

Invasive Species Strategy

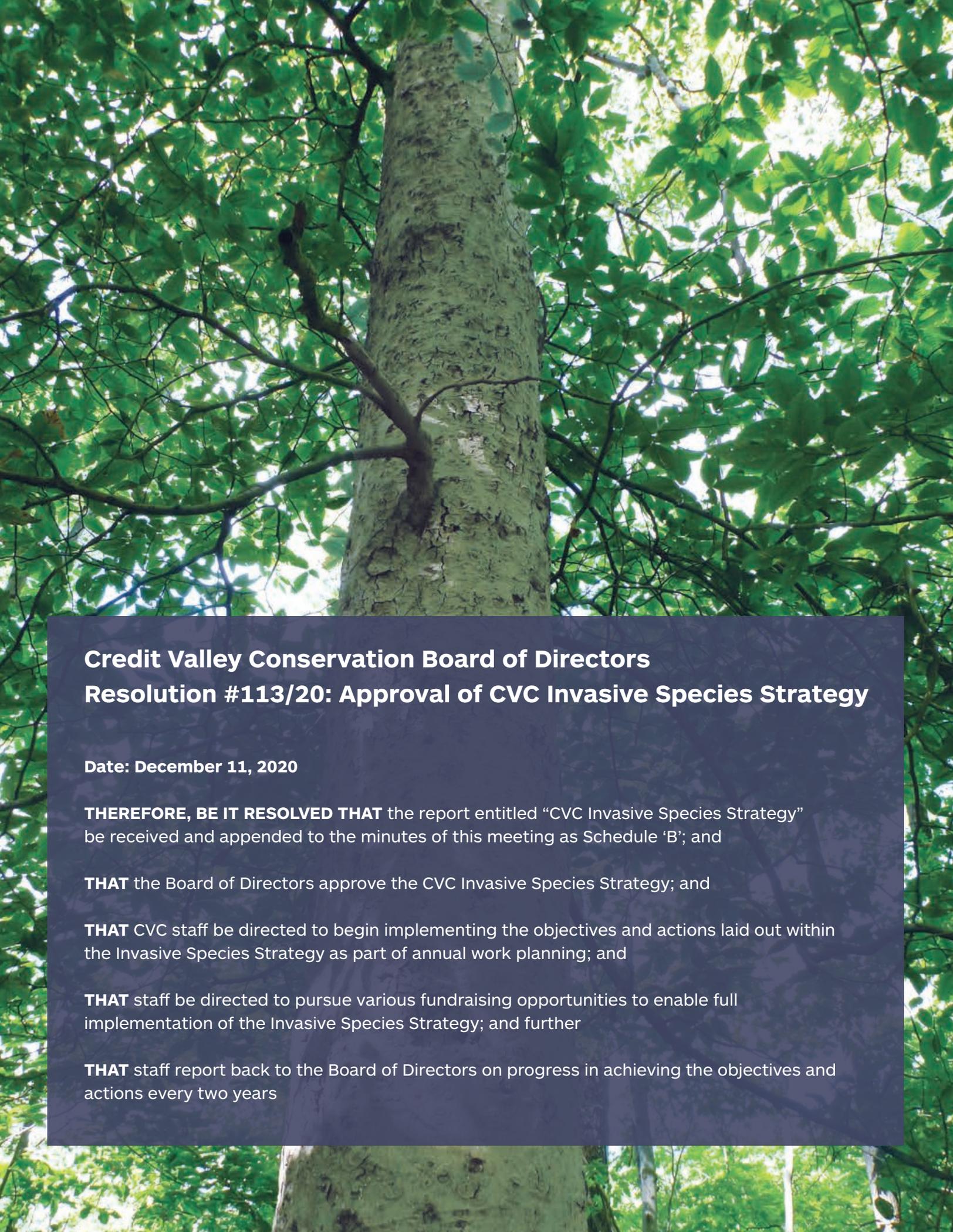
2020-2030



December 2020



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Credit Valley Conservation Board of Directors Resolution #113/20: Approval of CVC Invasive Species Strategy

Date: December 11, 2020

THEREFORE, BE IT RESOLVED THAT the report entitled “CVC Invasive Species Strategy” be received and appended to the minutes of this meeting as Schedule ‘B’; and

THAT the Board of Directors approve the CVC Invasive Species Strategy; and

THAT CVC staff be directed to begin implementing the objectives and actions laid out within the Invasive Species Strategy as part of annual work planning; and

THAT staff be directed to pursue various fundraising opportunities to enable full implementation of the Invasive Species Strategy; and further

THAT staff report back to the Board of Directors on progress in achieving the objectives and actions every two years

Acknowledgements

Credit Valley Conservation (CVC) acknowledges that the land on which we gather, and the entire Credit River Watershed, is part of the Treaty Lands and Territory of the Mississaugas of the Credit First Nation. The Credit River Watershed is also part of the traditional territory of the Huron-Wendat and Haudenosaunee, and home to many First Nations, Métis, and Inuit Peoples today. Treaties made with Indigenous Peoples are enduring and include responsibilities for both parties. We affirm that this land and water is our common source of life and we must all share responsibility for its care and stewardship for now and future generations.

We would like to thank the Mississaugas of the Credit First Nation for their support during the Invasive Species Strategy (ISS) process.

CVC would also like to acknowledge the assistance of all those who have worked and commented on the Invasive Species Strategy (ISS):

- The many stakeholders who gave their time and energy to participate in workshops and review the draft technical report.
- The contributions of North-South Environmental Inc. and the sub-consultant Urban Forest Innovations Inc. for their work writing the Background Report, helping to structure and revise the document as it went through various draft stages, and working with CVC staff to host internal and external workshops.

The management of invasive species supports CVC's mission. This strategy reflects efforts from CVC staff from all departments. Many CVC staff contributed to the ISS, either by writing sections for early drafts, providing statistics, figures, tables, and maps, or through review and feedback. In particular, we would like to acknowledge the work of the ISS's Steering Committee: Dawn Renfrew and Jon Clayton, as well the input from Bryana McLaughlin, Joe Pearson, Jacquelyn Kiers and Laura Timms. Lastly, the direction and feedback provided from Rod Krick, Kate Hayes, Tim Mereu and Deborah Martin-Downs.

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Program Manager, Terrestrial Restoration, CVC
December 2020

Executive Summary

Invasive species are one of the top threats facing biodiversity and natural systems across the globe. Invasive species are *non-native species that displace native species, dominate ecosystems, and impact ecological integrity and ecosystem function*. Their proliferation decreases biodiversity and can lead to significant environmental, social, and economic impacts. Ontario has the highest number of invasive species of any province or territory in Canada and the Credit River Watershed is no exception. Invasive species coverage in the lower and largely urbanized watershed is more than double that of the upper watershed and is increasing 1.5 times faster. Invasive species spread through a variety of vectors (e.g. wind, water, birds and other wildlife), but 53 per cent of them can be attributed to human activities.

There are currently 184 documented invasive species in the Credit River Watershed. Over the past decade, CVC has recorded that several of the documented invasive species are increasing in abundance or range including European Reed (Phragmites), LDD (formally known as Gypsy Moth), and Round Goby. Most noticeable in recent years was the arrival of the Emerald Ash Borer (EAB) which over a 10-year period has resulted in the death or decline of virtually all ash trees in the watershed.

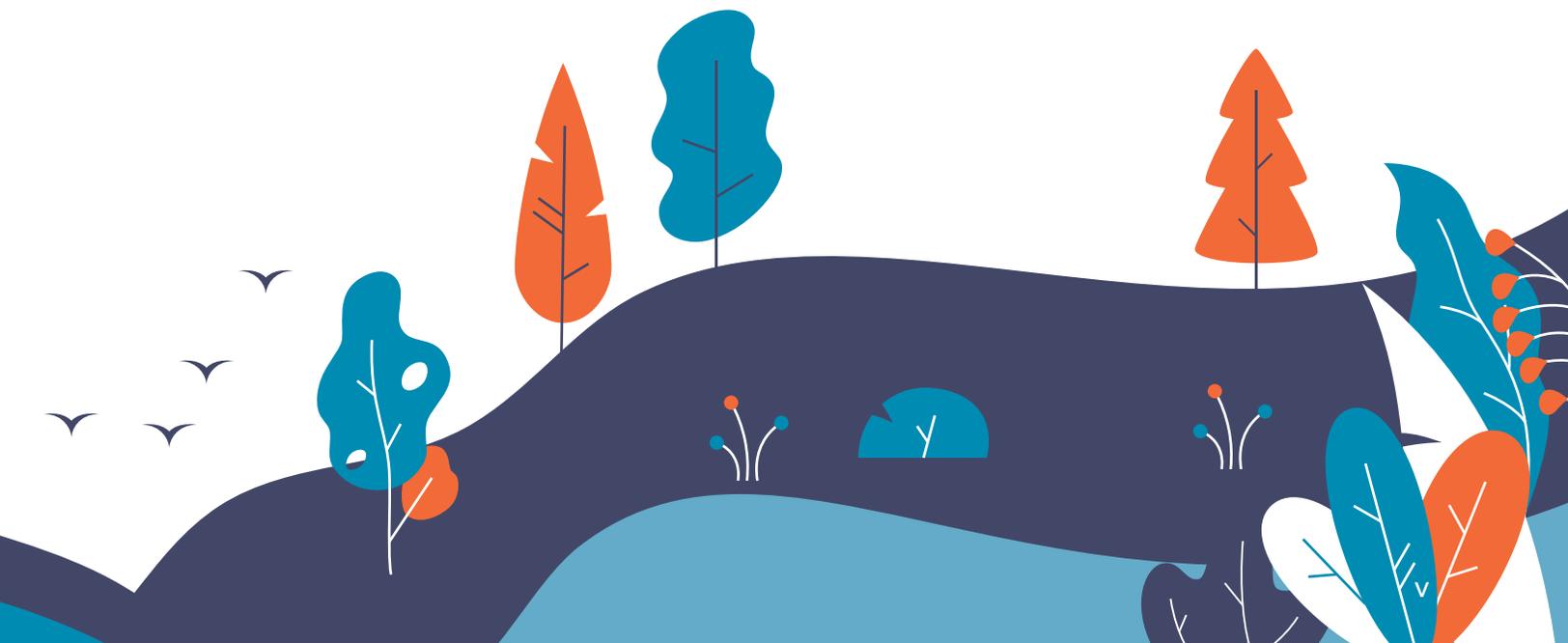
Over 90 per cent of surveyed vegetation communities across the watershed have been found to contain at least one invasive plant species with the potential to dominate the native ecosystem. When scaled down to just CVC properties this increases to over 95 per cent. As such, the health and resilience of almost all vegetation communities in the watershed is either compromised or at high risk of being compromised.





There are 56 additional invasive species that are at risk of being introduced to the watershed. These invasive species are known to have significant economic, health, or environmental impacts elsewhere in Canada or in the United States. Some of these, such as Hemlock Woolly Adelgid (HWA), which has the potential to decimate Eastern Hemlock, is currently less than 100km away and could easily appear in our forests at any time. When considering all current (EAB, LDD, Beech Bark

Disease) and emerging (Oak Wilt, Asian Long-horned Beetle, Beech Leaf Disease, and HWA) forest pests, 51 per cent of our inventoried woodlands within the watershed are vulnerable. Although species that are at risk of arriving are of significant concern, 72 or 39 per cent of invasive species currently found in the watershed are considered immediate management priorities (58 plants, 7 forest pests and 7 aquatic species).





Since the publication of the first Invasive Species Strategy (ISS) in 2009, Credit Valley Conservation (CVC) has emerged as a regional leader in invasive species management. Significant changes have occurred in this time with regard to federal and provincial invasive species policies, distribution of invasive species, science and research pertaining to invasive species management, and the implementation of invasive species management plans by Ontario municipalities and conservation authorities. This updated strategy guides CVC's continued invasive species management activities over the next 10 years. Vascular plants, invasive fish, and invasive forest pests and diseases are identified as actionable groups that CVC may be able to exert some control over, and priority for management will be placed on infestations that have the greatest negative impacts to ecosystems.

CVC controls infestations on properties it owns and/or manages using mechanical, chemical, and biological methods in adherence with current best management practices. Known priority infestations are

being tracked and treated; however, new species are often introduced and climate-assisted range expansion of more southerly species leaves the Credit River Watershed vulnerable to new invasions.

Invasive species do not recognize boundaries between provinces, municipalities or privately owned properties, making invasive species management an issue for all residents of the watershed. This strategy calls for all levels of government, conservation authorities, non-government organizations (NGO), and land managers and owners to be aware of the impacts of invasive species and work together to decrease their spread. Successful management requires input across organizational levels, from high-level policy decisions down to local on-the-ground control efforts. With so many organizations engaging in invasive species management within the Credit River Watershed, there are ample opportunities for partnership and collaboration but there is also danger of duplicating efforts or leaving gaps between programs.

