trail management guidelines).
 - Regulate local land use activities to decrease site conditions conducive to invasives or require some level of control maintenance.
 - Lobby for restrictions on the sale and use of priority invasive species on public and private lands and likewise permit and encourage native species.
 - Review and identify gaps in CVC policies and municipal by-laws.
 - Develop stronger native species policies.
- Outreach, Education and Stewardship (Educate and communicate widely)
 - Identify and communicate specific messages to target audiences including public land agencies, private residential and commercial/industrial landowners, farmers, non-governmental organizations and educators on appropriate stewardship practices applicable to invasive species identification, prevention, monitoring and control.
 - Develop an awareness strategy, including marketing and communication material for the general public. This also includes education curricula targeted through schools and outdoor education programs for children.
 - Educate target audiences at home and in public areas and through ‘inreach’ and outreach programs.
 - Promote behaviour change strategies where appropriate.
 - Utilize, rather than duplicate existing information (e.g. Ontario Federation of Anglers and Hunters Invasive Species hotline (OFAH), brochures, poster, and signage).
 - Provide technical expertise to interested landowners.
 - Post the strategic plan and other materials on a website and provide links to additional resources.
 - Develop and circulate user-friendly guidelines for managing priority species of concern.
 - Promote the Invasives Species Strategy with local and regional media contacts.
 - Promote native species and educate on local nursery sources, landscapers, pond / pet trade (CVC’s urban outreach program will caution people about invasive species in general, and provide information on local nurseries, pond plant providers, landscapers and other resources that offer native and non-invasive gardening alternatives).
 - Educate internal staff on invasive species identification and messaging for the public.
 - Invite input and review on this strategy and subsequent implementation programs from other municipal and regional partners.
 - Provide support in implementing invasive species management plans and help facilitate the work in conjunction with partners for invasive species control where appropriate.

Project Design and Evaluation

Project components within each program theme for invasive species may be designed to address the following evaluation criteria as suggested by An Invasive Alien Species Strategy for Canada (Government of Canada, 2004):

- Public Education Value (target most relevant groups and/or strongly impact large audiences)
- Risk Reduction Value (cost effective harm reduction, probability of success, target pathways of introduction for multi-species, focus on small populations outside main range)
- Significance of Target Species or Pathway (demonstrate impact on the environment, human health or economics)
- Leverage (match funds, in-kind support, volunteers, agency partners, minimal duplication)
- Sustainability and Diversity (long term plans and impact, multi-prong approach and adaptable, terrestrial and aquatic, regional representation, balance prevention and management)
- Technical Feasibility / Capacity (reasonable, available expertise, successful methods)
- Budget and Schedules (cost effective, resources, management, time frame)
- Evaluation and Monitoring (measurable targets of effectiveness vs. effort)

Existing Projects and Programs

Considering the above guidance framework CVC must review, build on, better coordinate and place in perspective its existing programs, projects and partner supported activities including:

Aquatic Invaders

- Rattray Restoration Environmental Assessment- Study that includes the determination of the impacts of invasive species e.g. carp (barrier controls), goose control and the adjustment of water depths/levels to encourage native species.
- Monitoring and opportunistic removal for goby / rusty crayfish and other new aquatic invaders.
- Northern Pike are non-endemic above the escarpment and have been targeted for removal from brook trout habitat through activities such as fishing derbies. This may in the future need reconsideration within the Credit River Fish Management Plan (Climate change may make some streams unsuitable for brook trout)
- Maintain sea lamprey barrier at Streetsville and barriers for non-native salmonids, MNR lampricide applications.
- Zebra mussel and other aquatic invaders signage and boat/bait regulation education/enforcement at Island Lake.

Terrestrial Invaders

- Design, document and guide volunteer attempts to control garlic mustard at Rattray Marsh.
- Norway maple girdling on CVC properties (Meadowvale, Willow Park, Rattray).

- European buckthorn removal on CVC owned and managed properties.
- Monitoring of purple loosestrife beetle populations. Collect and distribute as necessary.
- Control of Phragmites using blankets at Rattray Marsh.

Pests and Diseases

- City of Mississauga Canada goose egg oiling program.
- Support Gypsy moth control (Btk spray) in Mississauga.
- Continue CVC support for WNV Control Plan Implementation in Halton and Peel regions.
- Halton Lyme Disease monitoring. CVC field staff through safety training and field protocols are instructed on procedures for dealing with feeding ticks i.e. submitting them through their local physician to regional health units.

4.4 A CVC Workplan

The following is an outline of a short term workplan identified by CVC staff as being the next steps in implementing a watershed wide strategy for managing invasive species. Too often strategies are documents that convey very broad overarching themes, objectives and goals and it can be difficult to translate these into specific and realistic implementation actions. It is hoped this section will remedy that and set the stage for implementation and uptake by all CVC departments. The workplan provides background on work completed to date and planned next steps in implementation. As this workplan develops and knowledge is gained or science changes/develops, a longer term strategic workplan will be updated. **Table 2** lays out the various departments in CVC and directs their role in this strategy and the implementation of the various elements within this workplan.

Table 2: CVC departmental responsibilities in implementation

Strategy Task	CVC Department
Internal Coordination	Natural Heritage
Regional Watershed Monitoring	Natural Heritage , Water Resources
Reconnaissance monitoring and trails on CA lands	Lands
Public involved control (volunteers on CA Lands)	Stewardship , Natural Heritage, Lands
Removal on CA Lands	Lands , Stewardship, Natural Heritage
Removal on private lands	Stewardship (Outreach) , Natural Heritage
Site restoration and stabilization	Stewardship, Natural Heritage
Post Control effort monitoring on CA lands	Natural Heritage , Lands
External coordination (Strategy implementation)	Natural Heritage , Stewardship
Guidelines development	Planning , Lands, Natural Heritage
Science (control methods, priority species and areas, research)	Natural Heritage , Water Resources
Education (internal)	Natural Heritage , Education
Education (external)	Education , Natural Heritage, Stewardship
Materials development (brochures, website, fact sheets)	Communications , Education, Natural Heritage, Stewardship

* Bold indicates lead department, others represent a supporting role

4.4.1 Developing CVC Priority Invasive Species of Concern

Before steps can be taken to prevent, assess, control or monitor the spread of invasive species an understanding of what those species are and their degree of invasiveness or impacts is needed. **Appendix 1** provides a list of all invasive plant species of greatest conservation concern within the Credit River Watershed. The list will be refined with further input and local inventories, over the long term. This list has largely drawn upon the table of “Priority Invasive Plants in Southern Ontario” drafted by Urban Forest Associates Incorporated in 2000 and appearing in the SER’s Strategic Plan mentioned previously. The CVC list ranks species according to their degree of known invasiveness, i.e. priority 1 species are of the most concern while priority 4 species are considered minimally invasive. In some cases CVC staff by consensus elevated or lowered the status of some species based on familiarity with local conditions. Other species (priority 5) have been placed on a short or “watch” list that marks them as requiring observation by resource managers and the public to ascertain what their status or invasiveness might be and to even prompt timely control while they are still at the stage of “early invader”. In **Table 3** CVC staff identified a short or ‘critical’ list of these plant invasives drawing from the larger list in **Appendix 1**. This short list was created based on internal review and experiences of CVC staff.

The list of aquatic invasive species and diseases (of fish) in **Table 3** were drawn from other sources such as the OFAH and MNR lists. A prioritized list of aquatic invasive species and diseases of fish can be found in **Appendix 2**.

The list of animal pests in **Table 3** draws upon CVC’s local experience and the issues experienced at a local scale with this group of pests.

Forest pest and diseases are drawn from provincial lists but have been prioritized in **Table 3** for the watershed based on CVC staff experience. A full prioritized list of forest pests and diseases appears in **Appendix 3**. This appendix reflects judgements where actions to manage these species is still considered feasible. For example, while species such as butternut canker (*Sirococcus clavignenti-juglandacearum*), white pine blister rust (*Cronartium ribicola*), and oak decline are of a serious concern in the watershed, control and management options are not feasible or possible at a watershed scale to address the problem, therefore they are not a top CVC priority.

Those diseases affecting humans are drawn directly from the input of public health agencies.

Table 3: Priority list of invasive species of concern for the Credit River watershed

Forest/Successional Invasive Plants	
Common name	Scientific nomenclature
Common buckthorn	<i>Rhamnus cathartica</i>
Dog-strangling vine	<i>Cynanchum rossicum and nigrum</i>
English ivy	<i>Hedera helix</i>
Garlic mustard	<i>Alliaria petiolata</i>
Giant hogweed	<i>Heracleum mantegazzianum</i>

Goutweed	<i>Aegopodium podagraria</i>
Japanese knotweed	<i>Polygonum cuspidatum</i>
Manitoba maple	<i>Acer negundo</i>
Non-native honeysuckles (European fly, Tartarian, Morrow's, Amur, Japanese)	<i>Lonicera xylosteum</i> , <i>L. tatarica</i> , <i>L. morrowi</i> , <i>L. maackii</i> , <i>L. japonica</i>
Norway maple	<i>Acer platanoides</i>
Periwinkle	<i>Vinca minor</i>
Winged euonymus/Spindle tree	<i>Euonymus alatus and europaeus</i>
Wetland Invasive Plants	
Black alder	<i>Alnus glutinosa</i>
Common reed	<i>Phragmites australis</i>
Curly pondweed	<i>Potamogeton crispus</i>
Eurasian watermilfoil	<i>Myriophyllum spicatum</i>
European frog-bit	<i>Hydrocharis morsus-ranae</i>
Fanwort	<i>Cabomba caroliniana</i>
Floating heart	<i>Nymphoides peltatum</i>
Flowering rush	<i>Butomus umbellatus</i>
Himalayan balsam	<i>Impatiens glandulifera</i>
Purple loosestrife	<i>Lythrum salicaria</i>
Rough manna grass	<i>Glyceria maxima</i>
Aquatic Invasive Species	
Algae*	<i>Cladophora</i>
Algae (Rock snot)*	<i>Didymosphenia geminata</i>
Carp	<i>Cyprinus carpio</i> (Common), <i>Ctenopharyngodon idella</i> (Grass), <i>Hypophthalmichthys molitrix</i> (Silver), <i>Hypophthalmichthys nobilis</i> (Bighead), <i>Mylopharyngodon piceus</i> (Black)
Goldfish	<i>Carassius auratus</i>
Mosquito fish	<i>Gambusia affinis</i>
Oriental mystery snail	<i>Cipangopaludina chinensis</i>
Red-eared slider turtle	<i>Trachemys scripta elegans</i>
Round goby	<i>Apollonia melanostoma</i>
Ruby red fathead minnow	<i>Pimephales promelas</i>
Rudd	<i>Scardinius erythrophthalmus</i>
Ruffe	<i>Gymnocephalus cernuus</i>
Rusty crayfish	<i>Orconectes rusticus</i>
Sea lamprey	<i>Petromyzon marinus</i>
Snakehead	Genera <i>Channa</i> and <i>Parachanna</i>
Spiny/fish hook waterflea	<i>Bythotrephes longimanus</i>
Zebra and Quagga mussel	<i>Dreissena polymorpha</i> and <i>D. rostriformis bugensis</i>
Animal Pests	
Brown-headed cowbird*	<i>Molothrus ater</i>
Canada goose*	<i>Branta canadensis</i>

Feral cat	<i>Felis silvestris catus</i>
Feral dog	<i>Canis lupus familiaris</i>
Mute swan	<i>Cygnus olor</i>
Raccoon*	<i>Procyon lotor</i>
Forest Pests and Diseases	
Asian long horned beetle	<i>Anoplophora glabripennis</i>
Beech bark diseases*	<i>Nectria coccinea</i> var. <i>faginata</i> and <i>N. galligena</i>
Butternut canker	<i>Sirococcus clavigignenti-juglandacearum</i>
Dutch elm diseases	<i>Ophiostoma ulmi</i> , <i>O. himal-ulmi</i> , <i>O. novo-ulmi</i>
Emerald ash borer	<i>Agrilus planipennis</i>
Fall canker worm	<i>Alsophila pometaria</i> *
Forest tent caterpillar	<i>Malacosoma disstria</i> *
Gypsy moth	<i>Lymantria dispar</i>
Oak decline*	Both environmental and pest agents
Pine weevil	<i>Hylobius abietis</i>
Sirex wood wasp	<i>Sirex noctilio</i> (F.)
White pine blister rust	<i>Cronartium ribicola</i>
Diseases	
Columnaris (fish hosts)	<i>Flavobacterium columnare</i>
Lyme disease (tick host)*	bacterium- genus <i>Borrelia</i>
Viral hemorrhagic septicaemia (fish hosts)	Viral hemorrhagic <i>septicemia</i> virus
West Nile Virus (mosquito and bird hosts)	<i>Flaviviridae</i> family

* Species is native to Ontario

4.4.2 CVC Priority Areas of Concern

The next step in the process of developing a strategic work plan is to select those areas in the watershed where limited resources can be focussed to best meet the overall goals and objectives of the CVC Strategy.