The ISS provides five guiding principles which establish the context within which invasive species management in the Credit River Watershed should be conducted:

- 1** Implement invasive species management practices that respond to the guidance set in Ontario.
- 2** Restore impacted habitats in a manner consistent with CVC restoration practices and guidelines.
- 3** Use a science-based approach to a) develop invasive species priorities and b) guide invasive species management on CVC lands and within the watershed.
- 4** Employ adaptive management to continuously improve invasive species management and restoration of impacted native habitat.
- 5** Align this strategy with existing CVC, municipal, provincial and federal strategies and plans.

To respond to the threat of invasive species over the next decade, the ISS is grouped into the following three broad themes, with seven high level objectives:

- 1** Protect and manage healthy ecosystems
- 2** Connect with local communities, stakeholders and the public
- 3** Ensure public health and safety

For each theme supporting objectives, targeted actions and timelines over which these actions should take place is provided. Some actions are ongoing, such as monitoring and partner engagement, whereas others are distinct tasks to be completed over a given time period.

Theme 1: Protect and manage healthy ecosystems

The first theme identified within the strategy is to protect and manage healthy ecosystems. The suite of objectives and actions within this theme focus on:

- ☀ Determining the status of invasive species in the watershed.
- ☀ Preventing the entry and establishment of new invasive species.
- ☀ Eradicating new infestations before they have a chance to become fully established.
- ☀ Managing existing populations of priority species to prevent them from spreading to other areas in the watershed.

Many of the actions outlined within this theme are already underway and only require regular re-assessment of priorities as new data on the status of invasive species in the watershed becomes available. However, there are some new initiatives outlined that benefit from a more coordinated approach to invasive species management to enable CVC to make the best use of available resources. **Actions to ensure CVC is managing invasive species responsibly include:**

- ☀ Formalization of an integrated pest management framework (process for managing ecosystems which includes prevention, early detection through monitoring, rapid response to new infestations, management of new and existing priority species, and ongoing restoration) to prevent the worst impacts of invasive species using effective, economic, and environmentally sound techniques.



- ☀ Review existing CVC inventory, monitoring, and restoration performance monitoring programs and integrate invasive species monitoring where appropriate within the watershed.
- ☀ Working with partners to formalize an early detection and rapid response program within the watershed to ensure new species do not get established.
- ☀ Prioritization of species (e.g. Dog-strangling Vine) and sites for management through a science-based project decision flowchart and the creation of a project prioritization tool to ensure on the ground management is occurring where it will have the greatest impact.



Theme 2: Connect with local communities, stakeholders and the public

Invasive species spread rapidly once established and move beyond property boundaries; as such, collaboration by CVC with municipal partners, stakeholders and the public is critical to ensuring impacts are minimized throughout the watershed. Public engagement has been a focus of the Invasive Species Management Program (ISMP) over the last 10 years. **Actions to ensure that CVC maximizes its resources going forward through collaboration and engagement include:**

- ☀ Prepare a marketing and communications plan to achieve education and awareness.
- ☀ Collaborate with municipalities, other partners and the public to maximize efforts and impacts.
- ☀ Work with the private contractor industry and partners to develop a training program to increase ecologically sound invasive species management on private and public lands.

Theme 3: Ensure public health and safety

The final theme covered in this strategy is ensuring public health and safety. Safeguarding people, property, and communities from hazards is a priority for CVC, and is also an objective of CVC's Sustainable Forest Management Plan (2020). Aligning with this, the ISS prioritizes management of invasive species occurrences or their impacts that could threaten the health and safety of staff, visitors, and properties' natural and capital assets. **Actions on CVC owned and managed lands include:**

- ☀ Control of invasive species that are a health and/or safety hazard or can impact natural and capital (infrastructure) assets (e.g. Giant Hogweed, Zebra Mussel).
- ☀ Control of invasive species that can indirectly result in the creation of a hazard (e.g. hazard trees caused by EAB).

Existing and future invasive species are a threat to the health of the Credit River Watershed. Without a defined management strategy, the threat and the consequence will only magnify. In response, CVC has prepared a comprehensive invasive species management strategy that will guide our response in the coming years. CVC will continue to focus on maintaining healthy ecosystems, connecting with partners and landowners, and ensuring the health and safety of public and staff. Preventing the introductions of new invasive species and limiting the spread of established invasive species are among the most important and challenging aspects of invasive species management. The ISS identifies key objectives and actions that respond to the challenges facing the Credit River Watershed and charts a path forward to promote long-term ecosystem health and resilience.

Critical actions for future success of the ISS include:

- ☀ Creation of an integrated pest management framework
- ☀ Comprehensive and integrated monitoring program
- ☀ Rapid response plan of action
- ☀ Project prioritization process
- ☀ Management of priority invasive species

Existing funding will be allocated to enable CVC to best achieve of all these key actions. However, fully addressing the scope of the ISS in the long term will require additional funding, either through internal reallocation or through new and supplementary funding opportunities.

Managing invasive species is an objective shared with many of CVC's partners and exploring opportunities for leveraging resources and expertise with both municipalities and NGOs is mutually beneficial. CVC is well positioned to support municipal partners with on-the-ground invasive species management. CVC will also continue to support outreach and education activities to ensure residents are informed and aware of the impact invasive species have on the watershed.

Achieving the objectives of the ISS will not happen overnight. Implementing the actions and acquiring the resources to do so will be an ongoing and challenging pursuit. CVC's continuing commitment to managing invasive species goes beyond the 10 year term of this strategy. By prioritizing and implementing the



ISS over time, we are taking the necessary steps towards a healthier watershed, one that supports native species biodiversity and is

better prepared for climate change. The reward will be a thriving environment that protects, connects and sustains us.

LIST OF ACRONYMS USED IN REPORT

ALHB	Asian Long-horned Beetle
BMPs	Best Management Practices
CFIA	Canadian Food Inspection Agency
CVC	Credit Valley Conservation
DFO	Fisheries and Oceans Canada
DSV	Dog-strangling Vine
ECCC	Environment and Climate Change Canada
EDDMapS	Early Detection and Distribution Mapping System
EDRR	Early Detection and Rapid Response
EAB	Emerald Ash Borer
HWA	Hemlock Woolly Adelgid
IAS Collaborative	Invasive Alien Species Collaborative
IPM	Integrated Pest Management
ISAP	Invading Species Awareness Program
ISC	Invasive Species Centre
ISMP	Invasive Species Management Program
ISS	Invasive Species Strategy
IWMP	Integrated Watershed Management Program
NGOs	Non-governmental Organizations
OFAH	Ontario Federation of Anglers and Hunters
OIPC	Ontario Invasive Plant Council
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
OMNRF	Ontario Ministry of Natural Resources and Forestry
P.O.W.E.R.	Protect Our Water and Environmental Resources
SOR	Statutory Order and Regulation
UN	United Nations

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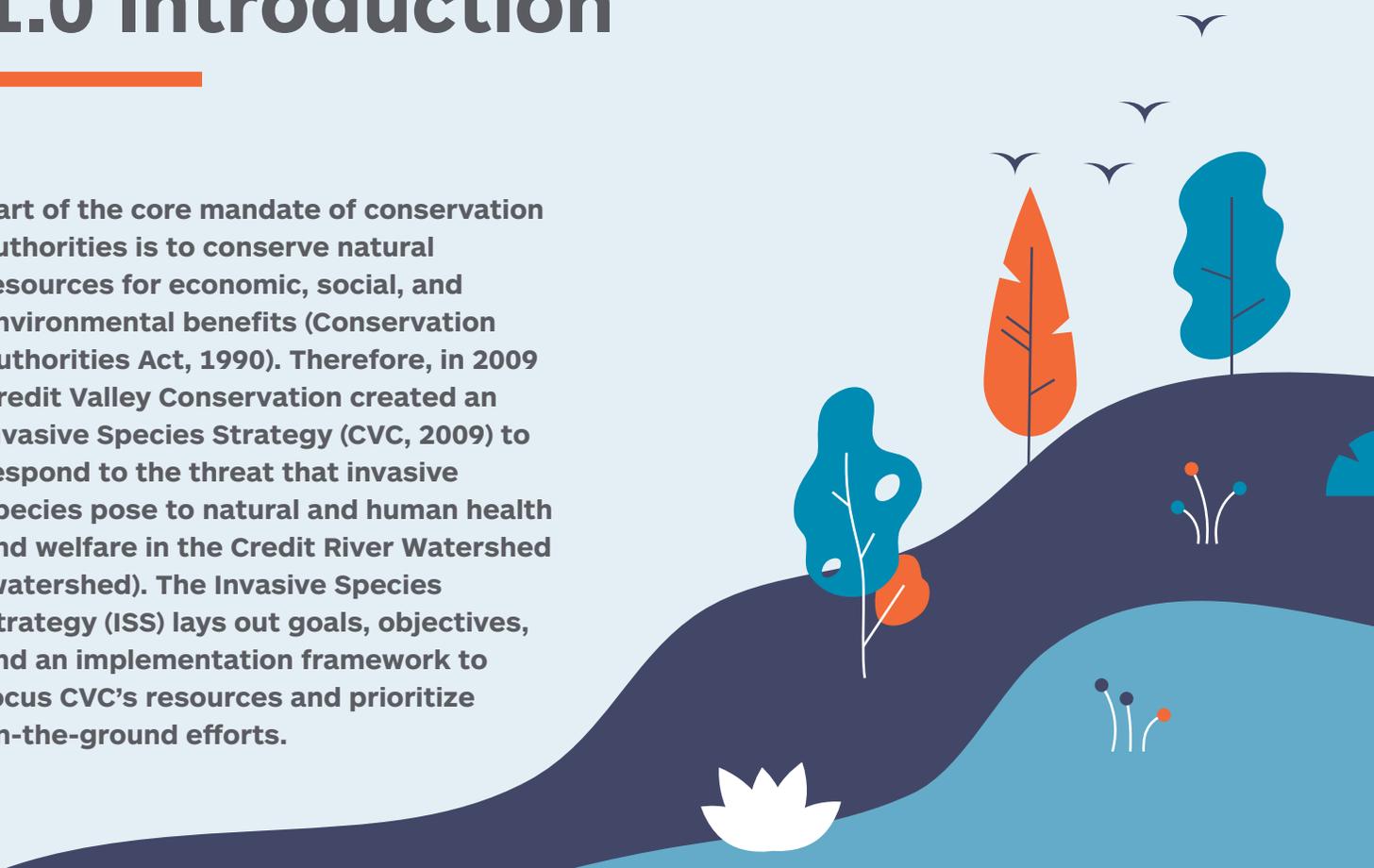
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1.0 Introduction

Part of the core mandate of conservation authorities is to conserve natural resources for economic, social, and environmental benefits (Conservation Authorities Act, 1990). Therefore, in 2009 Credit Valley Conservation created an Invasive Species Strategy (CVC, 2009) to respond to the threat that invasive species pose to natural and human health and welfare in the Credit River Watershed (watershed). The Invasive Species Strategy (ISS) lays out goals, objectives, and an implementation framework to focus CVC's resources and prioritize on-the-ground efforts.



Implemented 196 invasive species control projects managing 940 ha of natural areas



Hosted over 100 volunteer events and workdays



Planted over 8,100 trees and shrubs to restore natural habitat



From 2009-2019 the Invasive Species Management Program has:

Completed early detection monitoring at 197 sites across the watershed



Delivered 37 workshops and presentations



Removed over 10,000 hazard ash trees to keep our lands safe for staff and visitors



Figure 1. Invasive Species Management Program accomplishments (2009-2019).



CVC is now recognized as a regional leader in invasive species management and has been actively controlling invasive species, building partnerships, conducting research, and monitoring since at least the early 1990s. Following the completion of the first ISS and the establishment of CVC's Invasive Species Management Program (ISMP), CVC's invasive species management projects and funding have expanded substantially, allowing for considerable work to be accomplished including control projects, early detection monitoring, volunteer events and workdays, workshops and presentations, restoration plantings, and hazard ash tree removals (**Figure 1**).

The past decade has also witnessed significant changes to federal and provincial invasive species policies, in the distribution of invasive species, advances in the science and research pertaining to invasive species management, and in the development and implementation of invasive species management plans by Ontario municipalities and conservation authorities.

In response, CVC's ISS has now been updated to guide invasive species management in the Credit River Watershed until approximately 2030. The updated ISS will ensure that CVC continues to take a coordinated and pragmatic approach to invasive species management and contributes to invasive species management objectives at the regional, provincial, federal and global scales.



1.1 Purpose and Scope of the Invasive Species Strategy

CVC's 2009 ISS was one of the first such strategies created by a conservation authority or municipality in Ontario. Since then, a substantial amount of work has been done by CVC to manage invasive species on CVC lands, private lands, and public lands in the watershed. Invasive species management activities completed by CVC since 2009 are summarized in **Appendix A**, and the teams involved in implementing the ISS are summarized in **Appendix B**.

Since 2009, there have been significant changes in the science and approaches to invasive species management, including:

- ☀ Implementation of invasive species strategies and management plans by municipalities, other conservation authorities, and non-government organizations (NGOs).
- ☀ Enactment of invasive species legislation and implementation of new regulations by the federal and provincial governments.

- ☀ Changes in the distributions of invasive species both locally and globally associated with various dispersal pathways as a result of climate change and other environmental change.
- ☀ Extensive impacts and related costs of Emerald Ash Borer (*Agrilus planipennis* - EAB) in the Credit River Watershed.
- ☀ Advances in the scientific understanding of invasive species biology and management.

To reflect these changes, CVC initiated the ISS update in 2018, consulting with internal staff and external partners at key points in the process. The updated ISS is intended to contribute to CVC land management, planning, and restoration programs over the next ten years through the prioritization of invasive species and sites for management. It is also intended to support watershed municipalities, other partner agencies, NGOs, and individuals involved in land management and conservation. Finally, it is meant to encourage



action, foster commitment of resources and strengthen on-going partnerships.

Furthermore, between 2017 and 2019 the Invasive Species Centre (ISC) reached out to municipalities and conservation authorities in Ontario to find out the annual expenditures they are incurring related to invasive species management. This information was released in a report stating that the estimated total annual expenditure on invasive species management by municipalities and conservation authorities is \$50.8 million (Vyn, 2019). Therefore, the need for CVC to have an up-to-date and comprehensive strategy providing priorities for invasive species management is not only imperative from an ecological perspective, but a socio-economic one as well. As the leading conservation organization within the watershed CVC needs to continue to lead in invasive species management including prevention, early detection, and long-term control.

To ensure that intent and scope remain relevant, this ISS will be reviewed in 2025 through a mid-term report created to address any major developments. This ISS is intended to be adaptable to new management needs and changing environmental conditions, especially in the face of climate change and its implications for invasive species management.

Actions in this strategy are intended to be implemented as a part of CVC's day-to-day operations and management of CVC lands, as well as provide support, education and outreach to watershed partners and landowners. They consider the direct and indirect health and safety impacts of invasive species on staff and conservation area users. This document may also serve as a model to other private and public land holders of what they can do to address the spread of invasive species. To that end, CVC will encourage uptake and/or integration of this ISS with partners.



1.2 Plan Development and Engagement

High-level direction for all of CVC's programs is provided by its three-year strategic plan – *Our Future Taking Shape: Strategic Plan 2020-2022*. **While many directions and outcomes within the strategic plan link to the delivery of the ISS, the following are most pertinent:**

- ☀️ **Goal One, Direction One:** Study and monitor our environment ensuring we have the right information to base our decisions and management actions on to maintain a healthy natural heritage system and address climate change, land use change and invasive species.
- ☀️ **Goal One, Outcome Two:** A comprehensive understanding of watershed stressors, including climate change, land use change and invasive species, that inform strategies designed to address protection, mitigation, restoration and adaptation.

- ☀️ **Goal Three, Direction Seven:** Implement priority actions from the Invasive Species Strategy focusing on surveillance and response to emerging threats on our lands and adjacent lands where new invasions can be controlled, including Forks of the Credit and Jim Tovey Lakeview Conservation Area.

- ☀️ **Goal Three, Direction Eight:** Manage, enhance or restore natural features in existing and new conservation lands, including projects at Pinchin Pit, Terra Cotta and Silver Creek.

The ISS harmonizes with other CVC plans and strategies such as the Sustainable Forest Management Plan (CVC, 2020a - SFMP), the Credit River Fisheries Management Plan (CVC and Ministry of Natural Resources, 2002), and the Ecological Restoration Strategy and Guidelines (CVC, 2020b).

In developing this strategy CVC leveraged the diverse perspectives, expertise, and interests of CVC staff, stakeholders, and partners, through personal correspondence, meetings, workshops, and draft reviews. This engagement helped to identify and prioritize a wide range of issues for the ISS and played a key role in developing the principles, objectives, and actions. CVC's ISS is not intended to replace or supersede any plans or strategies external to CVC. Some municipalities and NGOs in the watershed manage invasive species but lack a formal plan or strategy. CVC's ISS or related elements can be adopted at a high level by these organizations to guide invasive species management within their local context. CVC has developed partnerships with many of these organizations and will continue to actively engage with external partners (see Section 3.2.3).



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2.0 Invasive Species in the Credit River Watershed

In 2011, the United Nations (UN) Convention on Biological Diversity recognized invasive species as one of the most significant threats to biodiversity worldwide (Figure 2). Healthy ecosystems with high biodiversity provide crucial ecological services including pollination, seed dispersal, water purification and nutrient cycling.



Biodiversity is not only important for ecosystem health and function, but also crucial for human survival providing food, shelter, fuel, and medicine. Furthermore, there are non-material benefits including spiritual and religious values, education and inspiration, and recreation and aesthetic values.

It is estimated that the Credit River Watershed provides at least \$371 million in ecological services annually (The Pembina Institute, 2009), if taking inflation into account this would increase to approximately \$443 million in 2020 (Bank of Canada Inflation Calculator, 2020). Loss and degradation of biodiversity weakens the ability of natural ecosystems to



▲ **Figure 2.** The top five threats to biodiversity as defined by the United Nations Convention on Biological Diversity (2011).

European Reed, commonly referred to as Phragmites, is an invasive perennial grass found throughout the Credit River Watershed in wetlands, on edges of waterbodies, and in roadside ditches. It creates dense stands that displace native species, fills in wetlands, creates fire hazards from the dead stalks, creates sight line issues along roads, and impedes recreational activities including boating, angling and swimming (OFAH/OMNRF Ontario’s Invading Species Awareness Program, 2012). It is estimated that Ontario municipalities and conservation authorities spend over \$3 million annually managing Phragmites (Vyn, 2019).

2.1 What are Invasive Species?

provide the ecological goods and services we rely on and enjoy. In response to critical concerns regarding loss of biodiversity, the UN has designated 2021 to 2030 as the Decade on Ecosystem Restoration. Managing invasive species is an important part of achieving the global target of restoring 350 million hectares of land to a natural state. Locally, this will help ensure the ecological goods and services the watershed provides will still be available for all residents to use and enjoy. Although invasive species management is a long term and costly endeavor, it must be prioritized as part of CVC’s commitment to conserve, restore, and manage the natural resources of the Credit River Watershed.

For the purposes of CVC’s ISS, invasive species are defined as **non-native species that displace native species, dominate ecosystems and impact ecological integrity and ecosystem functions**. They include birds, fish, insects, invertebrates, mammals, plants and pathogens. Invasive species may directly harm other species through infection, parasitization, or predation, or indirectly harm them through competing for space and resources (eg. light, moisture, food) reducing ecosystem biodiversity. They also can place a significant financial burden on agencies and organizations that manage them (Invasive Species Centre, 2020). Some familiar invasive species in the Credit River Watershed include European Reed (*Phragmites australis* ssp.

Invasive Plant Species Pathways of Introduction

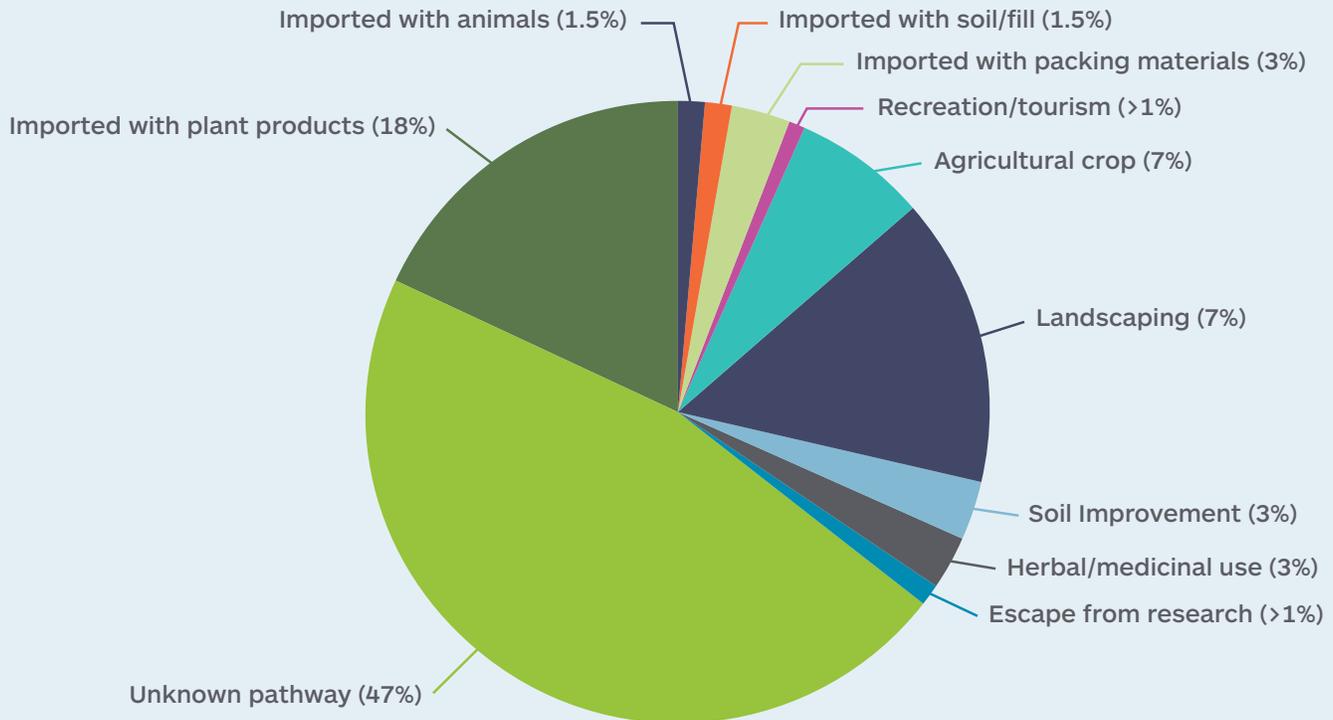


Figure 3. Invasive plant species pathways of introduction. Canadian Food Inspection Agency (2008).

australis), European Swallow Wort (*Vincetoxicum rossicum*, commonly known as Dog-strangling Vine (DSV), and will be referred to as such throughout this document), Round Goby (*Neogobius melanostomus*) and Mute Swan (*Cygnus olor*).

Invasive species spread through a variety of vectors (e.g. wind, water, birds and other wildlife), but over half (53 per cent) are associated with human activities (Figure 3). Human activities spread invasive plants and wildlife throughout the Credit River Watershed and globally, both unintentionally (e.g. on equipment and packaging) and intentionally (e.g. commercial trade of invasive horticultural plants).

2.2 Current State of Invasive Species in the Credit River Watershed

Ontario's Invasive Species Strategic Plan (Province of Ontario, 2012) notes that Ontario has the highest number of invasive species of any province or territory in Canada. The Credit River Watershed is no exception with 184 recorded invasive species out of over 1,500 species recorded in the watershed. Even though this represents only 12 per cent of the number of species in the watershed, it is a gross underrepresentation of the impact, due to their ecological traits that have led them to be classified as invasive.

There are currently 20 species listed under the Invasive Species Act that are either prohibited or restricted in Ontario. Currently none of the prohibited species have been found within the watershed; however, all four of the restricted species are present (Table 1):

	COMMON NAME	LATIN NAME
PROHIBITED	Bighead Carp	<i>Hypophthalmichthys nobilis</i>
	Black Carp	<i>Mylopharyngodon piceus</i>
	Brazilian Elodea	<i>Egeria densa</i>
	Common Yabby	<i>Cherax destructor</i>
	European Water Chestnut	<i>Trapa natans</i>
	Golden Mussel	<i>Limnoperna fortunei</i>
	Grass Carp	<i>Ctenopharyngodon idella</i>
	Hydrilla	<i>Hydrilla verticillata</i>
	Killer Shrimp	<i>Dikerogammarus villosus</i>
	Parrot Feather	<i>Myriophyllum aquaticum</i>
	Silver Carp	<i>Hypophthalmichthys molitrix</i>
	Snakeheads	<i>Channidae species</i>
	Stone Moroko	<i>Pseudorasbora parva</i>
	Water Soldier	<i>Stratiotes aloides</i>
	Wels Catfish	<i>Silurus glanis</i>
Zander	<i>Sander lucioperca</i>	
RESTRICTED	Black Dog-strangling Vine	<i>Cynanchum louiseae</i>
	Dog-strangling Vine	<i>Cynanchum rossicum</i>
	Japanese Knotweed	<i>Reynoutria japonica var. japonica</i>
	European Reed	<i>Phragmites australis subsp. australis</i>

Table 1. Species Regulated under the Ontario Invasive Species Act.