CVC will focus efforts on invasive species management in natural areas characterized as:

- Forests and wetlands.
- Aquatic habitats of the rivers, connected lakes, ponds and the Lake Ontario shoreline.
- Successional and meadow habitats will only be a focus of concern where they interface with forest and wetland habitats and represent an avenue for ingress of invasive species or they support rare species or communities. True prairie or savannah habitats are a top priority, but are either inaccessible or have not been identified.

Terrestrial System Priorities

Considering invasive plant, animal and forest pests and diseases, priorities will be established based on:

1. Protecting the largest and most diverse native communities with the least area/density of invasive species of most concern. Focus will begin on lands already designated and known as significant including Areas of National and Scientific Interest (ANSI), Environmentally Sensitive Areas (ESA) and Provincially Significant Wetland (PSW) core areas and other priority areas as identified by CVC's Terrestrial Ecosystem Enhancement Model (TEEM) project. Preliminary candidate areas, as identified by CVC staff, include:
 - Upper watershed: Caledon Lake Conservation Area (CA), Island Lake CA/Melville and Alton/Hillsburgh PSW.
 - Middle watershed along the Niagara Escarpment: Terra Cotta CA/Silver Creek CA, Belfountain CA/Forks of the Credit.
 - Lower watershed: Rattray Marsh CA, Creditview Bog, Mississauga Gardens (Riverwood) and/or Meadowvale Station Woods CA.

Areas not selected in the above procedure that have known locations for a significant number of regionally rare species (CVC Species of Conservation Interest) or community types will also be considered.

2. Areas in which there is a high degree of volunteer/public interest where resources for long term management are available such that the area can serve as a 'model site' for both public education, the exploration of control techniques and the engagement of volunteers.
3. Lands adjacent to and corridors connecting to areas selected in step 1.

Once these priority areas are selected sites will be identified for more detailed inventories of invasive species present. Lands that are publicly or CVC owned would be more conducive to initial assessments, mapping and prioritization for experimental controls and are therefore a good starting point. Willing volunteers should be accommodated and encouraged where available. They can relate to lands they use and public properties provide for better educational opportunities. Beginning in 2008 and continuing in 2009 surveys for invasive species will begin on the shortlist of sites already identified, with further sites being taken on in subsequent years as staffing and funding permits. CVC is expected to lead a critical role for invasive control programs at the local level. Coordinated action will be required with Aquatic System priorities (below), beginning with Island Lake CA, Fairy Lake and Forks of the Credit.

Once initial inventories are complete, areas will be further prioritized for action based on:

- Potential for impact and relative abundance of the invasive species (e.g. speed of spread, displacement of existing biodiversity).
- Health and safety criteria often take precedence (e.g. hogweed dermatitis, ravines at risk of slope collapse or clogged storm drains).

- It is most effective and efficient to concentrate on early invasions low in abundance first.
- Control methods will be considered along with their rate of success and resources required before implementing control projects (**Appendix 4 and 5**).

Of these areas, those known to be dominated by invasives, especially in urban areas, action should first focus on landowner education together with changes in land use practices and related activities that may easily re-introduce an invasive. Urban parks are an excellent place to highlight the merits of a program because of their higher visibility.

Agriculture communities are not addressed in this strategy. The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) has a weed management program that deals with weeds in the agricultural landscape. However, there are problematic species that may be identified that could be an issue in a naturalized setting as well. Another issue of concern is genetically modified crops that could provide a level of resistance to other plants through cross-pollination and could impact native genetic diversity. Other commercially valued non-natives, such as garden plants and genetically inappropriate nursery stock, may also be an issue that requires attention. These plants could increase the risk of invasive species becoming more competitive or could also impact native genetic diversity.

Aquatic System Priorities

Priorities for focusing efforts on the management of invasive aquatic species and fish related diseases while similar in approach to priorities set for the terrestrial system are slightly different given the obvious differences in the two natural systems. Coordinated action will be required between activities implemented both within the Terrestrial and Aquatic Systems.

Priorities will be similar for the terrestrial system and focus on:

1. Protecting the most productive and sensitive native communities with the least area/density of invasive species of most concern e.g. above the Niagara Escarpment. Additionally areas with known locations of regionally rare species (CVC Species of Conservation Interest) will be considered.
2. Areas in which there is a high degree of volunteer/public interest where resources for long term management are available such that the area can serve as a 'model site' for both public education, the exploration of control techniques and the engagement of volunteers.

Additionally a focus will be made on:

4. Areas with high boating activity and angler effort
 - a. Island Lake

- b. Fairy Lake
 - c. Ken Whillans
 - d. Terra Cotta
 - e. All brook trout waters
 - f. Erindale Park/Riverwood
5. Lake Ontario waterfront
6. Locations of major barriers that act to constrain invasive species (e.g. Streetsville dam for Sea Lamprey).

Similar to the terrestrial system, once locations of invasive species are known or detected, further prioritization will occur based on:

- Potential for impact and relative abundance of the invasive species (e.g. speed of spread, displacement of existing biodiversity).
- Health and safety criteria often take precedence (e.g. water quality concerns with and links between zebra mussel and the native algae *Cladophora*).
- It is most effective and efficient to concentrate on early invasions low in abundance first.
- Control methods (e.g. barriers) will be considered along with their rate of success and resources required before implementing control projects (**Appendix 4**).

Control projects at selected sites must not only focus on removal, but also pathways of travel and source areas that may be designated as low priority. This may require further research, other partnerships, public education programs, and adaptive management. Anglers will be a major audience in terms of both the outreach and education programs. CVC will also need to integrate with other efforts underway or being considered by the MNR and OFAH.

4.4.3 Control Programs

Once priority areas are established, efforts will be focused on these sites starting in 2008 either for inventory or control efforts. Control programs traditionally involve either the eradication of a problem species or in many cases can simply mean a management of that species to a level where impacts are socially or ecologically acceptable. Projects can range from physical removal of a species to educational events targeted at pathways of invasion, or may combine these and other management tools or programs (See **Section 4.3, subsection ‘Program themes’**). Work has already begun in Rattray Marsh in 2007 with a comprehensive invasive species inventory completed and an invasive species management plan drafted (**Appendix 8**). Control programs will begin implementation in 2008.

Ongoing commitment from CVC, partner municipalities and the province will be necessary for the success of any ongoing control program. If this does not occur gains made will readily be lost. Monitoring of completed projects has shown that ‘one off’

efforts and those tied to capital funding that last just a few years don't succeed in the long term and can often leave an area in a worse state than when the initial work began. Over the short to mid-term, control of invasive species needs to become an accepted and entrenched maintenance practice in both natural and cultural landscapes.

Effective control programs will incorporate elements of both private land stewardship and public education to be truly effective in each of the priority areas selected. Education and private land stewardship are expanded upon in the sections following.

In any control program it will be important to consider that some non-natives may be fulfilling lost ecological roles, such as hatchery fish programs run by the province, and forest cover provided by invasive trees. The restoration of native species (e.g. Atlantic salmon and native trees) through stocking and planting programs is supported by CVC. Consideration must also be given to the use of non-native, but non-invasive species in the successful restoration of extremely disturbed sites (e.g. gravel pits). This will be supported by CVC on a case-by-case basis. Where hardy native species are available, they will be the preferred option.

CVC will continue to support existing invasive species control programs (See **Section 4.3, subsection 'Existing Projects and Programs'**). CVC will seek future funding to supplement existing budgets and to expand the implementation of this Invasive Species Strategy.

Natural Area Management Plans

Management Plans for CVC properties should be consistent with and identify the need for invasive species management and control programs. Natural area management plans consider how lands will be used by the public and for operational maintenance, they decide on trail access, alignments and infrastructure placement and therefore should be abreast of how these decisions will impact the occurrence and spread of invasive species. CVC will incorporate elements of this strategy into this process as plans are initiated. Updates to policies related to the management of conservation area lands are also discussed in Sec. 4.4.6 Policy and Guidelines Updates.

Through CVC's Stewardship department, workshops are provided to assist private landowners with working through the provincial Natural Spaces Program Self-Assessment Workbook. This Rural Landowner Stewardship Guide is designed to help private landowners protect and enhance the quality of their natural environment. The goals of the guide are broad, but include promoting native plants and the monitoring and removal of invasive species. Through facilitated workshops and a series of self-guided worksheets landowners identify issues on their own property. The plant selection and use section provides a listing of invasive species, methods of control, and some additional web resources.

4.4.4 Monitoring

Adaptive environmental management refers to the process of analyzing management actions and the resulting environmental responses in an iterative fashion to enable a timely response or a shift in management to address these results. As such, monitoring is a key component to this Strategy and is almost as significant as the actual control of invasive species itself. It will allow CVC to adaptively manage its lands for invasive species to determine trends, effectiveness of actions taken, management planning, and to guide new efforts. Monitoring can be broken out into two streams:

1. Monitoring for new invasions: This may be prioritized into examining those habitats most at risk of invasion by investigating pathways of invasion (trails and wildlife corridors, sources, dynamism of community type and other ecological factors). For example, once invasives are controlled at a site, monitoring on a 2 or 3 year cycle of all high risk areas such as trails and connecting corridors could occur. On the other hand, lower risk areas in less disturbed habitats could probably occur less frequently e.g. 5 or 10 year cycles.
2. Monitoring at control sites to assess effectiveness of methods and techniques. This will be an important component of any control project, as the science around control methods of key invasive species is still developing and ever changing.

In both scenarios, monitoring must be considered before any project or program is implemented and should be incorporated as part of the ‘cost’ of implementation. Monitoring can take many forms and will vary in extent and method depending on the nature of the project and available resources e.g. funds, staff time or available volunteer resources.

4.4.5 Education and Stewardship

While referred to periodically in this document, education and stewardship can be regarded as vital for achieving several objectives of this strategy, including promoting awareness of invasive species, influencing the behaviour of consumers and landowners, and building community capacity for control programs. CVC staff will need to develop an effective education and communications program for invasive species by:

- Identifying priority target groups, education objectives and outcomes related to invasive species.
- Identifying key CVC staff and external partners and soliciting input on strategies and tactics.
- Developing an education and communication program, including evaluation strategies.
- Implementing the program and evaluating results.