Vegetation Communities are assemblages of plant species that form a relatively uniform patch within a specific space.

At this time, the prohibited species are all aquatic, and the restricted species are terrestrial. For species listed as prohibited it is illegal to import, possess, transport, release, breed/grow, buy/sell/lease or trade them anywhere in Ontario. For species listed as restricted, it is illegal to import, release, breed/grow, buy/sell/lease or trade. There are exceptions for both classes of species; however, these are mainly related to situations where the species are being managed or unintentionally caught (Province of Ontario, 2020a).

CVC's Natural Heritage Inventory (NHI) Program and Integrated Watershed Monitoring Program (IWMP) have collected significant amounts of species data through vegetation community surveys and monitoring plots. Urban areas are generally more heavily impacted by invasive plants than their rural counterparts. Invasive species coverage in the lower watershed is more than double that of the upper watershed and is increasing 1.5 times faster (CVC, 2020c).



CVC defines invasive plant species as having **moderate to transformative properties** are those which range from becoming locally dominant given certain conditions (moderately invasive) to those which exclude all other species and dominate sites indefinitely (transformers). **Minimally** invasive species are ones that do not pose an immediate threat to natural areas but do compete with more desirable native species.

From 2010 to 2019 over 90 per cent of vegetation communities surveyed across the watershed contain at least one invasive plant species described as having moderate to transformative properties. When looking specifically at CVC's conservation areas, this percent increases to 95 per cent of the vegetation communities (**Figure 4**). For example, over 96 per cent of the vegetation communities at Terra Cotta Conservation Area contain at least one plant species CVC considers detrimental to the natural habitat. If not prioritized for management these vegetation communities are at risk of reduced biodiversity and ecosystem function, not to mention the increased costs of management if it is not prioritized.

As threats to biodiversity continue to increase, the large natural spaces found within the Credit River Natural Heritage System, including CVC conservation areas, will become even more important to ensuring the health of the watershed. Managing invasive species is not just a concern to land managers and landowners who currently have invasive species present on their properties, but to all residents, as invasive species spread easily and far when not contained.

However, management is not practical for all invasive species and therefore CVC has identified which species are in and out of scope for management and of this ISS. Examples of invasive species that are in scope of this ISS are many invasive vascular plants (terrestrial, wetland and aquatic), including

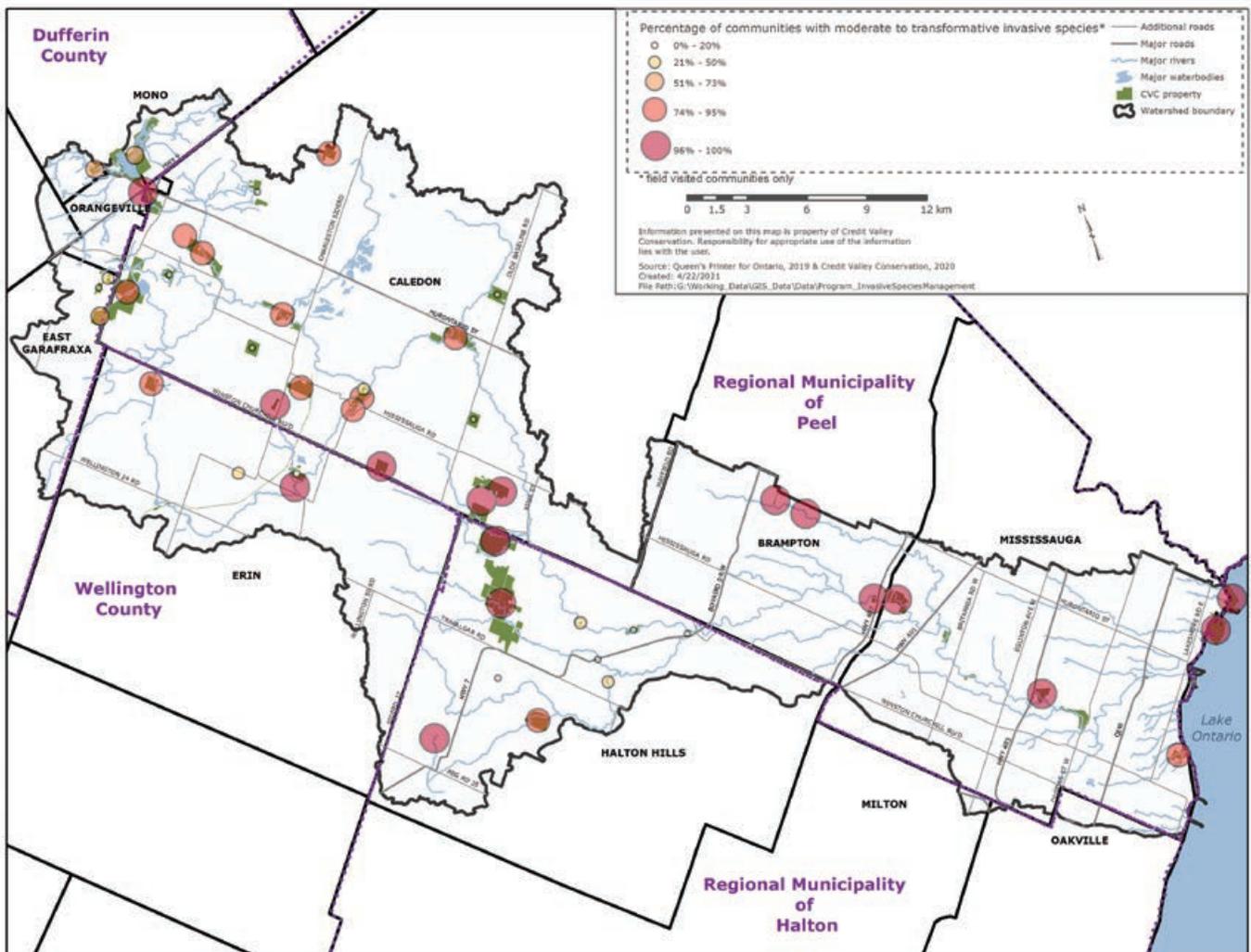


Figure 4. A map depicting the percentage of vegetation communities that have at least one moderate to transformative invasive species present at CVC conservation areas. Credit Valley Conservation, unpublished data (2010-2019).

Oriental Bittersweet (*Celastrus orbiculatus*) and Flowering Rush (*Butomus umbellatus*), and some fish species such as Common Carp (*Cyprinus carpio*), on CVC conservation areas. The management of forest pests and diseases is focused on mitigating the impacts of known and emerging species and aligns with CVC's *Sustainable Forest Management Plan* (2020).

Species that are not in the scope of this strategy include those that are the management responsibilities of other agencies, and where the costs incurred to control the species would be much higher than the ecological benefits gained by their

removal. Examples of species that are not within the scope of management by CVC include Spiny Water Flea (*Bythotrephes longimanus*), non-native Earthworms (*Lumbricina spp.*), and European Starling (*Sturnus vulgaris*).

Some native species can also dominate ecosystems and become a nuisance, particularly in disturbed habitats that are already less resilient to stressors; however, as they are native species CVC does not consider them to be invasive within the scope of this strategy. Examples of native species that can be considered a nuisance under some circumstances, but are not within the scope

INVASIVE SPECIES GROUPS	IN SCOPE	OUT OF SCOPE	REASONS OUT OF SCOPE
Vascular plants (terrestrial and aquatic)	✓		
Fish	✓		
Forest pests	✓		
Non—vascular plants	✓	✓	<ul style="list-style-type: none"> • Lack of feasible management techniques • Lack of knowledge or capacity to ID, track, and establish baseline data
Aquatic invertebrates		✓	<ul style="list-style-type: none"> • Management responsibility of other agencies • Lack of feasible management techniques • Lack of knowledge or capacity to ID, track, and establish baseline data
Birds		✓	<ul style="list-style-type: none"> • Management responsibility of other agencies • Cost vs. benefit ratio is too high
Earthworms		✓	<ul style="list-style-type: none"> • Lack of feasible management techniques • Lack of knowledge or capacity to ID, track, and establish baseline data
Insects (except for some forest pests)		✓	<ul style="list-style-type: none"> • Management responsibility of other agencies • Lack of knowledge or capacity to ID, track, and establish baseline data
Mammals (including domestic/feral)		✓	<ul style="list-style-type: none"> • Management responsibility of other agencies
Fish pests/diseases		✓	<ul style="list-style-type: none"> • Management responsibility of other agencies • Lack of knowledge or capacity to ID, track, and establish baseline data
Reptiles		✓	<ul style="list-style-type: none"> • Management responsibility of other agencies • Cost vs. benefit ratio is too high

Table 2. Invasive species groups that are in and out of scope.

of the ISS, include White-tailed Deer (*Odocoileus virginianus*), Canada Geese (*Branta canadensis*), Wild Grape (*Vitis riparia*) and Fall Cankerworm (*Alsophila pometaria*).

Table 8 summarizes species groups that are within or beyond the scope of the ISS. For some of the out of scope species CVC may play a supporting role (e.g provision of staff, materials, property access, etc.). Other out of scope species on the list such as the Red-eared Slider (*Trachemys scripta elegans*) may be caught or identified incidentally while staff are completing other monitoring and management work. While there are no formal management plans for the removal of these

out of scope species, incidental catches are dealt with on a case-by-case basis in consultation with those agencies with primary management responsibility. For all species listed in **Table 2**, CVC may lead or facilitate education and outreach to promote awareness of the impacts of invasive species and related messaging around individual management actions.

Since 2008 CVC has documented several species increasing in abundance or range including European Reed and Round Goby. As evidenced in **Figure 5**, records for Round Goby are high along the shoreline since they are found in large numbers in Lake Ontario.

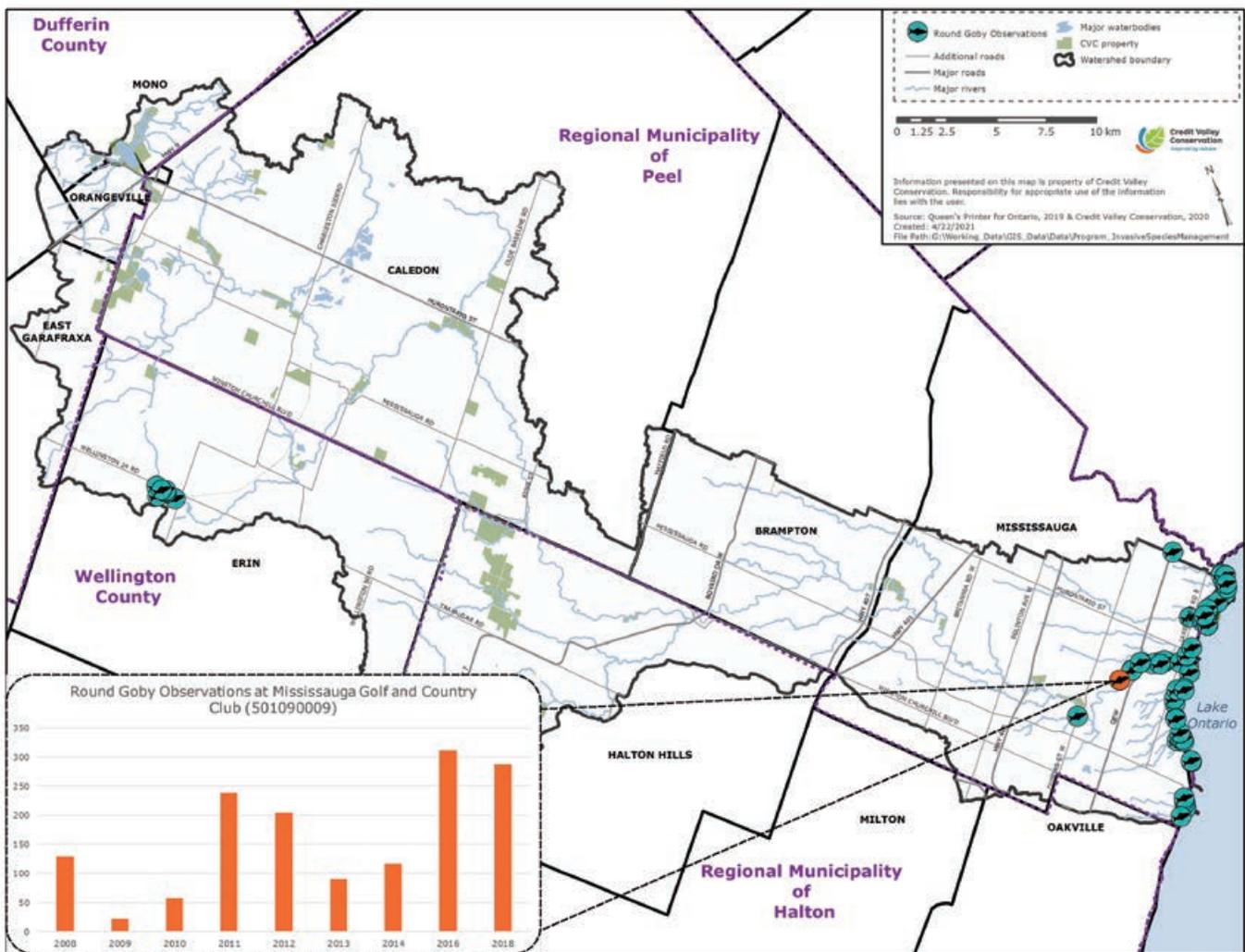


Figure 5. Locations where Round Goby have been caught within the Credit River Watershed and Lake Ontario shoreline during IWMP monitoring. Credit Valley Conservation, unpublished data (2008-2018).