Key components of these programs will focus on

1. Pathways of invasion, with a focus on human behaviour in natural areas (e.g. staying on trails, dumping of yard waste, unwanted pets) and purchasing patterns (e.g. gardening with native plants; **Appendix 6**).

2. Monitoring of occurrences and spread of invasive species (e.g., education on the identification of invasive species and encouraging the reporting of occurrences).
3. Control of invasives (e.g. communicating the best available science on methods of removal; **Appendix 4 and 5**).
4. For landscaping and related industries, phase out of invasive species use.
5. Encourage and demonstrate a new standard of ‘beautiful’ for gardens and yards in residential, industrial and public spaces through innovative landscaping practices and in the selection of native and non-invasive plants.

CVC’s existing stewardship programs will aid with education and community involvement in control. The Conservation Youth Corps will aid with control and monitoring. The urban outreach program will incorporate key messages into its delivery regarding invasive species and the role the public can play. The program will encourage the use of native plants and ecological landscaping on public and private lands, and note that landowners can manage invasive plants on their own lands. Educational materials on invasives from other departments and other organizations will be included in urban outreach efforts. Educational materials may also to be updated and created to serve the needs of this new program. This may include updates to the CVC website and landowner packages to owners of both new and existing homes adjacent to targeted natural areas. In addition, some hands-on removal and replacement with natives will be included in site level work with urban landowners and non-governmental organizations.

Educational materials will need to be updated and created to serve the needs of his new program. This may include updates to the CVC website, landowner packages to owners of both new homes and existing homes adjacent to targeted natural areas.

4.4.6 Policy, Guidelines Updates and Advocacy

As this Strategy is implemented it will be important that internally CVC reflects these new approaches and science within its own operating policies. To that end updates will be needed and are taking place to ensure this.

Already, in tandem with this Strategy, CVC is developing its own set of Land Management policies (Authority Land Management Guide, 3.1.E) (CVC, 2007b) that directly addresses invasive species and other practices that influence their spread and introduction into CVC’s Conservation Areas. These policies direct the manner in which the management of Conservation Areas can be modified to reduce the potential for invasion, remove existing populations of invasives, and promote the use of native species. Since Conservation Areas are largely selected for their natural heritage features (ANSIs, ESAs, PSWs, etc.) these protected open-spaces become an inherent starting point to fight against invasive species to preserve their original biologically diverse character.

Secondly, in CVC’s administration on CA lands of the Managed Forest Tax Incentive Program starting in 2006, invasive species were included in the qualitative information gathered for each forest compartment. CVC forestry crews continue to note presence and extent of spread of invasive woody species as new inventory data is collected for each

property. Updates and operational guidelines that directly address invasive species with respect to CVC's forestry operations are forthcoming in the near future.

In addition, through the planning and development review process CVC staff provide recommendation on the selection of appropriate native and non-invasives species in planting plans submitted by proponents. These guidelines are being more formally compiled into landscaping guidelines that will be accessible to developers/proponents and local municipalities. Other site level management principles that address invasive species and their spread will be incorporated in the review process over time (e.g. issues addressing fill quality/placement/movement, transportation and pathways of spread on site).

More broadly, legislation and enforcement at the federal and provincial levels are lacking both in preventing new introductions of invasive alien species and tools and mechanisms for controlling those already established. Acts and regulations are either absent or restricted in their application. As an example, the provincial Weed Act generally only applies to weeds that threaten agricultural enterprises and the listed plant invasives are agriculture specific. Other Acts such as the Plant Protection Act are used only to regulate non-plant pests, but a case for including plants as a 'pest' of another plant could be made. At the Municipal level local bylaws and permitting requirements can also address the issues of invasive species. Tools available at the municipal level include bylaws under various sections of the Municipal Act for nuisance weeds and 'clean' private property that could where there is will, advance the case for managing the spread of invasive species.

A place to begin is to review all existing legislation to determine its applicability for invasive species control/management and work with related agencies to identify opportunities and gaps within this regulatory framework.

4.4.7 Partnerships

Invasive species are a far reaching problem that cross over jurisdictional boundaries and individual agency mandates, and therefore are a problem that cannot be dealt with by one agency alone. It will be important to coordinate efforts with other agencies pursuing a similar path. Communicating and working with local municipalities, MNR officials and federal agencies will be fundamental in formulating a management and regulatory framework within the jurisdiction. Working with non- governmental agencies such as local naturalist groups and the Ontario Federation of Anglers and Hunters will also be important in mobilizing efforts and resources to address this pervasive issue. (See **Appendix 7** for a list of current CVC partners). Immediate efforts could focus on forming a local workgroup or council to make elements of this strategy operational and to coordinate effort and pool resources.

It will also be important to seek out new partnerships with non-traditional partners such as those representing the local nursery and pet trade to explore cooperative programs that

will mitigate those pathways of invasion that can be traced back to these particular industries.

CVC will also promote, and to the extent possible directly aid with management of invasive species in its education, outreach and stewardship programs such as Conservation Youth Corps, urban outreach, and Rural Landowner Programs.

CVC will also work with and participate in the Ontario Invasive Plants Group, a relatively new independent provincial body made up of a broad spectrum of stakeholders that will attempt to coordinate the activities of organizations, develop strategies for and disseminate expertise dealing with invasive species in the province.

4.4.8 Science/Research

CVC will continue to keep up with existing science through scientific literature review (maintain library and files of each species of concern, updated lists of references, compiling brochures and educational material), documenting our own research, and through workshop and conference attendance.

5.0 Conclusion

The success of this Strategy will be dependent on the inclusiveness of the manner in which it has been drafted and formulated. Every reasonable effort has been made to include interested key stakeholders in its development as both reviewers and partners in implementation.

Sustained commitment will be necessary both organizationally and financially to realize the goals and objectives of the Strategy. For this, CVC will need to provide the leadership and advocacy that this will require. It is hoped that further commitments at both the federal and provincial level to address invasive species and the preservation of native biodiversity will be forthcoming in the near future to bolster the efforts in the implementation of this Strategy.

While the issues with invasive species can sometimes seem overwhelming and insurmountable we must consider that it has taken centuries of habitat destruction and the introductions of invasive species to create what we now see as a threat to the ecological integrity of our natural environment, and to the health of all of its inhabitants, including us. It is only reasonable then to assume that it may take us a significant amount of time to develop the solutions and the management scenarios necessary to correct our mistakes. Knowing this, and the length of the road we must travel, now is the time to begin that journey.

References

- Alaska Natural Heritage Program. Available online:
http://akweeds.uaa.alaska.edu/pdfs/potential_species/bios/Species_bios_HERMAN.pdf
(accessed August 7th, 2009).
- Associated Press. 2007. *Plant lovers want nurseries to stop selling invasive plants that threaten environment*. Lakeline Vol.27 No.3.
- City of Nanaimo. Available online.
http://www.nanaimo.ca/uploadedfiles/Site_Structure/Community_Services/Parks_Rec_Culture/gianthogweed.pdf (Accessed August 12th, 2009).
- Credit Valley Conservation, Totten Sims Hubicki Associates, Donald G. Weatherbe and Associates, EBNFLO Environmental, D.W. Draper and Associates, Schroeter and Associates, Blackport Hydrogeology 2003. Water Quality Strategy: Phase I Report Conditions Assessment Analysis Approach – Final Report August 2003.
- Credit Valley Conservation. 2007a. *Strategic Plan 2006*.
- Credit Valley Conservation. 2007b. *Authority Land Management Guide*.
- Dorning, M. and D. Cipollini. *Leaf and root extracts of the invasive shrub, Ionicera maackii, inhibit seed germination of three herbs with no autotoxic effects*. Ecological Restoration. Vol. 25 #3, September 2007.
- Environment Canada, U.S. Environmental Protection Agency, New York State Department of Environmental Conservation and the Ontario Ministry of the Environment (MOE), 1998. Lakewide Management Plan for Lake Ontario.
- Global Invasive Species Database. Available online:
<http://www.issg.org/database/species/ecology.asp?fr=1&si=891&sts=> (accessed August 8th, 2009).
- Government of Canada. 1999. *Canadian Environmental Protection Act (1999)*.
- Government of Canada. 2004. *An Invasive Alien Species Strategy for Canada (September 2004)*.
- Government of Ontario. 2005. *Protecting what sustains us: Ontario's biodiversity strategy*.
- Lee, H., Bakowsky, W., Riley, R., Bowles, J., Puddister, M., Uhlig, P., and S. McMurray. 1998. Ecological land classification for southern Ontario: first approximation and its application.

- Havinga, Donna and the Ontario Invasive Plants Working Group. 2000. *Sustaining Biodiversity - A Strategic Plan for Managing Invasive Plants in Southern Ontario*.
- Huebner, C.D. 2007. *Competitive ability of *Ailanthus altissima* and an overview of other RWU-4557 invasive plant studies*. *Ecological Restoration*. Vol. 25 #2, June 2007.
- Holman, M.L., Dunwiddie, P.W. and R.G. Carey. *Investigating the rapid spread of invasive knotweed in a riparian setting*. *Ecological Restoration*. Vol. 25 #2, June 2007.
- Kaufman, S.R. and W. Kaufman. 2007. *Invasive plants: a guide to identification and the impacts and control of common North American species*. Mechanicsburg, PA. Stackpole books.
- Kaiser, J. 2001. *The vascular plant flora of the Region of Peel and the Credit River watershed*.
- Kim, K.D., and K. Ewing. *Controlling *Phalaris arundinacea* with live willow stakes: a density dependent response*. *Ecological Restoration*. Vol. 25 #2, June 2007.
- Lafrancois, B.M. and J. Glase. 2007. *No two sides to this story*. *Conservation Magazine*. July-Sept 2007.
- The Nature Conservancy. 2009a. Available online: <http://tncweeds.ucdavis.edu/esadocs/documnts/vincmaj.pdf> (accessed August 7th, 2009)
- The Nature Conservancy. 2009b. Available online: <http://tncweeds.ucdavis.edu/alert/alrtglyc.html> (accessed August 7th, 2009)
- Plant Conservation Alliance's Alien Plant Working Group. Available online: <http://www.nps.gov/plants/alien/fact/aepo1.htm> (accessed August 7th, 2009).
- Sage R. and H. Coiner. 2007. Powerpoint Presentation at the 2007 Ontario Terrestrial Invasive Plants Group AGM: Global Change and Invasive Plants in Canada.
- Simberloff, D. 1996. *Impacts of introduced species in the United States*. *Consequences* 2(2). Available at <http://gcrio.org/Consequences>.
- White D.J., E. Haber and C. Keddy. 1993. *Invasive plants of natural habitats in Canada: an integrated review of wetland and upland species and legislation governing their control*. Canadian Wildlife Service, Ottawa, Canada. 121 p.
- Wisconsin Department of Natural Resources Invasive Species Gallery. Available online: http://dnr.wi.gov/invasives/fact/buckthorn_com.htm (accessed August 5th, 2008).

Appendix 1: Invasive Plant Species in the Credit River Watershed

This list will be updated on a yearly basis as information improves on some species and new species are noted within the watershed. *This list has been adapted from the original provided in the SER's Sustaining Biodiversity Strategy (Havinga et al., 2007)*

Legend	
Utilized Habitats	
UF-	Upland forest, tableland forest types with mostly dry to fresh soils
FF-	Floodplain forest, generally lowland forest types with fresh to moist soils
W-	Wetland, includes swamp, marsh, and aquatic communities
MS-	Meadow and Successional, includes meadow, woodland, savannah and prairie

* Note that scientific nomenclature and common names may vary across literature. To compound this situation many species listed below have horticultural variants which cause further confusion for readers of this list. For this reason readers should be aware of these cautions and speak to a knowledgeable professional or CVC staff when dealing with any species that shares either the same genera as a species listed here or a similar common name.