Hemlock Woolly Adelgid (HWA) is an invasive insect that is extremely destructive to Eastern Hemlock (*Tsuga canadensis*) which is a keystone species due to its creation of a unique forest component. The retention of lower branch needles provides dense shade and cooling effects, and provides shelter and food sources to birds and animals during the winter (Hemlock Restoration Initiative, 2017).

HWA feed on newly developed twigs causing needle loss and eventually tree mortality (Young *et al.*, 1995). Since HWA feed on all age classes of hemlocks and the lack of hemlock re-establishment post HWA, it is predicted that Eastern Hemlocks could functionally disappear from our forests over the next several decades (Ellison *et al.*, 2005).

HWA has been detected in Ontario in 2012 (Etobicoke), in 2013-2015 (Niagara Gorge), and in 2019 (Niagara Glen and Wainfleet). The Etobicoke and Niagara infestations have been, or are, in the process of being eradicated; however, the Wainfleet infestation is beyond control. New York and Michigan also have substantial infestations; therefore, it is expected that HWA will continue to spread in Ontario and is a threat to the watershed (Government of Canada, 2020c).

Round Goby populations at a site not far upstream of the lake (Mississauga Golf and Country Club) are found to be generally increasing. Although a single individual was found in Erindale Park in 2016, the presence of high gradients and likely seasonal variation are believed to be restricting gobies moving further upstream (Blair *et al.*, 2018). In 2013, Round Gobies were found and later confirmed to be established in Hillsburgh; however, these are believed to have been bait bucket releases by anglers.

New invasive species continue to be detected in the Credit River Watershed. Since the first ISS was prepared in 2008, 38 new invasive species have been found in the watershed, such as EAB.

Although there are 184 known invasive species currently present in the watershed, there are 56 additional species that are known to have significant economic, health or environmental impacts elsewhere in Canada or in the United States. These species are considered at risk of being introduced in the watershed, and are therefore considered “watch” species (**Table 3**). Invasive “watch” species, such as Hemlock Woolly Adelgid (*Adelges tsugae* -HWA), have been identified in nearby municipalities and it is likely only a matter of time before they arrive in the watershed.

Invasive "Watch" Species

	COMMON	LATIN		COMMON	LATIN
PLANTS	Bohemian Knotweed	<i>Reynoutria x bohemica</i>	PLANTS	Tansy Ragwort	<i>Jacobaea vulgaris</i>
	Brazilian Water-milfoil	<i>Myriophyllum aquaticum</i>		Water Chestnut	<i>Trapa natans</i>
	Brazilian Waterweed	<i>Egeria densa</i>		Water Lettuce	<i>Pistia stratiotes</i>
	Callery Pear	<i>Pyrus calleryana</i>		Water Soldier	<i>Stratiotes aloides</i>
	Carolina Fanwort	<i>Cabomba caroliniana</i>		Wineberry	<i>Rubus phoenicolasius</i>
	Chinese Privet	<i>Ligustrum sinense</i>	FOREST PESTS & DISEASES	Asian Long-horned Beetle	<i>Anoplophora glabripennis</i>
	Cut-leaved Teasel	<i>Dipsacus laciniatus</i>		Beech Leaf Disease	
	Diffuse Knapweed	<i>Centaurea diffusa</i>		Hemlock Woolly Adelgid	<i>Adelges tsugae</i>
	Empress Tree	<i>Paulownia tomentosa</i>		Oak Wilt	<i>Bretziella fagacearum</i>
	European Frogbit	<i>Hydrocharis morsus-ranae</i>		Spotted Lanternfly	<i>Lycorma delicatula</i>
	Giant Knotweed	<i>Reynoutria sachalinensis</i>	AQUATIC SPECIES	Allegheny Crayfish	<i>Faxonius obscurus</i>
	Great Yellowcress	<i>Rorippa amphibia</i>		Bighead Carp	<i>Hypophthalmichthys nobilis</i>
	Himalayan Knotweed	<i>Koenigia polystachya</i>		Black Carp	<i>Mylopharyngodon piceus</i>
	Hydrilla	<i>Hydrilla verticillata</i>		Bloody-red Mysid	<i>Hemimysis anomala</i>
	Japanese Angelica-tree	<i>Aralia elata</i>		Didymo Algae (Rock Snot)	<i>Didymosphenia geminata</i>
	Japanese Chaff Flower	<i>Achyranthes japonica</i>		Fishhook Waterflea	<i>Cercopagis pengoi</i>
	Japanese Stiltgrass	<i>Microstegium vimineum</i>		Grass Carp	<i>Ctenopharyngodon idella</i>
	Japanese Virgin's Bower	<i>Clematis terniflora</i>		Louisiana Crayfish	<i>Procambarus clarkii</i>
	Japanese Wisteria	<i>Wisteria floribunda</i>		Marbled Crayfish	<i>Procambarus virginalis</i>
	Kobus Magnolia	<i>Magnolia kobus</i>		Mosquito Fish	<i>Gambusia affinis</i>
	Kudzu	<i>Pueraria montana</i>		Ruffe	<i>Gymnocephalus cernuus</i>
	Oval-leaved Privet	<i>Ligustrum ovalifolium</i>		Rusty Crayfish	<i>Faxonius rusticus</i>
	Porcelain-berry	<i>Ampelopsis brevipedunculata</i>		Silver Carp	<i>Hypophthalmichthys molitrix</i>
	Siebold Viburnum	<i>Viburnum siebold</i>		Snakehead	Genera <i>Channa</i> and <i>Parachanna</i>
	Small-flowered Jewelweed	<i>Impatiens parviflora</i>		Spiny Waterflea	<i>Bythotrephes longimanus</i>
	Small Carpetgrass	<i>Arthraxon hispidus</i>		Tench	<i>Tinca tinca</i>
	Starry Stonewort	<i>Nitellopsis obtusa</i>		Tubenose Goby	<i>Proterorhinus semilunaris</i>
	Swollen Bladderwort	<i>Utricularia inflata</i>		VHS (Viral Hemorrhagic Septicaemia)	

Table 3. Known invasive Species outside of the Credit River Watershed, but have yet to be found within it, and are therefore considered “watch” species.

When the other potential forest pests and diseases are considered including Asian Long-horned Beetle (*Anoplophora glabripennis*- ALHB), Oak Wilt (*Bretziella fagacearum*), and Beech Leaf Disease, the resulting impact on our forests is devastating (Figure 6).

Vulnerable Woodland Communities due to Invasive Forest Pests and Disease

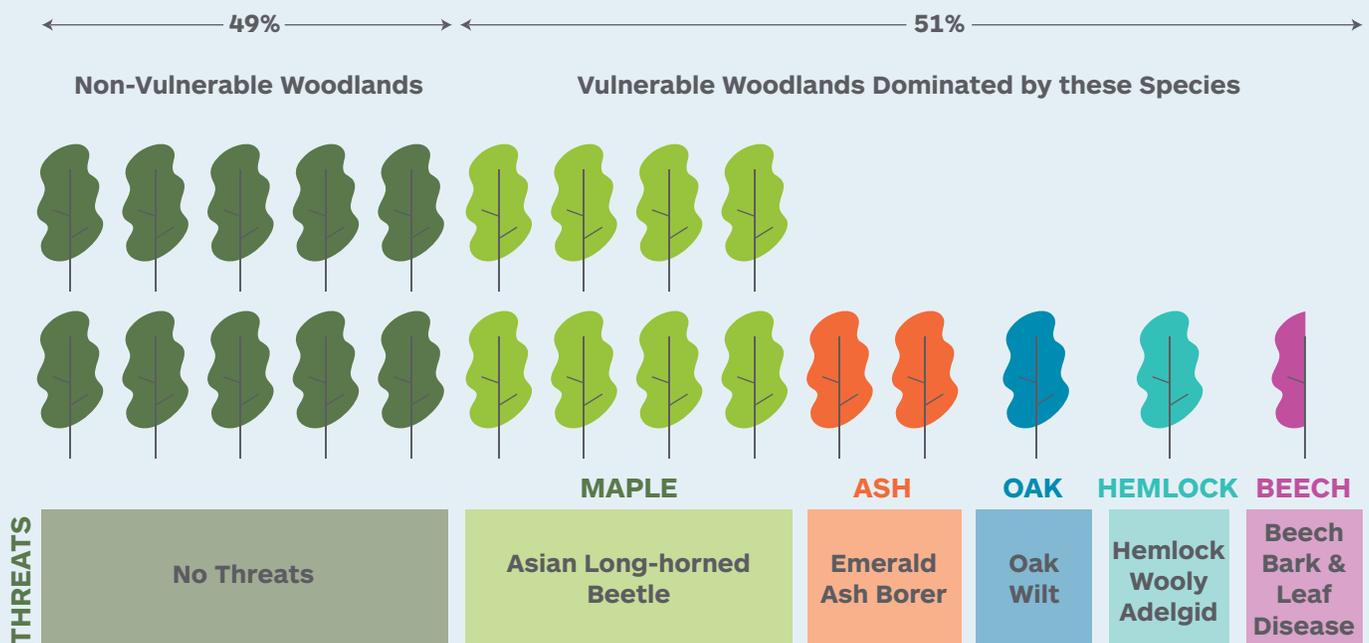


Figure 6. The per cent of inventoried woodland communities vulnerable to invasive forest pests and diseases.

Currently 51 per cent of the inventoried forest communities across the watershed are vulnerable to the current (EAB, Beech Bark Disease) and emerging (ALHB, HWA, Oak Wilt, Beech Leaf Disease) forest pests (Figure 7). The devastating impacts of EAB have already been seen throughout the watershed on ash, which dominate nine per cent of the inventoried woodlands. Currently beech trees are being impacted by Beech Bark Disease which is caused by a beech scale (*Cryptococcus fagisuga*) and a canker fungus (*Neonectria faginata*). This insect-fungus complex is leading to a mortality of large mature trees girdled by the canker and a slow

decline in trees with less serious infections (McLaughlin and Greifenhagen, 2012). As of 2017, only eight per cent of all monitored beech trees within the watershed were free of any symptoms (CVC, 2020d). To add to the stress on beech trees, a new pathogen, Beech Leaf Disease, reached Ontario in 2017. It is now present in Toronto and along the shore of Lake Erie (Province of Ontario, 2020b). Beech dominate two per cent of inventoried woodlands within the watershed; however, they are also commonly found throughout maple dominated forests as well. Eastern Hemlock are also at risk of an invasive pest attack, as described above. Although they