List based on the original SER Ontario Invasive species list. Invasive Exotic Species Ranking for Southern Ontario
 © Urban Forest Associates Inc.
 January 2002

Scientific Name	Common Name	Utilized Habitats		
		Primary	Secondary	Tertiary
Category 1-Transformers- Species that exclude all other species and dominate sites indefinitely. Plants in this category are a threat to natural areas wherever they occur because they tend to disperse widely (for example, through transport by birds or water). They are the top priority for control but control may be difficult. Upon detection immediate removal is recommended and control of spread into other areas.				
<i>Acer negundo</i>	Manitoba maple	FF	UF	MS
<i>Aegopodium podagraria</i>	Goutweed	FF	UF	MS
<i>Alliaria petiolata</i>	Garlic mustard	UF	FF	MS
<i>Alnus glutinosa</i>	Black alder	W	FF	
<i>Butomus umbellatus</i>	Flowering rush	W		
<i>Celastrus orbiculatus</i>	Oriental bittersweet	MS	FF	UF
<i>Cynanchum nigrum</i>	Black swallow-wort	MS	UF	FF
<i>Cynanchum rossicum</i>	Pale swallow-wort	MS	UF	FF
<i>Glyceria maxima</i>	Rough manna grass	W	FF	
<i>Heracleum mantegazzianum</i>	Giant hogweed	W	FF	
<i>Hesperis matronalis</i>	Dames rocket	FF	MS	
<i>Hydrocharis morsus-ranae</i>	European frog-bit	W		
<i>Impatiens glandulifera</i>	Himalayan balsam	W	FF	
<i>Lonicera japonica</i>	Japanese honeysuckle	UF	FF	MS
<i>Lonicera mackii</i>	Amur honeysuckle	UF	FF	MS
<i>Lonicera morrowi</i>	Morrow's honeysuckle	UF	FF	MS
<i>Lonicera tatarica</i>	Tartarian honeysuckle	UF	FF	MS

<i>Lonicera x bella</i>	Hybrid honeysuckle	UF	FF	MS
<i>Lonicera xylosteum</i>	European fly honeysuckle	UF	FF	MS
<i>Lythrum salicaria</i>	Purple loosestrife	W		
<i>Morus alba</i>	White mulberry	UF	FF	MS
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	W		
<i>Nymphoides peltata</i>	Floating heart	W		
<i>Phragmites australis</i>	Common reed	W		
<i>Polygonum cuspidatum</i>	Japanese knotweed	W	FF	
<i>Potamogeton crispus</i>	Curly pondweed	W		
<i>Rhamnus cathartica</i>	Common buckthorn	UF	FF	MS
<i>Vinca minor</i>	Periwinkle	UF	FF	MS
<p>Category 2 - Highly invasive- Species that are highly invasive but tend to dominate only certain niches or do not spread rapidly from major concentrations. Many spread by vegetative means or seeds that drop close to the parent plant. Most persist in dense populations for long periods. Control where necessary and limit their spread into other areas.</p>				
<i>Acer platanoides</i>	Norway maple	UF	FF	MS
<i>Acer pseudoplatanus</i>	Sycamore maple	UF	FF	MS
<i>Ailanthus altissima</i>	Tree-of-heaven	UF	FF	MS
<i>Cirsium arvense</i>	Canada thistle	MS		
<i>Convallaria majalis</i>	Lily-of-the-valley	UF	FF	
<i>Coronilla varia</i>	Crown vetch	MS		
<i>Elaeagnus umbellata</i>	Autumn olive	MS		
<i>Hedera helix</i>	English ivy	UF	FF	
<i>Lysimachia nummularia</i>	Moneywort	FF		
<i>Miscanthus sacchariflorus</i>	Eulalia	W		
<i>Miscanthus sinensis</i>	Eulalia	W		
<i>Populus alba</i>	White poplar	MS	FF	
<i>Rhamnus frangula</i>	Glossy buckthorn	W	FF	UF
<i>Robinia pseudo-acacia</i>	Black locust	MS	FF	UF
<i>Rosa multiflora</i>	Multiflora rose	MS	FF	UF
<i>Scilla siberica</i>	Scilla	FF	UF	
<i>Typha angustifolia</i>	Narrow-leaved cattail	W		
<i>Typha x glauca</i>	Hybrid cattail	W		
<i>Ulmus pumila</i>	Siberian elm	UF	FF	MS
<p>Category 3- Moderately invasive- Species that are moderately invasive but can become locally dominant given certain conditions e.g. soils, recreational impacts or disturbances. Control where necessary and limit their spread into other areas.</p>				
<i>Abutilon theophrasti</i>	Velvet-leaf	MS		
<i>Acer ginnala</i>	Amur maple	MS	FF	UF
<i>Acinos arvensis</i>	Mother-of-thyme	MS		
<i>Artemisia absinthum</i>	Absinth sage	MS		
<i>Barbarea vulgaris</i>	Yellow rocket	MS		
<i>Berberis thunbergii</i>	Japanese barberry	UF	FF	
<i>Berberis vulgaris</i>	Common barberry	UF	FF	
<i>Berteroa incana</i>	Hoary-alyssum	MS		
<i>Betula pendula</i>	European birch	W	MS	
<i>Bromus inermis</i>	Smooth brome	MS		

<i>Carduus nutans</i>	Nodding thistle	MS		
<i>Centaurea maculosa</i>	Spotted knapweed	MS		
<i>Convolvulus arvensis</i>	Field bindweed	MS		
<i>Crataegus monogyna</i>	Singleseed hawthorn	MS		
<i>Dactylis glomerata</i>	Orchard grass	MS		
<i>Dipsacus sylvestris</i>	Teasel	MS		
<i>Elaeagnus angustifolia</i>	Russian olive	MS		
<i>Eleutherococcus sieboldianus</i>	five-leaved aralia	UF	FF	
<i>Elymus repens</i>	Quack grass	MS		
<i>Euonymus alata</i>	Winged euonymus	UF	FF	
<i>Euonymus europaeus</i>	Spindle-tree	UF	FF	
<i>Euonymus fortunei</i>	Wintercreeper euonymus	UF	FF	
<i>Euphorbia cyparissias</i>	Cypress spurge	MS		
<i>Festuca arundinacea</i>	Tall fescue	MS		
<i>Forsythia suspensa</i>	Weeping forsythia	UF	FF	
<i>Forsythia viridissima</i>	Forsythia	UF	FF	
<i>Galium mollugo</i>	White bedstraw	UF	FF	MS
<i>Galium verum</i>	Yellow bedstraw	MS		
<i>Geranium robertianum</i>	Herb robert	UF	FF	
<i>Glechoma hederacea</i>	Ground ivy	FF	MS	
<i>Humulus japonicus</i>	Japanese hop	FF	MS	W
<i>Iris pseudoacorus</i>	Yellow flag	W		
<i>Kochia scoparia</i>	Summer cypress	MS		
<i>Ligustrum vulgare</i>	Privet	MS	UF	FF
<i>Lotus corniculatus</i>	Bird-foot trefoil	MS		
<i>Lycopus europeaus</i>	Bugleweed	W		
<i>Lysimachia nummularia</i>	Creeping Jennie	FF		
<i>Melilotus alba</i>	White sweet clover	MS		
<i>Melilotus officinalis</i>	Yellow sweet clover	MS		
<i>Pastinaca sativa</i>	Wild parsnip	MS		
<i>Pinus sylvestris</i>	Scots pine	MS		
<i>Poa pratensis</i>	Kentucky bluegrass	MS		
<i>Ranunculus repens</i>	Creeping buttercup	MS		
<i>Rhodotypos scandens</i>	Jetbead	UF	FF	MS
<i>Rorippa amphibia</i>	Marsh cress	W		
<i>Salix alba</i>	White willow	FF		
<i>Salix fragilis</i>	Crack willow	FF		
<i>Salix x rubens</i>	Hybrid willow	FF		
<i>Saponaria officinalis</i>	Bouncing-bet	MS		
<i>Solanum dulcamara</i>	Bittersweet nightshade	FF	W	
<i>Sorbaria sorbifolia</i>	False spiraea	UF	FF	MS
<i>Syringa vulgaris</i>	Lilac	MS		
<i>Tanacetum vulgare</i>	Tansy	MS		
<i>Thymus praecox</i>	Creeping thyme	MS		
<i>Urtica dioica ssp. dioica</i>	European stinging-nettle	FF	UF	MS
<i>Vicia cracca</i>	Cow vetch	MS		
<i>Vicia sativa ssp. nigra</i>	Common vetch	MS		

<i>Vicia tetrasperma</i>	Slender vetch	MS		
Category 4- Minimally Invasive- Species that do not pose an immediate threat to natural areas but do compete with more desirable native species. Once established, many can reproduce aggressively and become difficult to eradicate. Some are similar to native species and are often substituted by nurseries. Control where necessary and limit their spread to other areas.				
<i>Aesculus hippocastanum</i>	Horse-chestnut	UF	FF	
<i>Ajuga reptans</i>	Creeping bugleweed	FF	UF	MS
<i>Alnus incana ssp. incana</i>	European white alder	W	FF	
<i>Campanula rapunculoides</i>	Creeping bellflower	FF	UF	MS
<i>Euphorbia esula</i>	Leafy spurge	MS		
<i>Hemerocallis ssp.</i>	Day lily	MS		
<i>Hieracium aurantiacum</i>	Orange hawkweed	MS		
<i>Hieracium caespitosum</i>	Yellow hawkweed	MS		
<i>Hieracium lachenalii</i>	Common hawkweed	MS		
<i>Hieracium x floribundum</i>	Pale hawkweed	MS		
<i>Hypericum perforatum</i>	St. John's-wort	MS		
<i>Inula helenium</i>	Elecampane	MS		
<i>Linaria vulgaris</i>	Butter-and-eggs	MS		
<i>Lolium perenne</i>	Perennial rye grass	MS		
<i>Malva moschata</i>	Musk mallow	MS		
<i>Medicago lupulina</i>	Black medick	MS		
<i>Medicago sativa</i>	Alfalfa	MS		
<i>Mentha x piperita</i>	Peppermint	MS		
<i>Myosotis scorpioides</i>	True forget-me-not	W		
<i>Nepeta cataria</i>	Catnip	MS		
<i>Origanum vulgare</i>	Wild marjoram	MS		
<i>Pachysandra terminalis</i>	Japanese spurge	UF	FF	MS
<i>Phalaris arundinacea</i>	Reed canary grass	W		
<i>Populus x canadensis</i>	Carolina poplar	UF	FF	
<i>Rumex acetosella</i>	Sheep sorrel	MS		
<i>Salix caprea</i>	Goat willow	W	FF	
<i>Salix purpurea</i>	Purple willow	W		
<i>Senecio jacobaea</i>	Tansy	MS		
<i>Setaria spp.</i>	Foxtail	MS		
<i>Sorbus aucuparia</i>	European mountain ash	UF	FF	
<i>Symphoricarpos albus var.laevigatus</i>	Western snowberry	UF	FF	
<i>Trifolium arvense</i>	Rabbit-foot	MS		
<i>Trifolium pratense</i>	Red clover	MS		
<i>Trifolium repens</i>	White clover	MS		
<i>Tussilago farfara</i>	Sweet coltsfoot	W	MS	
<i>Viburnum opulus sp. opulus</i>	Guelder rose	FF	UF	W
Category 5- Potentially Invasive - Species to Monitor- Some of these species have the potential to become invasive in Ontario. They can reproduce aggressively on occasion but have not yet been shown to be a serious threat to natural areas in Ontario. Some are very similar to indigenous species and may therefore be difficult to identify. Where the early stages of invasion are detected, removal is recommended. Monitoring of occurrences strongly suggested.				
<i>Anthiscus sylvestris</i>	Wild Chervil	MS	FF	W