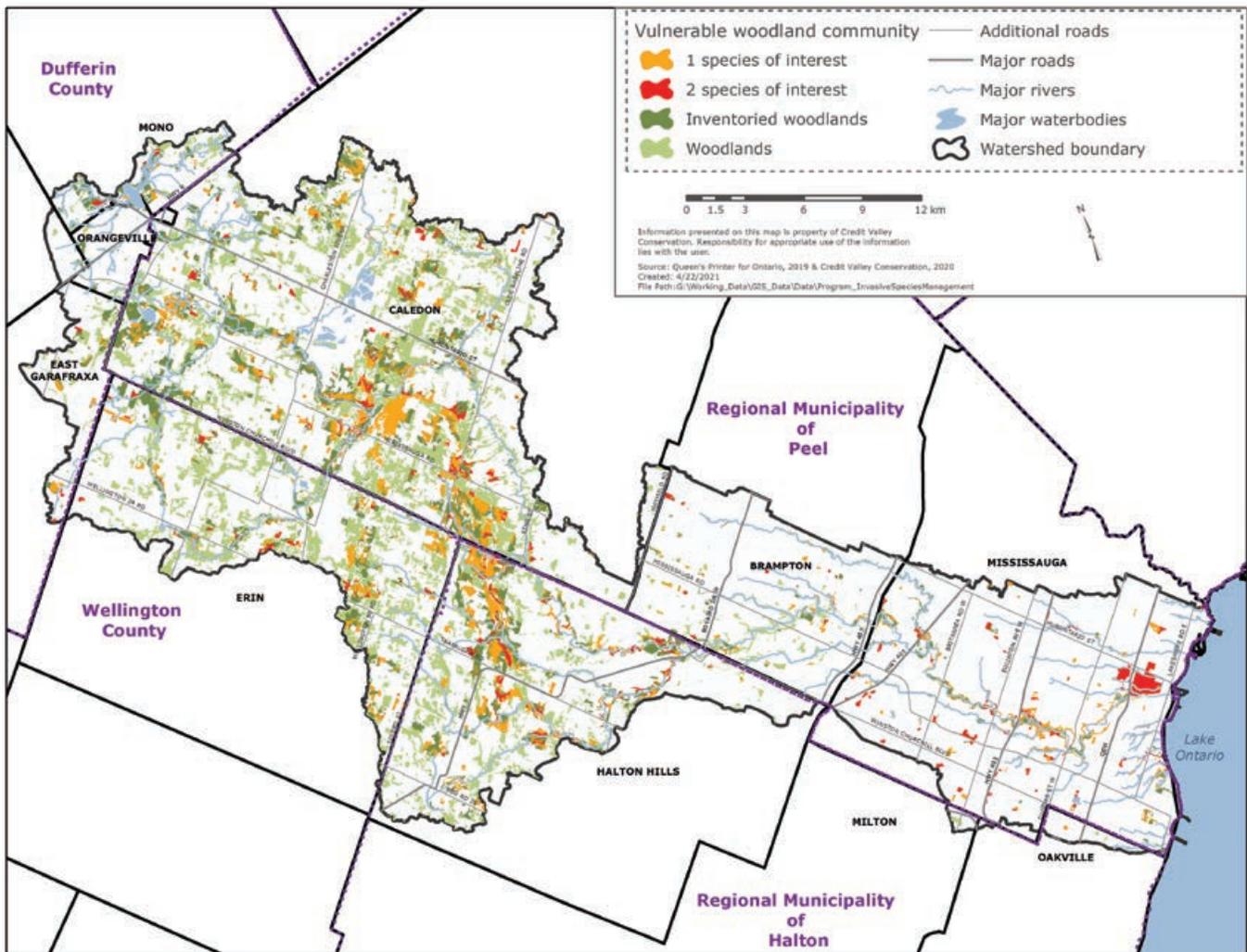


Figure 7. A map depicting the location of inventoried woodland communities that are vulnerable to one or two invasive forest pest species either present or emerging across the watershed. Credit Valley Conservation and City of Mississauga, unpublished data (2013-2020).

only dominate five per cent of our inventoried woodlands they are considered a keystone species due to their creation of a unique forest component providing dense shade (Hemlock Restoration Initiative, 2017). Within the watershed six per cent of the inventoried woodlands are dominated by native oak which are currently vulnerable to the invasive fungus Oak Wilt which restricts the flow of water and nutrients through the trees resulting in mortality in as little as one year. The closest known location is on Belle Isle in Detroit, only 500m from the Canadian Border (Invasive Species Centre, 2018). The last forest pest on the horizon is ALHB. Although a lazy insect, so unlikely to spread rapidly like EAB, it's

preferred host is maple and within the inventoried woodlands in our watershed, 42 per cent are dominated by maple. Furthermore, although they prefer maple, ALHB will also use other deciduous species including birch, poplar, willow and elm (Government of Canada, 2016). Therefore, if they were to find their way to the watershed, this could substantially impact the forest communities if early detection efforts are not prioritized to ensure a rapid response. Additionally, when the invasive plant species that are already threatening and outcompeting the regrowth of our forest habitats are factored in the direness of the situation becomes even more alarming.



Other invasive species, such as Kudzu (*Pueraria montana*) a species found abundantly in the southern United States (and is only currently found in Ontario in Leamington), do not yet pose an imminent risk of introduction to the watershed. However, they may eventually arrive here as annual temperatures rise, and their ranges increase northward. By 2050 climate change is projected to increase average annual temperatures by up to 2.2 degrees Celsius (Auld *et al*, 2016), leading to warmer winter conditions, decreased days below freezing and a change in seasonal weather patterns. Invasive species currently limited by temperature constraints may begin to expand their ranges northward as conditions become more suitable for their survival.

CVC maintains lists of the invasive species present in the watershed and the known watch species for terrestrial plants, forest pests and diseases and aquatic species. These lists include ecological and management ranks, and are updated

occasionally based on new science, new management options, and changes in invasive species distributions in the watershed and surrounding areas. **Appendix C provides the lists as of 2020 but the most up-to-date lists for the following groups can be accessed at cvc.ca/invasives:**

- 1 terrestrial plants**
- 2 forest pests and diseases**
- 3 aquatic species**

However, prevalence does not necessarily influence prioritization for management in the watershed, particularly in high quality habitats along the Credit River Natural Heritage System. Although species on the watch lists are top priority if they were to be found in the watershed, there are currently 74 invasive species within the watershed that are considered management priorities by CVC. Of these management priorities, 60 are plants, 7 are forest pests and 7 are aquatic species (**Table 4**).

Invasive Species Prioritized For Management

	COMMON	LATIN		COMMON	LATIN
PLANTS	Amur Corktree	<i>Phellodendron amurense</i>	PLANTS	Periwinkle	<i>Vinca minor</i>
	Amur Maple	<i>Acer tataricum</i> <i>ssp. ginnala</i>		Purple Crown-vetch	<i>Securigera varia</i>
	Amur Silvergrass	<i>Miscanthus sacchariflorus</i>		Purple Jewelweed	<i>Impatiens glandulifera</i>
	Autumn Olive	<i>Elaeagnus umbellata</i>		Purple Loosestrife	<i>Lythrum salicaria</i>
	Black Locust	<i>Robinia pseudoacacia</i>		Purple Willow	<i>Salix purpurea</i>
	Black Swallowwort	<i>Vincetoxicum nigrum</i>		Rough Mannagrass	<i>Glyceria maxima</i>
	Chinese Silvergrass	<i>Miscanthus sinensis</i>		Russian Olive	<i>Elaeagnus angustifolia</i>
	Chinese Wisteria	<i>Wisteria sinensis</i>		Scots Pine	<i>Pinus sylvestris</i>
	Climbing Euonymus	<i>Euonymus fortunei</i>		Sea Buckthorn	<i>Hippophae rhamnoides</i>
	Common Barberry	<i>Berberis vulgaris</i>		Showy Fly Honeysuckle	<i>Lonicera x bella</i>
	Curly-leaved Pondweed	<i>Potamogeton crispus</i>		Siberian Elm	<i>Ulmus pumila</i>
	Dog-strangling Vine/ European Swallowwort	<i>Vincetoxicum rossicum</i>		Spreading Hedge- parsley	<i>Torilis arvensis</i>
	Dwarf Honeysuckle	<i>Lonicera xylosteum</i>		Sycamore Maple	<i>Acer pseudoplatanus</i>
	English Ivy	<i>Hedera helix</i>		Tatarian Honeysuckle	<i>Lonicera tatarica</i>
	Erect Hedge-parsley	<i>Torilis japonica</i>		Tree-of-heaven	<i>Ailanthus altissima</i>
	Eurasian Water-milfoil	<i>Myriophyllum spicatum</i>		White Mulberry	<i>Morus alba</i>
	European Black Alder	<i>Alnus glutinosa</i>		White Poplar	<i>Populus alba</i>
	European Buckthorn	<i>Rhamnus cathartica</i>		Wild Chervil	<i>Anthriscus sylvestris</i>
	European Euonymus	<i>Euonymus europaeus</i>		Wild Parsnip	<i>Pastinaca sativa</i>
	European Lily-of-the-valley	<i>Convallaria majalis</i>		Winged Euonymus	<i>Euonymus alatus</i>
	European Privet	<i>Ligustrum vulgare</i>		Winter Aconite	<i>Eranthis hyemalis</i>
	European Reed	<i>Phragmites australis</i> <i>ssp.</i> <i>australis</i>		Yellow Floatingheart	<i>Nymphoides peltata</i>
	Fig-root Buttercup	<i>Ficaria verna</i>		Yellow Iris	<i>Iris pseudacorus</i>
	Five-leaved Aralia	<i>Eleutherococcus</i> <i>sieboldianus</i>		Imported Willow Leaf Beetle	<i>Plagiodera versicolora</i>
	Flowering-rush	<i>Butomus umbellatus</i>		LDD	<i>Lymantria dispar dispar</i>
	Garlic Mustard	<i>Alliaria petiolata</i>		Japanese Beetle	<i>Popillia japonica</i>
	Giant Hogweed	<i>Heracleum</i> <i>mantegazzianum</i>		Large Pine Weevil	<i>Hylobius abietis</i>
	Glossy Buckthorn	<i>Frangula alnus</i>		Pine Shoot Beetle	<i>Tomicus piniperda</i> (L.)
	Goutweed	<i>Aegopodium podagraria</i>		Satin Moth	<i>Leucoma salicis</i>
	Japanese Barberry	<i>Berberis thunbergii</i>		Sirex Wood Wasp	<i>Sirex noctilio</i> (F.)
	Japanese Honeysuckle	<i>Lonicera japonica</i>		Amur Carp (Koi)	<i>Cyprinus rubrofuscus</i>
	Japanese Knotweed	<i>Reynoutria japonica</i>		Common Carp	<i>Cyprinus carpio</i>
	Japanese-spurge	<i>Pachysandra terminalis</i>		Frog Virus 3 (FV3) (type species of Ranavirus genus)	
Maack's Honeysuckle	<i>Lonicera maackii</i>	Goldfish	<i>Carassius auratus</i>		
Morrow's Honeysuckle	<i>Lonicera morrowii</i>	Round Goby	<i>Neogobius melanostomus</i>		
Multiflora Rose	<i>Rosa multiflora</i>	Rudd	<i>Scardinius erythrophthalmus</i>		
Norway Maple	<i>Acer platanoides</i>	Sea Lamprey	<i>Petromyzon marinus</i>		
Oriental Bittersweet	<i>Celastrus orbiculatus</i>				

Table 4. Invasive species currently present and prioritized for management in the Credit River Watershed.



Some of the more widespread species found in the watershed include EAB, European Buckthorn (*Rhamnus cathartica*), DSV, Garlic Mustard (*Alliaria petiolata*), non-native honeysuckles (*Lonicera spp.*), Norway Maple (*Acer platanoides*), European Reed, Chinese and Amur Silver Grass (*Miscanthus sinensis* and *M. sacchariflorus*), LDD (*Lymantria dispar dispar*- formally known as Gypsy Moth), Common Carp, Goldfish (*Carassius auratus*) and Round Goby. There

are also some species that are prioritized for management by other organizations, such as Quagga and Zebra Mussels (*Dreissena bugensis* and *D. polymorpha*), due to their impacts on infrastructure. Furthermore, for some species there may be no tools or techniques available to contain or slow their spread, like EAB, and therefore management is focused on the impacts the species cause and not the actual species itself.

Allelopathy is a plants ability to release harmful chemicals from plant parts negatively impacting other species (Ferguson et al, 2016). For many invasive species including Garlic Mustard this alters soil chemistry negatively impacting microorganisms and nutrient cycling which in turn impacts native plant growth (Rodgers et al, 2008).



Figure 8. Garlic Mustard invades the forest understory, competes with native species for light and space, and has allelopathic properties.



Figure 9. Giant Hogweed can cause photo-dermatitis and is a health risk.

2.3 What are the Impacts of Invasive Species?

Invasive species are one of the most serious threats to biodiversity in the watershed. They dominate ecosystems where the factors limiting growth in their native range are absent, where disturbance is present, and where native species lack natural defenses to resist their spread or impacts. Some invasive species, such as forest pests and pathogens, directly harm native species (e.g. through allelopathy or infection) while others indirectly harm native species by competing for resources and space (**Figure 8**). Furthermore, some species such as Giant Hogweed (*Heracleum mantegazzianum*- **Figure 9**) can have serious health impacts to humans through contact with the sap leading to blisters, burns and even blindness if the sap enter the eyes (Nielsen *et al*, 2005).

Additionally, other invasive species, such as EAB, pose indirect threats to human health and property by killing ash trees that then create safety hazards for humans.

Impacts to biodiversity are not necessarily limited to a particular group of plants or animals but may be far ranging. For example, where invasive species displace native plants that provide food for insects and other wildlife, populations of those species may also decline. Biodiversity is directly influenced by ecological integrity as ecosystems with a greater diversity of native species are typically more resilient to disturbance and environmental change. Where biodiversity is compromised, ecosystems become less resilient to disturbance and stress. There can

also be a reduction in ecosystem functions such as air quality, water filtration, flood control, and erosion prevention. In the face of a changing climate, these ecosystem services are needed more than ever.

There has also been an increase in severe weather events across the watershed, including higher average temperatures, more heat waves, and more intense precipitation events. Maintaining diverse, high-functioning landscapes is key to buffering the effects of climate change and minimizing impacts to human health and well-being.

The economic costs of management are significantly lower when resources are invested in prevention and early detection. Once an invasive species is established, the costs for management are substantially higher and less efficient (Vyn, 2019).

The State of Victoria (2015) in Australia has created a generalized invasion curve depicting that the economic return on project investment is one hundred times higher when investing in prevention as opposed to management after the species is established (Figure 10). Furthermore, the longer a species is present the more costly management becomes (State of Victoria, 2015).

The estimated annual socio-economic costs to municipalities and conservation authorities in Ontario of \$50.8 million does not include federal or provincial government funding (Vyn, 2019). The costs in Ontario grow even higher when you consider the combined potential impacts on healthcare, agriculture, fisheries, forestry, tourism and recreation. Factoring in these industries brings the annual cost up to \$3.6 billion in Ontario (Vyn, 2017).

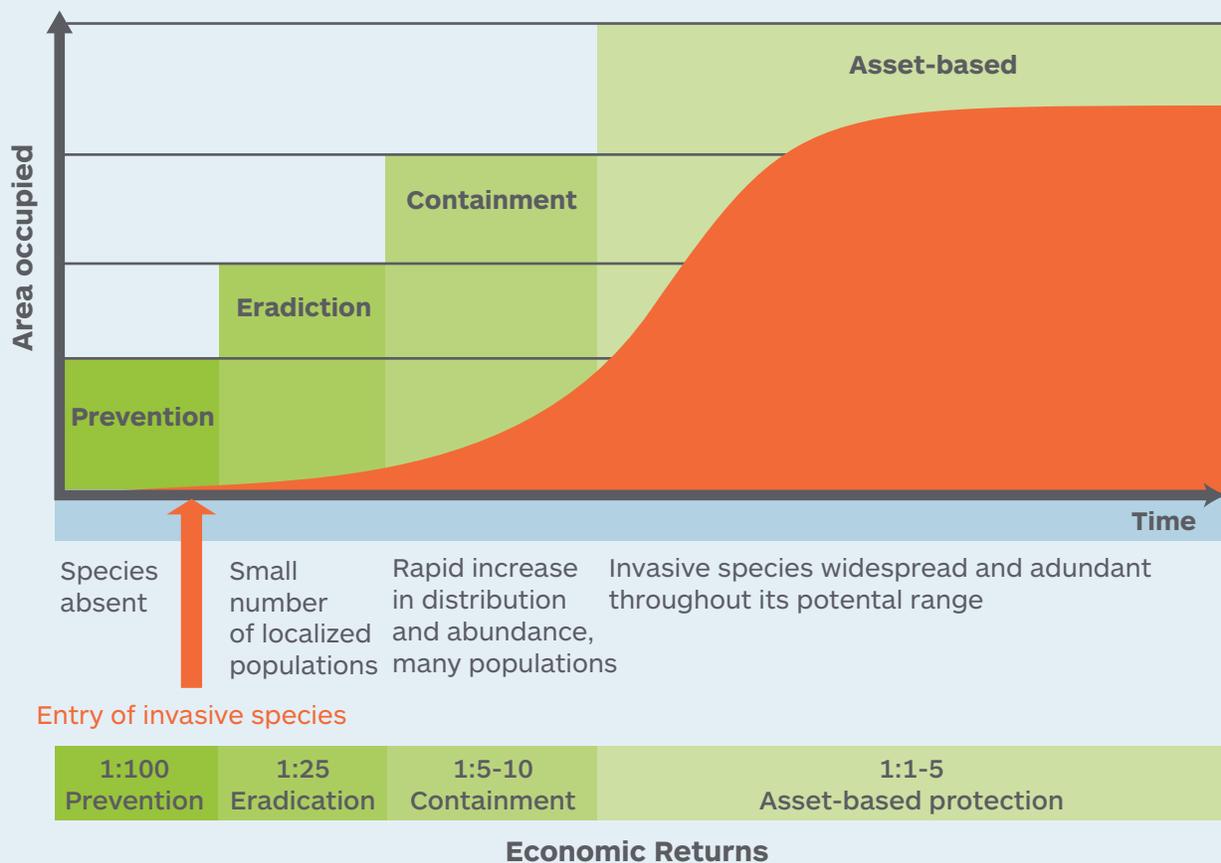


Figure 10. Generalized invasion curve depicting the economic returns for each stage of invasive species management (State of Victoria, 2015).

From data collected between 2017- 2019 the three highest annual expenditures that Ontario municipalities and conservation authorities are currently investing in for an individual invasive species include:

EAB

(Agrilus planipennis)

\$29,727,378

Zebra Mussels

(Dreissena polymorpha)

\$4,486,761

LDD

(Lymantria dispar dispar)

\$4,474,562

(Vyn, 2019)

Unfortunately, it is generally easier to obtain resources to manage invasive species once the species is established and the impacts are apparent. Most municipalities and conservation authorities in Ontario are spending the highest proportion of invasive species-related money managing the impacts of established invasive species: 65.8 per cent for conservation authorities and 79.6 per cent for municipalities. Furthermore, the annual expenditure for conservation authorities (\$314,724) was greater than for municipalities (\$218,148) (Vyn, 2019). However, to really get ahead of the problem, more funding is required for prevention, early detection, and rapid response, and even rapid response efforts can be costly as seen with the ALHB eradication efforts in Ontario which cost the CFIA \$35 million (Bullas-Appleton, 2020).





Credit: Thierry Poire

2.4 Management Techniques for Invasive Plants and Animals

CVC uses a variety of tools to remove and control invasive species but rarely is there any single technique that will effectively eradicate or suppress an invasive species. A combination of techniques is often necessary, with repeated applications over several years to reduce or eliminate the population of the target species effectively. For invasive plants, ongoing management of

ecological restoration sites following removal of an invasive species is often necessary to prevent resurgence of the target species or secondary invasions by other species.

CVC staff follow established best management practices (BMPs) for invasive species management and have shared knowledge and information with external

Asian Long-horned Beetle Control: Early Detection and Rapid Response

In 2003 Asian Long-horned Beetle (ALHB) was discovered in Toronto. This insect has the potential to cause billions of dollars of damage to Ontario's forests as it attacks and kills many hardwoods, including maple, birch, poplar, willow, and elm (Government of Canada, 2020b). CFIA took on a primary role in coordinating the response with support from the Canadian Forest Service, Ontario Ministry of Natural Resources and Forestry, the cities of Toronto and Vaughan, York Region, Toronto and Region Conservation Authority, private forestry contractors, and the United States Department of Agriculture to conduct monitoring, research, and control of the beetle (Toronto City Council, 2004).

The only known control measure for ALHB is the removal of every host tree from within a 400m radius of any infested trees, as this is the distance 99 per cent of the population is expected to fly. In 2013, there was a second outbreak in Mississauga and an even larger 800m radius of host trees were removed to ensure the beetle's total eradication (Province of Ontario, 2020c). These drastic measures, often involving private property and little notice, were enforced through the CFIA's ability to issue control orders under the broad scope of the Plant Protection Act (Toronto City Council, 2004). In total more than 30,000 tree removals took place in the affected zones (City of Vaughan, 2013). A multi-year quarantine on the movement of all wood products and host nursery stock out of the affected area was also put in place, with strict enforcement, and was only lifted in June 2020 after the outbreak was identified as eradicated (Government of Canada, 2020a). Although the measures could be considered extreme and very costly (the CFIA spent \$35 million to manage ALHB (Bullas-Appleton, 2020)), the swift decisive mobilization efforts were effective and ALHB have not been seen in Ontario since 2013. If these early detection and rapid response efforts had not been undertaken or successful it would have only been a matter of time before the 9,000 plus hectares of deciduous and mixed forests of the Credit River Watershed would have been devastated by this aggressive beetle.

partners to help prepare these resources (e.g., Ontario Invasive Plant Council's (OIPC's) BMPs and technical bulletins for invasive plants). BMPs, technical bulletins and other resources provide specific information about management techniques for invasive species, and CVC will continue to apply these techniques to its invasive species management activities.

Best Management Practices

(BMPs) are methods that consider ecological impacts, effectiveness, and fiscal implications. BMPs are the most practical way to manage an invasive species while considering the ecological implications.

The successful biocontrol of **Purple Loosestrife** (*Lythrum salicaria*) in the 1990s using *Neogalerucella* beetles has significantly reduced one of the first publicly known invasive plant species from devastating wetlands in Ontario. CVC participated in this biocontrol effort releasing beetles in the lower watershed in 1995, 1997 and 1999. These releases had been effective at keeping the Purple Loosestrife populations to minimal densities thereby allowing other wetland species to thrive. However, by 2015 CVC staff began noticing the resurgence of Purple Loosestrife in the upper watershed and in 2016 another release was done by CVC to bolster the *Neogalerucella* beetle populations. The beetles were released at two sites and are now being monitored to determine if the release will once again succeed in getting the Purple Loosestrife under control.



Figure 11. Chemical control of invasive shrub re-sprouts.

Management techniques can be classified into three broad categories:

- 1** mechanical control (e.g. cutting, excavating, mowing, burning)
- 2** chemical control (e.g. herbicides, insecticides, fungicides - **Figure 11**)
- 3** biological control (i.e. introduction of organisms which feed on or infect the target species)

New or improved herbicides and other chemical controls have been used, and biocontrol options are being researched, but the general approaches to management of invasive species have not changed significantly. Management of invasive species is a long-term investment. Very rarely is it accomplished in less than three years, and more often it is a five to ten-year process requiring adaptive management and significant financial contributions to be successful. Even after eradication, there can be substantial costs to restoring or jump starting the natural regeneration of the impacted area.

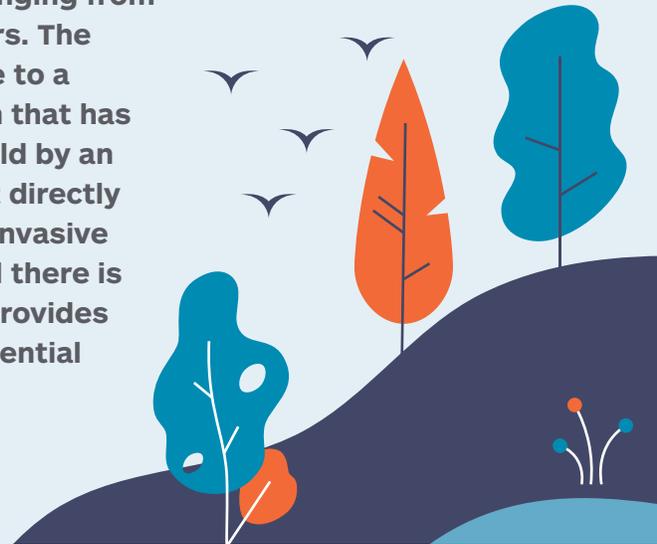
Emerald Ash Borer (EAB), a beetle native to Asia, has caused devastation across North America to native ash trees, and is a great example of **adaptive management** and the **long-term** commitment needed for invasive species management. It is thought to have arrived in Ontario through movement of wood packaging or pallets from the Detroit area in 2002. When it was first detected in Canada the Canadian Food Inspection Agency (CFIA) attempted to cut down infested trees, but it was determined to be an ineffective control strategy. Instead regulated areas were established to restrict the movement of potentially infested wood items from areas with EAB (Government of Canada, 2014a). By 2008, EAB had made its way to the Credit River Watershed. Through funding support by Halton and Peel Regions CVC responded by assessing all properties for ash trees to determine the location, health and liability risk of all ash trees along trails and property boundaries, before removing all ash trees that posed a hazard to public safety. Between 2014 and 2020 CVC cut 13,000 hazard ash trees. Select mature ash trees are also being injected with TreeAzin, an environmentally safe bio-insecticide treatment that helps protect healthy ash trees from becoming infected with EAB. Select areas off trail with high densities of ash are also being prioritized for management to help re-establish a diverse forest habitat. These management efforts have cost CVC over \$3 million since 2013.





3.0 Roles and Responsibilities, Program Gaps and Opportunities

There are numerous roles and responsibilities in responding to the threat of invasive species, with those responsible ranging from the federal government down to individual land managers. The extent of involvement can also range from a primary role to a supportive role. A primary role is held by an organization that has a direct responsibility to the role. A supportive role is held by an organization that will help fulfil the role, but they are not directly responsible. Due to the number of activities involved in invasive species management and the diversity of those involved there is a high likelihood for duplication of efforts. This section provides information on current efforts and programs, as well potential opportunities arising from known gaps.



3.1 Roles and Responsibilities

Implementation of invasive species management requires input from many organizations at different functional levels, from broad policy decisions down to site-specific on-the-ground control efforts. Roles at the federal and provincial levels tend to focus on high-level coordination, policy development, strategies and enforcement of legislation and regulations. Roles at the regional and local levels (municipalities, conservation authorities, NGOs) tend to focus on implementation, which is where duplication of effort is most likely.