<i>Artemisia vulgaris</i>	Common mugwort	MS		
<i>Cornus alba</i>	Tatarian dogwood	W	FF	
<i>Daphne mezereum</i>	Mezer's Daphne	FF		
<i>Fraxinus excelsior</i>	European ash	FF	UF	
<i>Humulus lupulus</i>	Common hop	MS		
<i>Isatis tinctoria</i>	Dyer's woad	MS		
<i>Lapsana communis</i>	Nipplewort	MS		
<i>Najas minor</i>	Minor naiad	W		
<i>Populus tremula</i>	European aspen	UF	FF	MS
<i>Prunus avium</i>	Bird cherry	MS	UF	FF
<i>Prunus mahaleb</i>	Perfumed cherry	MS	UF	FF
<i>Sambucus racemosas sp. racemosa</i>	European red elder	FF	UF	MS
<i>Tilia cordata</i>	European linden	UF	FF	
<i>Torilis arvensis</i>	Hedge parsley	FF	MS	UF
<i>Ulmus glabra</i>	Scotch elm	UF	FF	
<i>Viola odorata</i>	Sweet violet	UF	FF	
Category 6- Watch list- These are invasive species known to have significant economic, health or environmental impacts in adjacent jurisdictions and are not yet known to be present in the Credit River watershed, but are at risk of being introduced. Awareness and monitoring of these species and immediate removal upon detection is the recommended action.				
<i>Ampelopsis brevipedunculata</i>	Porcelainberry	UF	FF	
<i>Cabomba caroliniana</i>	Fanwort	W		
<i>Egeria densa</i>	Waterweed	W		
<i>Hydrilla verticillata</i>	Hydrilla	W		
<i>Microstegium vimineum</i>	Japanese stilt grass	UF	FF	
<i>Myriophyllum aquaticum</i>	Parrotfeather	W		
<i>Persicaria perfoliata</i>	Mile-a-minute weed	MS	FF	W
<i>Phellodendron amurense</i>	Amur cork-tree	UF		
<i>Pistia stratiotes</i>	Water Lettuce	W		
<i>Pueraria lobata</i>	Kudzu	MS	FF	UF
<i>Stratiotes aloides</i>	Water soldier	W		
<i>Trapa natans</i>	Water-chestnut	W		
<i>Polygonum x bohemicum</i>	Bohemian Knotweed	W	FF	
<i>Polygonum sachalinense</i>	Giant Knotweed	W	FF	
<i>Polygonum polystachyum</i>	Himalayan Knotweed	W	FF	

Appendix 2: Aquatic Invasive Species and Fish Diseases in the Credit River Watershed

Common Name	Scientific Name
Category 1- High priority- Species that are present in the watershed that have the potential for disrupting entire aquatic communities. Species distribution and occurrence is such that efforts to eradicate may prove successful if undertaken in a timely manner.	
Rusty crayfish	<i>Orconectes rusticus</i>
Category 2- Medium priority- Species that are present in the watershed that have the potential for disrupting entire aquatic communities. The characteristics of dispersal and introduction of this species to new areas of the watershed is such that containment over the long term is not likely feasible. Efforts should focus on actively monitoring and management over the long term.	
Algae*	<i>Cladophora</i>
Carp	<i>Cyprinus carpio</i> (Common), <i>Ctenopharyngodon idella</i> (Grass), <i>Hypophthalmichthys molitrix</i> (Silver), <i>Hypophthalmichthys nobilis</i> (Bighead), <i>Mylopharyngodon piceus</i> (Black)
Round goby	<i>Apollonia melanostoma</i>
Sea lamprey	<i>Petromyzon marinus</i>
Zebra and Quagga mussel	<i>Dreissena polymorpha</i> and <i>D. rostriformis bugensis</i>
Category 3- Low priority- This category includes species where an understanding of impacts or potential threat is uncertain. Efforts should focus on monitoring and opportunistic removal.	
Goldfish	<i>Carassius auratus</i>
Oriental mystery snail	<i>Cipangopaludina chinensis</i>
Red-eared slider turtle	<i>Trachemys scripta elegans</i>
Ruby red fathead minnow	<i>Pimephales promelas</i>
Category 4-Watch listed- These are species that are not as yet present in the watershed. In effect these species are on a 'watch list' of species that have the potential to impose significant impacts on aquatic systems should they be introduced. Rapid response to detection is advisable on any new reports.	
Algae (Rock snot)*	<i>Didymosphenia geminata</i>
Bloody-red mysid	<i>Hemimysis anomala</i>
Columnaris	<i>Flavobacterium columnare</i>
Louisiana crayfish	<i>Procambarus clarkia</i>
Mosquito fish	<i>Gambusia affinis</i>
Rudd	<i>Scardinius erythrophthalmus</i>
Ruffe	<i>Gymnocephalus cernuus</i>
Snakehead	Genera <i>Channa</i> and <i>Parachanna</i>
Spiny/fish hook waterflea	<i>Bythotrephes longimanus</i>
VHS	Viral hemorrhagic septicaemia

* Species is native to Ontario

Appendix 3: Forest Pests and Diseases in the Credit River Watershed

Important to consider with all forest pests and diseases is that abiotic factors often play an important role in outbreaks and occurrences of many of these species. Changing climates and impacts relating to human activity (urban development, recreational impacts) can weaken native tree species making them susceptible to pests and pathogens that in normal circumstances would not have had a serious or long term ecological or economic impact.

Common Name	Scientific Name
Category 1- Transformer Invasive- These are species that are either present in the watershed or for which the watershed is vulnerable to invasion by. These species colonize rapidly and have the potential to devastate forest ecosystems at a watershed scale. These species have both significant ecological, social and economic impacts. In short, these species transform the character and composition of native forests indefinitely. Management actions are often complicated, multi-stakeholder and exorbitant in costs.	
Asian long-horned beetle	<i>Anoplophora glabripennis</i>
Emerald ash borer	<i>Agrilus planipennis</i> [Containment seems to be failing for this species, it may now be a Category 4]
Category 2- High Priority- Similar to the above species, however impacts tend to be more localized, but have the potential to be controlled when management actions are enacted	
Fall canker worm	<i>Alsophila pometaria</i> *
Gypsy moth	<i>Lymantria dispar</i>
Oak decline	Combination of abiotic stressors (drought, development, pollution) and biotic pests (two-lined chestnut borer* and <i>Armillaria</i> root rot complex*)
Pine weevil	<i>Hylobius abietis</i>
Sirex wood wasp	<i>Sirex noctilio</i> (F.) [Rank may change as knowledge is gained on this species, and the current situation unfolds]
Pine shoot beetle	<i>Tomicus piniperda</i> L.
Category 3- Low priority- These species are ones that have impacts that are local and often self regulated by environmental conditions, but can have significant local impacts.	
Forest tent caterpillar	<i>Malacosoma disstria</i> *
White pine blister rust	<i>Cronartium ribicola</i>
Category 4- Established Transformers- These are species that can have enormous impacts as per Category 1, but are also species where containment has failed and have established themselves in the watershed and for which control and management options are limited if not non-existent. In short, these species have already done or are continuing their damage unchecked and have altered/are altering the composition and character of forested landscapes	
Beech bark diseases	<i>Nectria coccinea</i> var. <i>faginata</i> * and <i>N. galligena</i> *
Butternut canker	<i>Sirococcus clavignenti-juglandacearum</i>
Dutch elm diseases	<i>Ophiostoma ulmi</i> , <i>O. himal-ulmi</i> , <i>O. novo-ulmi</i>

* Species native to Ontario

Appendix 4: Guidelines for Implementing Control

Before applying a treatment for controlling an invasive species there are many factors to consider. The table below broadly outlines some of the advantages and disadvantages of a number of control methods which should assist with determining the most appropriate method of control in a given context. The final decision will be dependent on a complex number of issues dictated by site context, condition, and available resources

Method	Description	Advantages	Disadvantages	Notes
Pruning, cutting, digging, girdling, mechanical harvest for aquatic plants	Directly removes or kills plants or prevents reproduction.	Immediate results. Can replant with preferred species.	Labour intensive. Disturbs area for recolonization or requires replanting. May also require proper disposal of waste matter.	Success can vary depending on time and completeness of removal. Seed banks or roots can regrow.
Burning	Destroys vegetation by fire, or sets it back enough that native species adapted to fire are given a competitive advantage	Natural control that benefits some native communities and species. Large areas can be covered	Invasives may recolonize from seed bank or roots. Safety concerns Requires professionals.	Needs to be repeated over many years, not effective for all invasives e.g. fire encourages dog strangling vine
Blanketing / Sola risation	Using black blanket materials to block the sun and theoretically raises temperature to sufficiently kill underlying seeds.	Can cover areas with less effort. Easily seen for interpretive opportunities.	Can be expensive over large areas. Aesthetic concerns and ecological impacts, such as destruction of native vegetation and seed banks, soil organisms. Vandalism. May take a few years. Plants can grow through some fabrics and rips.	Area needs to be replanted immediately after blanket removal, soil should be inoculated with beneficial soils organisms
Hunting, trapping & fishing	Directly kills/removes animals.	Provides recreational and food/fur opportunities at little to no cost. Can be restricted to agency or other assigned staff/volunteers.	May not have significant impacts on overall populations. Public/political opposition. Can incur costs and safety concerns.	
Biological controls	Use of natural predators, parasites or diseases.	Effective use via natural pathways.	Difficult to control or recall. May result in other unknown impacts on other species, requiring much research	

Pesticides	Directly sets back or removes species	Can be both cost effective and time consuming depending on context	May be impacts on other species. Public aversion to pesticide use.	Requires licensed personnel and permits.
Pest food & shelter controls (garbage and property standards)	Direct prevention of access to food resources and other habitat requirements	Effective and an environmentally friendly control that will reduce the problem over time	Enforcement an issue. Will not completely eradicate problem	Generally, this is a part of an eradication program and should be considered with other methods
Fish barriers	Physically prevents access to upstream areas; types are velocity, height or electrical barriers	Contains spread of invaders to a specific stream reach	Also prevents passage of native species unless fish ladders are used; if so, this can be costly to maintain and operate and is not effective for all species	Requires assessment and permits, which may be time consuming
Integrated Pest Management	Integration of all methods	Most effective method	Requires intensive planning. Pre-planning can be time consuming	Few operators have the experience, knowledge or resources to implement

Are you using Pesticides?

When the decision has been made to use pesticides the following must be considered and planned for:

- *Method and tools. Spraying or painting, injection (pellet or hack and squirt)?*
- *Required permits from local municipality, Ministry of Environment, Department of Fisheries and Oceans (if near or in water)*
- *Use of licensed operators (safety considerations: protective equipment, public safety)*

The following must also be considered when deciding which chemical to use and its properties (Tu, M., Hurd, C., & J.M. Randall, 2001. Weed Control Methods Handbook, The Nature Conservancy, <http://tncweeds.ucdavis.edu>, Version: April 2001):

1. Effectiveness of method against the target species.
2. Mechanisms of dissipation (persistence, degradation, and likelihood of movement via air or water to non-target organisms).
3. Behaviour in the environment (in soils, water, and vegetation).
4. Toxicity to birds and mammals, aquatic species, and to other non-target organisms (including algae, fungi, and soil organisms).
5. Application considerations
6. Safety
7. Human toxicology

Case Study: Considerations in Invasive Plant Removal

The following general recommendations come from the City of Toronto and their experiences with the management of key invasive species and shed some light on some of the complex decisions and considerations that must be taken into account when undertaking any invasive management strategy.

Invasive Species Management Recommendations/Methods – City of Toronto Urban Forestry Revised Sept 2007

Woody invasive (tree/shrub/vine) infestation removal

- Weed succession must be considered – i.e. opening up sites to other invasives including Garlic mustard and Dog-strangling vine – may need to control those species first; slowly remove woody invasives; phase removals and replanting over several years
- Phased removal strategy can include removing seed-bearing stems first
- Trail issues/trampling – consider leaving stems in place on trail edges instead of removing material off site to avoid opening site to trampling – consider girdling/basal bark treatment
- Herbicide foliar treatment for vines seems to be more effective to allow more absorption of pesticide into root system – consider cutting first and spraying resprout to minimize pesticide use and drift

Manual vs. chemical methods

- Safety – City of Toronto Pesticide By-law requires 15 metre pesticide buffer from playgrounds – other methods must be chosen for these areas
- Manual methods such as digging can cause disturbance to soil causing further invasions and uprooting of native plants

Herbicide considerations

- Roundup (Glyphosate) vs. Garlon (Triclopyr) for woody species; city experience has found Garlon more effective in dormant season and for specific species including Buckthorn and Asiatic bittersweet .Garlon (Triclopyr) may be more appropriate in presence of rare grasses or sedges – does not harm these species since it is more selective than Roundup (Glyphosate)

Environmental considerations

- Buffer from water – City of Toronto Pesticide By-law guideline is 5 metre buffer from water; may be able to use control methods for woody species close to water such as girdling or EZJect herbicide capsules
- Methods chosen to minimize runoff/drift – wicking (wiping or painting applications) vs. spraying where possible

- City of Toronto Public Health guidelines – 15 metre buffer from playgrounds – use alternative methods in these buffer zones

Appendix 5: Select Recommendations on Invasive Species Removal

The following is a list of the most current prescriptive methods of control for a select number of invasive plant species. The recommendations are a combination of methods supplied by Tove Christensen and Silvia Strobl of the MNR, the City of Toronto Parks, Forestry and Recreation department (Cara Webster pers. comm.) and CVC. Other sources used are listed throughout the text. This list will be refined over time as new information becomes available. Species are organized by Upland Shrubs, Upland Flora, Wetland Flora and the appendix concludes with Trees.

Choice of methods may vary depending on a number of criteria, e.g. whether you are opting for non-chemical (pesticide) methods, the size and intensity of the infestation you are dealing with, and whether there are non-target plants in the vicinity that you must preserve, adjacency of water or public safety concerns. The tables below attempt to provide some guidance in this regard. Note, when using pesticides always be aware of and respect current regulations and legislation.

Infestation Level definitions:

Light	A patch or patches of plants that is small. Isolated clusters of plants can be easily counted or distinguished across an area of habitat. Patches generally do not exceed more than 5 metres in diameter and are remote from other patches of the invasive plant.
Moderate	Isolated small patches are beginning to blend into each other, but are not yet one cohesive 'infestation'. Patches can be anywhere from 5 metres to 50 metres (e.g. the length of two tennis courts placed end to end) in diameter and may be associated with other nodes of infestation. The plants in question are not yet a part of the dominant community form; whether in the ground, shrub, or canopy layer.
Heavy	The plant species in question are almost consistently found in abundance across the habitat. The plant species forms a dominant or co dominant component of the habitat either in the ground, shrub or canopy layer.

Upland Shrubs

Autumn Olive

- See notes for Buckthorn and Honeysuckles

Other notes: Hand wrenching not recommended as this shrub will heavily sucker from un-removed roots fragments.

Buckthorns, Common and Glossy (Rhamnus cathartica, R. frangula)

Habitat

- Open areas, disturbed forest edges, ravines, forests, thickets, wetlands.
- Will germinate in full sun or shade.
- Shade tolerant under forest canopy.
- Needs light to be released into canopy.

Reproduction and Dispersal

- Prolific seed production, seed dispersed by birds.
- Produces seed at very young age.
- Root suckers, resprouts vigorously from cut stumps.
- Forms a persistent seed bank. Seed can remain viable for 2-3 years (Kaufman et al., 2007).

Recommended Method of Control

- 4-5 years of control can be required to control seedbank.
- Burning effective if repeated over several years.

Infestation level	Method/Management
Light (pioneer)	<p>Non-herbicide</p> <p><i>Hand wrenching if shrubs are still small and soil disturbance can be minimized as this may bring the seed bank to the surface. Girdling alone not effective.</i></p>
Light to heavy and large areas	<p>Chemical</p> <p><i>It is suggested that an over-the-counter product such as EcoSense or EcoClear (A mixture of horticultural vinegar and citrus oils) could be effective at smaller scales. The stump is cut about 2 or 3 inches above the ground and then mashed up with an axe. Stump is then thoroughly soaked with the solution. An early summer application followed by a second application (stump must be re-wounded again) 3 or 4 weeks later can be highly effective.</i></p> <p><i>Basal bark application of 30% Garlon in an oil carrier is the</i></p>

	<i>most effective. Coat a 5cm or so band on bark totally around each stem, or use a 5% foliar spray in late summer, early fall. As a less expensive but also slightly less effective alternative, apply 100% Roundup-Weathermax (WM) with a paint brush after peak flowering (May-July) to cut/girdled stems. Both methods will require follow-up treatments as no method is 100% effective</i>
--	---

Other notes: Suckers resprout vigorously after cutting. Buckthorn leaf litter increases the soil nitrogen content, which creates conditions favourable for buckthorn growth and which may harm native plants adapted to original soil conditions (Kaufman et al., 2007).

Honeysuckles (Non-native) (Lonicera tartarica, L. mackii, L. morrowii, L. bella)

Habitat

- *Disturbed successional communities, wetlands, woodland edges, woodlands.*
- *Moderately shade tolerant, canopy gaps.*

Reproduction and Dispersal

- *Prolific seed production berries highly attractive to birds, which disseminate seeds widely across the landscape.*
- *Sprouting occurs in established populations.*

Recommended Method of Control

- *Burning effective repeated over several years.*

Infestation level	Method/Management
Light to moderate	Non-herbicide <i>Hand wrenching if shrubs are still small and soil disturbance can be minimized. Repeated yearly cutting to ground level in shaded forest can result in high mortality.</i>
Light to heavy	Chemical <i>Girdling/cutting to ground and application of 100% Roundup-Weathermax (WM) with paint brush (will require follow-up treatments to control resprouting). Basal bark application of 30% Garlon in an oil carrier is also very effective if done in early or late spring. Later season applications of Garlon have mixed success</i>

Other notes: Recent studies have shown that some honeysuckles can have allelopathic effects similar to those of garlic mustard (Dorning et al., 2007)

Upland Flora

Canada thistle (Cirsium arvense)

Habitat

- Cultivated fields, pastures, roadsides, disturbed sites, forest openings, shorelines, savannahs, prairies.
- Grows best in open, disturbed sunny sites on well-drained, deep moist loamy clay soils.

Reproduction and Dispersal

- Reproduces primarily by vegetative growth of root system.
- Vertical roots can grow as deep as 6.8 m, horizontal roots can spread as much as 6 m in one season, patches can spread 1-2 m/year. Readily propagates from stem and root fragments.
- Produces seed, almost exclusively insect pollinated.

Recommended Method of Control

- Best strategy is to establish trees and shade this species out.
- Late spring burning can be highly effective, although it may be necessary to continue for several years.
- Stem weevil, bud weevil and stem gall fly are commercially available biological controls.

Infestation level	Method/Management
Light to heavy	Non-herbicide <i>Deep root system makes hand pulling difficult. Repeated mowing, just as flowers are about to open continued over several years can be effective.</i> Chemical <i>Spot application with Glyphosate or with selective herbicide Clopyralid, or Metsulfuron. Spraying at flowering time (mid-June to early July) with Glyphosate can be quite effective.</i>

Dog-strangling Vines (DSV) (or Swallow-worts) (Cynanchum rossicum, C. nigrum)

Habitat

- Fields, hydro corridors, disturbed forest edges, ravines.
- Not tolerant of heavy shade, but is capable of transforming healthy forest over time into more open woodlands.

Reproduction and Dispersal

- Prolific seed production, seed wind-dispersed over long-distances.
- Able to regenerate from root crown pieces.

Recommended Method of Control

- Burning ineffective and can encourage populations.

Infestation level	Method/Management
Light	Non- herbicide <i>Can be controlled by removing plants, including root systems. Only effective in loose soils when plants are still</i>

	<p><i>young. Solarisation for up to 2 years an option in small monoculture patches.</i></p> <p>Chemical <i>Wick with glove (car wash mitt) – spray 22% Roundup-WM (mixed with dye) – carefully wipe onto leaves to avoid damage to other plants; 2 treatments per season, follow-up required.</i></p>
Heavy infestations in isolated colonies or woodlot edges	<p>Non-herbicide <i>Solarisation for up to 2 years, followed by replanting of native aggressive species. Mowing and cutting is ineffective to reduce biomass and contain population.</i></p> <p>Chemical <i>Spray with 3-5% Roundup-WM, applied by backpack sprayer at onset of flowering; minimum 2 treatments per season for 2-3 years. Second treatment 2 to 3 weeks later. Garlon and Arsenal also effective.</i></p>
Heavy infestations in linked corridors	<p>Chemical <i>Pesticide application cannot be justified on this basis – too much labour & herbicide product would be required – not sustainable; possible strategy - introducing competitive vegetation in gradual phases over time and cutting DSV manually to allow vegetation to establish & eventually shade out DSV.</i></p>

Other notes: Some recent information has shown that DSV treated in shaded areas with glyphosphate does not respond well. May need to consider alternatives or higher concentrations than those listed above.

Garlic Mustard (*Alliaria petiolata*)

Habitat

- River floodplains, forests, roadsides, wooded edges and forest openings.
- Tolerates full sun to full shade, prefers partial canopy.
- One of a few non-native herbs that dominate the understory of forested areas.

Reproduction and Dispersal

- Biennial, a rosette of leaves formed during first half of a two-year cycle.
- In second spring, rosettes develop rapidly into mature plants that flower, produce seed and die by late June.
- A single plant can produce thousands of seeds that scatter as much as several meters from the parent plant.
- Long-distance dispersal is most likely aided by humans and wildlife (e.g., deer).
- Spreads rapidly, can displace native plants within 10 years of becoming established.

Recommended Method of Control

- 2-5 years of treatments will be necessary to deplete seed banks.
- Burning stimulates germination of stored seeds and seedling growth, and must be conducted annually for 3 to 5 years to achieve effective control.
- Four beetles are currently being investigated as biocontrols, may be available within 5 or 6 years.

Infestation level	Method/ Management
Light	<p>Non-herbicide</p> <p><i>Pull out plants at time of flowering prior to seed pod development (early May); Pulling may not be feasible on erosion-prone sites. Soils disturbance must be minimized. In long established populations, pulling may simply unearth buried seeds. Pulling can only be effective if site can be revisited a number of times a year over an extended number of years sufficient to exhaust the seed bank</i></p>
Moderate-heavy in large patches/ woodlot edges etc. ; monocultures	<p>Non-herbicide</p> <p><i>Cutting with brushcutters or manually at time of flowering is effective only if repeat cutting performed 2-4 weeks later; plants have to be cut as close to base as possible otherwise they will resprout. Must repeat over several years</i></p> <p><i>Solarisation- placement of tarp/plastic over select areas.</i></p> <p><i>Replanting with aggressive native species and mulching around plantings to counter disturbance of seed bed. Proceed in a phased approach.</i></p> <p>Chemical</p> <p><i>Glyphosate(Amitrol or Garlon may be more effective) provides effective control of heavy infestations when applied in mid-spring; in the fall and early spring Glyphosate (3% solution) can be applied to rosettes, provided temperature is above 10° C. Where lack of snow cover provides the opportunity spraying three times between November and March can be very effective.</i></p>
Moderate-heavy in large patches in highly significant areas	<p>Chemical</p> <p><i>Due to the widespread distribution of Garlic mustard – control with herbicide is not recommended on a large scale; selective patches could be sprayed with 3% Roundup-WM in late fall while plants are in the rosette stage – should only be considered after other methods have been attempted.</i></p>

Other notes: Garlic mustard has known allelopathic effects that prevent the successful germination and growth of native species. Consider this in restoration.

Giant hogweed (Heracleum mantegazzianum)

Habitat

- Commonly found along riverbanks, streams and wet places with soil deep enough for tap root development
- Germination of seeds requires moisture

- *Giant Hogweed thrives on a variety of sites and can tolerate well drained and saturated sites with silty and sandy soils*

Reproduction and Dispersal

- *One plant can produce between 27 000-50 000 seeds*
- *Seeds dispersal may occur short distances by wind or by watercourse*
- *Seed longevity is about 7 years*
- *In addition to reproduction by seeds individuals can reproduce by bud growth on both crown and stalk*

Recommended Method of Control

- *Management programs should span between 5-7 years to account for the plants capability of storing carbohydrates below ground as well as the plants ability to produce thousands of seeds. Non-herbicide, chemical and biocontrol methods may all be implemented in giant hogweed control.*

Infestation level	Method/Management
Light	<p>Non-Herbicide <i>Pulling may be effective as long as it is ensured that all roots are removed. It is also effective to cut roots 3-4 inches beneath soil surface in early spring. Great care and precaution must be taken to avoid skin contact with clear sap which causes photodermatitis. Follow-up required in mid-season to deal with resprouts and over subsequent years.</i></p> <p><i>Solarisation with a black tarp or plastic can be effective over several years of application.</i></p> <p>Chemical <i>10% Glyphosate (Round-up Ultra 2 or Weathermax) may be applied to plants during budding or in early May-June by cutting the stem and injecting Glyphosphate into the hollow stem. Active ingredients 2,4-D, TBA and MCPA are not effective since they do not kill root stalks.</i></p>
Moderate-Heavy	<p>Non-herbicide <i>Consistent mowing may deplete energy stores in the roots.</i></p> <p>Biocontrol <i>Springtime grazing by domesticated animals may be effective since Giant Hogweed has no known harmful effect on either pigs or cattle. Animals with dark</i></p>

pigmented skin are recommended as some skin irritation has been observed on livestock with lighter pigmented skin.

Chemical

See as above, however cut and inject may not be practical at this level, rather use a foliar/spray application and a reduced concentration of Glyphosphate at 2%. Foliar spray application generally the faster acting and most effective approach.

Goutweed (Aegopodium podagraria)

Habitat

- *Commonly found along roadsides, forest understories and forest edges.*
- *Moist soils and shaded areas are easily invaded by goutweed.*
- *Goutweed is known to carpet the forest ground cover where it out competes native wildflowers (Kaufman et al., 2007).*

Reproduction and Dispersal

- *When shaded goutweed can spread via underground stems. Seeds do not germinate in the shade.*
- *Seeds are generally not long lived and germinate within their first year (Plant Conservation Alliance, 2009).*
- *Populations commonly escape garden boundaries into natural areas.*
- *Seeds have no special adaptation to facilitate dispersal through animals or wind.*

Recommended Method of Control

- *When pulling, care should be taken to ensure that rhizomes have been removed*
- *There is no known biological control in North America (Kaufman et al., 2007).*

<i>Infestation level</i>	<i>Method/Management</i>
<i>Light</i>	<p><u><i>Non-herbicide</i></u> <i>May be pulled with the removal of rhizomes. Pulling may disturb the soil in a way that encourages seed recruitment. Will need to revisit in subsequent years to deal with resprouts.</i></p> <p><u><i>Solarisation</i></u> <i>Patches can be covered with a dark plastic sheet in the spring (Kaufman et al., 2007). Leave plastic down for up to 2 years</i></p>
<i>Moderate-heavy</i>	<p><u><i>Chemical</i></u> <i>Spraying with glyphosate herbicides</i></p>

	<p><i>Contact herbicides are ineffective since goutweed readily recovers from defoliation. Repeated applications will be necessary over the course of one season.</i></p> <p><u><i>Non-herbicide</i></u> <i>May be mowed frequently or mowed and then covered with a heavy mulch (Kaufman et al., 2007).</i></p>
--	---

Other notes: *Seedlings need strong light to establish, in woody areas population growth is mainly due to rhizomes (Plant Conservation Alliance, 2009).*

Kentucky Bluegrass (Poa pratensis)

Habitat

- *Meadows, open woodlands, disturbed sites.*
- *Favours moist conditions, avoids acid soils and heavy shade.*

Reproduction and Dispersal

- *Reproduces by seed and rhizomes.*
- *Germination primarily occurs in early spring, but can also occur in early autumn if soil moisture is adequate.*
- *Readily expands population base vegetatively and aggressively; sod-forming.*

Recommended Method of Control

- *Spring burning is the most widely used tool to control cool season grasses. However, it may be necessary to burn annually for several years. Burning most likely to be effective at "boot" stage, when flowering head still enclosed in sheath.*

Infestation level	Method/Management
Light to heavy	<p>Non-herbicide <i>Difficult to eradicate with non chemical controls. Small patches can be hand grubbed, making sure all roots are removed.</i></p> <p>Chemical <i>Glyphosate has been effectively used to shift dominance from non-native to native grasses. Apply in early spring while native species are dormant.</i></p>

Periwinkle (Vinca minor)

Habitat

- *Rich moist soils*
- *Does not tolerate full sunlight, is shade tolerant and often found in open forests (Kaufman et al., 2007).*

Reproduction and Dispersal

- *Underground runners and rootlets that form at leaf nodes allow periwinkle to quickly spread (Kaufman et al., 2007).*
- *Periwinkle produces seed but primarily spreads through runners.*

Recommended Method of Control

It has been found that the effectiveness of glyphosate has been compromised due to the plants waxy leaves. There is no known biocontrol method for periwinkle control.

Infestation level	Method/Management
Light	Non-herbicide <i>If pulled by hand ensure that root fragments are completely removed. Since periwinkle hardly spreads through seeds, recruitment of new seeds through pulling is not an issue (Kaufman et al., 2007).</i>
Moderate-Heavy	Chemical <i>After cutting, plants may be sprayed with a 3% solution of Roundup. Cutting allows greater level of herbicide uptake.</i> <i>Triclopyr has been found to be less effective than glyphosate.</i> <i>Herbicides containing 2,3,6-TBA may be applied in spring and need to be washed into soil where it can be take up by roots. 30lb/acre of 2,3,6-TBA should be used.</i> <i>Goal, a herbicide that contains the active ingredient oxyfluren may be effective</i>

Other notes: No biological controls are known. Periwinkle is a very robust plant and many of the herbicides that are used to control it may have impacts on surrounding native plants.

Wetland Flora

Himalayan Balsam (Impatiens glandulifera)

Habitat

- *Moist riverbanks, damp woods.*

Reproduction and Dispersal

- *Annual, single plant can produce up to 800 seeds, which are explosively released several metres from adult plant.*

- *Seeds can survive long periods in water, and can float downstream to invade new areas.*

Recommended Method of Control

Infestation level	Method/Management
Light to heavy and small/large patches	<p>Non-herbicide <i>Cut once in full flower July to August to deplete seed bank; interplant with trees and shrubs and slowly out shade over time. Repeat in successive years to address resprouts. Solarisation an option in small patches.</i></p> <p>Chemical <i>Foliar treatment with 2-3% Glyphosate.</i></p>

Japanese Knotweed (*Polygonum cuspidatum*)

Habitat

- *Damp to dry soils, along streams and rivers, in low-lying areas, waste places, old homesteads.*
- *Found primarily in moist, unshaded habitats.*
- *Does not appear to invade forest understories.*

Reproduction and Dispersal

- *In North America, seeds do not appear to be a significant mode of reproduction.*
- *Mainly reproduce through extensive rhizomes that reach 15-20 m in length.*
- *Rhizome fragments are washed downstream or transported in fill.*
- *Rhizomes can regenerate from small fragments and when buried up to 1 m deep.*

Recommended Method of Control

Infestation level	Method/Management
Light to moderate small patches	<p>Non-herbicide <i>Cutting 1-2 times over season for several years and grubbing small resprouts while making sure all rhizome fragments are removed. Remove material from site. Solarisation can also be used, be aware that tarp must extend at east 3 or 4 metres beyond outer boundary to prevent rhizomes escaping under the tarp. Leave in place 2 years.</i></p>
Light to heavy and small/large patches	<p>Chemical <i>Cut 1-2 times over season; spray resprout in early fall and following spring with 1.34% Roundup-WM. Will need to treat in</i></p>

	<p><i>subsequent years.</i></p> <p><i>Stem injection can also be successful-Use 5% solution of Roundup Pro, 5mL per plant. Inject into stem/petiole of basal leaves or between the 1st and 2nd nodes of the stem. Not 100% effective, so follow up will be needed. Monitor area for several years after treatment</i></p>
Patches along water edges within MOE buffer distance	<p>Non-herbicide</p> <p><i>Cut 3 times over field season; interplant with aggressive native species including shrub willows etc.</i></p>

Other notes: *Recent studies have shown that if treated and top killed, the rhizomes can persist for up to 2 years before resprouting. This stresses the need for monitoring and long term control (Holmen et al., 2007).*

Purple Loosestrife (Lythrum salicaria)

Habitat

- *Wetlands, stream and river banks, lakeshores, ditches and other disturbed wet areas.*

Reproduction and Dispersal

- *Perennial, single plant can produce hundreds of thousands of seeds, seeds have high viability; rapid build up of seedlings possible.*
- *Dispersal mainly by wind, but seeds also transported on feet of waterfowl and other wetland animals, also dispersed by water currents.*
- *Can spread vegetatively by resprouting from cut stems and regeneration from pieces of root stock.*

Recommended Method of Control

- *University of Guelph studied and piloted the use of several European beetles as a control agent. Results were successful. Beetles can be purchased as a very effective control agent when dealing with large populations.*

Infestation level	Method/Management
Light	<p>Non-herbicide</p> <p><i>Can be removed by hand; entire rootstock must be pulled out. Commercially available (Galerucella spp.) beetles.</i></p>
Light to heavy	<p>Chemical</p> <p><i>Most commonly controlled with Glyphosate, (check re: brand approval for use over water); treatment should occur after peak blooming period (July-August).</i></p>

Giant Reed (Phragmites australis)

Habitat

- *Readily invades open wetlands, especially those with disturbance.*

Reproduction and Dispersal

- Produces wind born seeds, but moves most rapidly through a stoloniferous root system.

Recommended Method of Control

Infestation level	Method/Management
Light	Non-herbicide <i>Hand wrenching or cutting at flowering (late July) below lowest leaf (leaving 6" stump). Will need to repeat over several years.</i>
Moderate to heavy	Non-herbicide <i>Solarisation over 1 year when in monocultures.</i> <i>*Mowing 2 times a season with follow up spot spraying is the best integrated approach.</i> Chemical <i>Apply 2% Glyphosate in late summer when Phragmites is in full bloom. Research suggests an earlier June application may be better than later season applications. Arsenal (Imazapyr) at similar concentrations more effective than Glyphosphate. Repeated treatments will likely be necessary. After 2 or 3 weeks following application of Glyphosate, cut or mow down the stalks to stimulate the emergence and growth of other plants previously suppressed. A foliar spray can be applied or injected with a handheld or backpack sprayer with a nozzle into the cut stem. The latter option works best overall and when working in areas with non-target native species in the area, but can be more time consuming.</i>

Other notes: Has known allelopathic effects on other wetland plants

Reed Canary Grass (*Phalaris arundinacea*)

- See notes for Giant Reed.

Other notes: Post treatment restoration recommendations – some success in the United States has been had with live staking areas treated by Glyphosate with aggressive native willow species 2 to 3 feet apart e.g. *Salix exigua*, *S. discolor*. This method reduced reed canary grass biomass by 68 to 56% respectively (Kim et al. 2007).

Rough manna grass (*Glyceria maxima*)

Habitat

- Nutrient rich, moist soils.
- *Glyceria maxima* is a wetland plant and does best along river banks and in fresh water (Global Invasive Species Database, 2009).

Reproduction and Dispersal

- Flowing water is the main seed dispersal method but livestock also play a lesser role.
- Dense populations use vegetative reproduction to spread into adjacent areas.
- Seed production occurs in summer and autumn.
- Most seeds tend to germinate immediately but some remain dormant for a few years (Global Invasive Species Database, 2009).

Recommended Method of Control

- Since *Glyceria maxima* grows in and around water herbicides should be used with precaution to ensure that impact on non target plants and organisms is minimal. Different surfactants in many different herbicide products have been shown to cause damage to fish and amphibians.

<i>Infestation Level</i>	<i>Method/Management</i>
<i>Light</i>	<p><u>Non-herbicide</u> If removal is done by hand ensure that the roots are removed to avoid resprouting. Revisit to deal with resprouts.</p>
<i>Moderate-Heavy</i>	<p><u>Solarisation</u> Dark plastic coatings may be placed over patches. Leave in place for 2 seasons.</p> <p><u>Non-herbicide</u> Cutting may be done in the fall to deplete carbohydrate stores utilized in spring growth. Cut areas may also be flooded to discourage regrowth (Nature Conservancy, 2009b)</p> <p>Herbicides like Round up Biactive and Weedmaster 360 may be used with care (Global Invasive Species Database, 2009).</p>

Other notes: Grazing is not encouraged since young shoots have high concentrations of cyanide (Nature Conservancy, 2009b). Most methods call for immediate revegetation with native species upon removal of *glyceria maxima*.

Trees

Siberian Elm (Ulmus pumila)

Habitat

- *Disturbed woods, roadsides, pastures, alongside streams.*
- *Tolerant of poor soils and low moisture.*

Reproduction and Dispersal

- *Produces 1-seeded samaras that are wind dispersed.*
- *Seeds germinate readily and seedlings grow rapidly, forms thickets of hundreds of seedlings in bare ground.*

Recommended Method of Control

Infestation level	Method/Management
Light to heavy	Non-herbicide <i>Small seedling can be removed by hand or with weed wrench. Girdling in late spring to mid summer effective if follow up occurs to deal with resprouting.</i> Chemical <i>Can also be controlled using cut stem applications of 20% Glyphosate in the fall.</i>

Manitoba Maple (Acer negundo)

Habitat

- *Disturbed woods (more often floodplains), roadsides, pastures.*
- *Tolerant of poor soils.*

Reproduction and Dispersal

- *Produces winged seeds that are wind dispersed.*
- *Seeds germinate readily and seedlings grow rapidly, forming monoculture woodlands.*

Recommended Method of Control

Infestation level	Method/Management
Light to heavy	Non-herbicide <i>Hand wrenching if trees are still small and soil disturbance can be minimized. Girdling mostly ineffective as it resprouts heavily, follow up over several years needed to deal with resprouts.</i> Chemical <i>Girdling/cutting and application of 100% Roundup-Weathermax (WM) with paint brush (will require follow-up treatments to control resprouting) in fall.</i>

Norway Maple (*Acer platanoides*)

Habitat

- Disturbed forests often associated in areas of development.
- Tolerant of poor soils and forms a dense canopy.

Reproduction and Dispersal

- Produces winged seeds that are wind dispersed.
- Seeds germinate readily and seedlings grow rapidly often replacing native maples as the dominant tree species.

Recommended Method of Control

Infestation level	Method/Management
Light to heavy	<p>Non-herbicide <i>Hand wrenching if trees are still small and soil disturbance can be minimized.</i></p> <p>Chemical <i>Girdling/cutting and application of 100% Roundup-Weathermax (WM) with paint brush (will require follow-up treatments to control resprouting) in fall. Basal bark application of 30% Garlon also effective. With large trees a second application may be needed.</i></p>

Tree-of-Heaven (*Ailanthus altissima*)

- See notes for Norway maple.

Other notes: Post treatment restoration recommendations- studies have shown that in low light conditions shade tolerant species such as red maple can out-compete this species. Similarly in open conditions staghorn sumac has proven to out-compete tree-of-heaven (Huebner, 2007). This species is also known for its ability to sucker from root stock. Any method that allows for the cutting of the trunk seems to encourage root suckering. The City of Toronto is now experimenting with nicking the bark and applying a herbicide through these cuts to kill both the tree and suppress the biological triggers for root suckering.

Efficacy Notes for Basal Bark Treatments

Basal Bark Treatments with **Triclopyr** (Garlon) (Nature Conservancy. 2007). <http://tncweeds.ucdavis.edu/tools/painter.html>. Accessed December 18, 2007). Should not be used in temperatures over 80° F as chemical will volatilize and drift.

Stem diameter	Species	Treatment
<15 mm	Buckthorn, Norway maple, tree-of heaven	Paint 10 inches of stem, one side
15mm-50mm		Paint 10 inches of stem, both sides

>50 mm		Paint full circumference of stem
Any	Thicker barked species: Honeysuckle, Multiflora rose, Barberry, Oriental bittersweet	Cut stump and paint

Appendix 6: Sources (Nurseries) for Native Plants

Southern Ontario Native Plant Nurseries

Acorus Restoration Native Plant Nursery
RR#1
Walsingham, Ontario
Contact: Paul Morris or Darleen Degrieck
Phone#: (519) 586-2603
Fax#: (519) 586-2447
email: info@ecologyart.com
website: www.ecologyart.com

The Backyard Ark
158 Grove Street
Guelph, Ontario N1E 2W7
Contact: Leslie Work
Phone#: (519) 823-9882
email: leswork@gto.net

Grand Moraine Growers- Native Plants & Wildflowers
7369 12th Line, RR2
Alma, Ontario N0B 1A0
Contact: Paul Shepherd
Phone#: (519) 638-1101
Fax#: (519) 638-1124
email: pems@sentex.net
website: www.sentex.ca/~pems/

Grow Wild
4735 Durham/ York 30
Claremont, Ontario L1Y 1A3
Contact: Keri Pidgen
Phone#: (705) 738-5496
email: info@grow-wild.com
website: www.grow-wild.com

Jack & Ginger Native Plant Nursery
1 Clevedon St.
Toronto, Ontario
Contact: Grant Baverstock & Shawn Patille
Phone#: 416 990 3973
Fax#: 416 244 1085
email: native_plants@hotmail.com

Nith River Native Plants
4265 Wilmot-Easthope Road
Phone#: (519) 780-1816
website: www.nithrivernativeplants.com

Pterophylla
RR#1
Contact: Mary E. Gartshore & Peter J. Carson
Walsingham, Ontario N0E 1X0
Phone#: (519) 586-3985
email: gartcar@kwic.com

Sweet Grass Gardens
Six Nations of the Grand River
R.R.#6, 470 Sour Springs Road
Hagersville, Ontario
Contact: Ken & Linda Parker
Phone#: 519-445-4828
Fax#: 519-445-4826
email: info@sweetgrassgardens.com
website: www.sweetgrassgardens.com

WILD Canada - Native Plant Nursery & Ecological
Consulting
#75 - 39th Street North
Wasaga Beach, Ontario
Contact: Scott & Wendy Martin
Phone#: 705-429-4936
Fax#: 705-446-0822
email: info@wildcanada.ca
website: www.wildcanada.ca

Wild Ginger Native Plant Nursery
RR#1
Port Hope, Ontario L1A 3V5
Contact: Emony Nicholls
Phone#: 705-740-2276
email: wildgingernpn@yahoo.ca
website: www.wildgingernursery.ca

Native Plant Nurseries
124 Cedarvale Blvd.
Stouffville, Ontario L4A 7X3
Contact: Rob Johnson
Phone#: (905) 642-9048
email: nativeplantnurseries@yahoo.com

Native Plant Source
318 Misty Cres.
Kitchener, Ontario
Contact: Jeff Thompson
Phone#: (519) 748-2298
Fax#: (519) 748-2788
email: info@nativeplantsource.com
website: www.nativeplantsource.com

Wildflower Farm
10195 Hwy 12 West
RR# 2
Coldwater, Ontario
Contact: Paul Jenkins
Phone#: 1 866 GRO WILD
email: info@wildflowerfarm.com
website: www.wildflowerfarm.com

WildThings Plant Farm
RR3
Clifford, Ontario
Contact: John Harris
Phone#: (519) 338-3228
Fax#: (519) 338-3228
email: wild.things@sympatico.ca
website: www.wild-things.ca

Appendix 6: Partner Organizations in Invasive Species Management

City of Mississauga

Gavin Longmuir, Forestry Manger
t. (905) 615-3200, ext 5148
f. (905) 615-3098
e. gavin.longmuir@mississauga.ca

Halton-North Peel Naturalists

<http://haltonnorthpeelnaturalists.org>

Halton - Peel Woodlands and Wildlife Stewardship

Greg Bales, Stewardship Coordinator
c/o Ministry of Natural Resources, Aurora District
50 Bloomington Road West
Aurora ON L4G3G8
t. (905)713-7410
f. (905)713-7361
e. greg.bales@ontario.ca

Riverwood Conservancy

Douglas Markoff, Director
1447 Burnhamthorpe Road West
Mississauga ON L5C 2S7
t. (905) 279-5878

Ontario Ministry of Natural Resources

Mark Heaton
Area Biologist, Halton/Peel/Toronto - AURORA DISTRICT
50 Bloomington Road West
Aurora ON L4G3G8
t. (905) 713-7406
e. mark.heaton@ontario.ca

Ontario Federation of Anglers and Hunters

Website: <http://www.invadingspecies.com>
t. 1-800-563-7711

Royal Botanical Gardens

Field Botanist & Herbarium Curator or Terrestrial Ecologist
680 Plains Rd. West
Burlington, ON
t. (905) 527-1158
f. (905)577-0375

City of Brampton

Joe Ferreira, Pesticide Specialist

Parks and Community Services

City of Brampton

t. (905) 874-2906

f. (905) 874-2917

e. joe.ferreira@brampton.ca

South Peel Naturalists

<http://www.spnc.ca>

Appendix 7: Rattray Marsh Invasive Plant Species Management Plan

See CVC Website to download this document
www.creditvalleyca.ca/invasives