The various roles include:

- ☀ Legislation and Policy
- ☀ Funding
- ☀ Research, Science and Monitoring
- ☀ Outreach and Education
- ☀ Coordination
- ☀ Enforcement/Regulation
- ☀ Site Level Management
- ☀ Advocacy



LEGISLATION AND POLICY

Federal and provincial agencies create legislation and policies to provide high level guidance and a framework for jurisdictional actions. **Some of the agencies that administer acts include the following:**

- ☀ Environment and Climate Change Canada (ECCC)- Canadian Environmental Protection Act.
- ☀ Fisheries and Oceans Canada (DFO)- Fisheries Act.
- ☀ Canadian Food Inspection Agency (CFIA)- Plant Protection Act.
- ☀ Ontario Ministry of Natural Resources and Forestry (OMNRF)- Invasive Species Act.
- ☀ Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA)- Weed Control Act.

Some examples of Strategies that are related to invasive species management include:

- ☀ The ECCC created An Invasive Alien Species Strategy, 2004.
- ☀ The OMNRF released the Ontario Invasive Species Strategic Plan, 2012.

Federal and provincial acts and policies are then adopted in principle and translated into more detailed and action-oriented strategies, plans, and goals by municipalities and conservation authorities. CVC's ISS is an example of a local level action-oriented strategy that is informed by broader federal and provincial guidance. Other examples of strategies prepared by other organizations in Ontario are found in [Table 5](#).

Organization	Title	Date
Rare Charitable Research Reserve	Invasive Species Management: Work Plans and Priority Areas	2014
City of St. Thomas	St. Thomas Phragmites Action Plan	2016
Central Lake Ontario Conservation Authority	Invasive Species Management Strategy	2017
London (City)	London Invasive Plant Management Strategy	2017
Mississauga (City)	City of Mississauga Invasive Species Management Plan and Implementation Strategy	2019
Kettle Creek Conservation Authority	Invasive Plant Management Plan-Draft	2020

Table 5. Examples of strategies prepared by other organizations in Ontario.

FUNDING

Funding is generally provided at the provincial and federal level as a mechanism to implement acts and policies. There are also grants available which organizations can apply to for invasive species management. **Examples of funding structures or partnerships include:**

☀ The Invasive Species Centre (ISC) provides education, connects stakeholders, and coordinates and supports management projects. It is funded through OMNRF, DFO, Natural Resources Canada, and CFIA.

☀ The Invading Species Awareness Program (ISAP) provides education and awareness, addresses key pathways contributing to introductions and/or spread, and facilitates monitoring and early detection. It is run by the Ontario Federation of Anglers and Hunters in partnership with the OMNRF.

CVC's ISMP is primarily funded by municipal partners. This dedicated funding allows the ISMP to implement priority actions for invasive species management. In previous years provincially funded grants awarded to CVC resulted in expanded control efforts on managing priority projects on CVC, public and private properties. However, these project specific grants do not support long-term program operations. If provided further funding CVC has the technical knowledge and experience to expand the current program and provide increased support to partners and landowners in the watershed.

The **Invasive Alien Species (IAS) Collaborative** is a collaboration between several Ontario organizations ranging from land managers to NGOs including CVC, City of Toronto, City of Burlington, Central Lake Ontario Conservation Authority, Toronto and Region Conservation Authority, Royal Botanical Gardens (Burlington), OIPC, ISC, and Protect Our Waters and Environmental Resources (P.O.W.E.R).



RESEARCH/SCIENCE/MONITORING

CFIA, DFO, and OMNRF also participate directly in/or support science, research, and monitoring related to new and existing invasive species. However, other organizations are also involved, typically partnering with an agency or providing support to citizen science programs through volunteer opportunities. **Examples of research, science and monitoring within Ontario include:**

- ☀ The CFIA undertakes monitoring and research regarding emerging pests such as ALHB and Oak Wilt.
- ☀ The CFIA is tracking the spread of EAB, HWA and other forest pests.
- ☀ The DFO conducts early warning surveillance for Asian carp and directly manages Sea Lamprey (*Petromyzon marinus*) in Canadian waterways.
- ☀ The Ontario Federation of Anglers and Hunters (OFAH) Invasive Species Awareness Program (ISAP) administers the Invasive Species Hotline and the Early Detection and Distribution Mapping System (EDDMapS) Ontario.
- ☀ An Early Detection and Rapid Response (EDRR) pilot program was initiated by the Invasive Alien Species (IAS) Collaborative in

2015 and the OIPC and ISC rolled out the program in Peel Region, Halton Region, Sault Ste. Marie, and Thunder Bay to pilot a comprehensive early detection and rapid response network across Ontario. The EDRR project aimed to work at the community level to train and equip volunteers with the skills and resources needed to better detect and reduce invasive species in Ontario. The ISC, the OIPC, and the Eastern Ontario Model Forest received additional funding in 2020 to expand the EDRR into Quinte, Kingston and Rideau regions.

- ☀ Local NGO Protect Our Water and Environmental Resources (P.O.W.E.R) has engaged in citizen science through coordinating volunteer opportunities including mapping European Reed occurrences along all roadsides in the Region of Peel.

Integrated Pest Management (IPM)

is a process for managing ecosystems to prevent the worst impacts of invasive pests using effective, economic, and environmentally sound techniques. The major components of an IPM program include prevention, identification, monitoring, management, and evaluation (IPM Ontario, 2017).

CVC's role is more suited to monitoring and surveillance rather than research, which occurs primarily at provincial and federal levels. However, CVC does collaborate in adaptive management research where possible. An example of this is in the research on biocontrols for EAB where CVC has partnered with Canadian Forestry Services in the release of the parasitic wasps *Tetrastichus planipennisi* and *Oobius agrili* on CVC lands.

Although there are several organizations involved in monitoring, locations are prioritized based on the organization's priorities and scope. Presently, within the watershed CVC is one of the select few active in on-the-ground monitoring and currently it is only focused on HWA at select priority sites at CVC conservation areas. However, there are many more watch species that require monitoring attention to ensure early detection and rapid response efforts are effective, not only within the watershed, but throughout Ontario. This is an integral part of any organization's integrated pest management (IPM) framework, because if new species are not detected early, then the adaptive management required will significantly increase in cost and effort.

The **Asian Carp Response Plan**, coordinated by the Department of Fisheries and Oceans (DFO), with support from the Ontario Ministry of Natural Resources and Forestry is a prime example of a functioning **EDRR program** within Ontario. This plan describes the response to Asian carp detections in the Great Lakes. It has various levels, triggers (such as species, number of fish, and fertility), and actions. It clearly outlines the command structure which includes the roles and responsibilities of those involved (Asian Carp Canada, 2020).

The term Asian carp refers to four species – Bighead Carp (*Hypophthalmichthys nobilis*), Silver Carp (*Hypophthalmichthys molitrix*), Grass Carp (*Ctenopharyngodon idella*) and Black Carp (*Mylopharyngodon piceus*). They were introduced to the southern United States in the 1970s and have since spread northward. The DFO conducted a Socio-Economic Impact Assessment in 2014 to determine what the financial impacts to fishing (commercial and recreational), recreational boating, wildlife viewing, and beaches and lakefront use would be if Asian carps were to establish a population and spread within the Canadian Great Lake waters. Over a 20-year period starting in 2018, the financial cost was estimated to be \$179 billion dollars (Government of Canada, 2014b).



OUTREACH AND EDUCATION

Many agencies and organizations recognize the key role of outreach and education in invasive species management, including the following examples:

- ☀ The Canadian Council for Invasive Species works to connect various agencies and land practitioners across Canada to invasive species related initiatives such as the Play Clean Go campaign.
 - ☀ The CFIA hosts online information related to forest pests, technical training through workshops, and presentations.
 - ☀ The ISC distributes a quarterly newsletter and bi-weekly e-blast to provide invasive species information.
 - ☀ The ISC and OIPC administer the EDRR Network in Ontario. The EDRR provides a public platform for collecting invasive species observations and connecting EDRR practitioners.
 - ☀ A collaboration between OIPC, CVC, OFAH and OMNRF resulted in the creation of the Landowner's Guide to Managing and Controlling Invasive Plants in Ontario.
 - ☀ The City of Brampton has information on their website on various invasive species and what management they are undertaking within the city.
 - ☀ The City of Mississauga has information on their website on various invasive species and what management they are undertaking within the city. They also hold information sessions for residents to provide further information.
 - ☀ The Town of Caledon has information on their website about forest pests including EAB and ALHB.
 - ☀ P.O.W.E.R has set up educational outreach booths within the watershed to disseminate outreach materials and information to the general public.
 - ☀ Many organizations within the watershed including The Riverwood Conservancy, the Canadian Foundation of University Women, and local naturalist clubs bring in guest speakers to present on various topics including invasive species education and awareness.
- CVC engages in invasive species outreach and education through a variety of media including our website, social/mainstream media, community workdays, workshops, presentations, and site visits.



COORDINATION

Coordination efforts can range from national and provincial initiatives, down to watershed or community-based undertakings. **Some examples of coordination efforts in Ontario include:**

- ☀ The DFO coordinates invasive species management in the Great Lakes and other international waterbodies (e.g. Asian Carp Program).
- ☀ The CFIA focuses on the coordination of detection and management of new invasive species that may enter Canada.
- ☀ The OMNRF is responsible for coordinating efforts on new invasive species that may enter Ontario.

- ☀ The ISC and the OIPC have been coordinating the Ontario EDRR network.

CVC coordinates invasive species management efforts on CVC owned and managed lands. In some instances where an infestation is determined to be a watershed priority, CVC has played a primary role with financial and in-kind support from partner organizations to coordinate invasive species management (e.g. DSV management on the Caledon Trailway and at Forks of the Credit Provincial Park).

ENFORCEMENT/REGULATION

There are several agencies responsible for enforcement and regulation at various levels, from regulating imports into Canada to actions undertaken on specific landholdings.

Some examples of those responsible for enforcement and regulation include:

- ☀ The Canada Border Services Agency plays an active role in stopping invasive species from entering Canada by air, land and water (Government of Canada, 2020d).
- ☀ The CFIA is responsible for plant protection import requirements under the Plant Protection Act regulating potentially harmful organisms or plant pests that are imported into Canada. This also includes organisms that may be contaminated with plant pests or are shipped in material that may be a plant pest or contaminated with a plant pest (Government of Canada, 2017).
- ☀ The DFO's Fishery Officers and Guardians enforce invasive aquatic species under Statutory Order and Regulation (SOR)/2015-121 which lists 103 invasive aquatic species that are regulated in Canadian waterways (Government of Canada, 2019a).
- ☀ The CFIA regulates the use of biological controls (biocontrols) for invasive species such as the *Galerucella* beetles used for Purple Loosestrife control (Government of Canada, 2019b).
- ☀ The OMNRF's Conservation Officers enforce and educate on laws protecting our natural resources, including the Invasive Species Act's prohibited and restricted invasive species (Province of Ontario, 2020d).



- ☀ The City of Mississauga passed a *Nuisance Weed and Tall Grass Control* by-law in 2017 stating that “Every Owner of Land shall destroy and remove all Nuisance Weeds and Nuisance Weed Seeds on their Lands.” The list of nuisance weeds includes several invasive plant species including DSV, European Buckthorn and Giant Hogweed (City of Mississauga, 2017). Under the by-law, City of Mississauga has the authority to enforce landowners to manage the species listed.

However, in many circumstances violations are reported incidentally, as there are not enough enforcement officers to cover all of Ontario, let alone Canada. At this time CVC only has an indirect role in invasive species related enforcement on CVC conservation areas, where CVC's Provincial Offences Officers enforce and educate conservation area visitors on the Conservation Authorities Act, for example encroachment violations where a plant species (which could include potential or known invasive species) has spread or is dumped from neighbouring properties.



SITE LEVEL MANAGEMENT

Typically, landowners or managers are responsible and accountable for invasive species management at the site level. When individual invasive species are regulated by provincial or federal agencies, site level management may be coordinated by responsible agencies or designated authorities; for example, CFIA's management of ALHB, and OFAH's management, through ISAP, of Water Soldier (*Stratiotes aloides*) in the Trent-Severn Waterway. **Within the watershed some examples of invasive species management include:**

- ☀ The City of Mississauga has several invasive species programs including an IPM program to monitor and control LDD, an EAB Active Management Plan, and a Giant Hogweed monitoring and control program (Culbert, 2019).
- ☀ The City of Brampton has been managing all occurrences (public and private properties) of Giant Hogweed within the city, has been managing hazard ash due to EAB, and has a LDD program.
- ☀ The Riverwood Conservancy has been managing several invasive species infestations including Garlic Mustard, European Buckthorn, and European Reed.
- ☀ In collaboration with private landowners and Parks Ontario, CVC has been working to manage the largest known infestation of DSV in the Credit River Watershed.

At the site level, CVC currently manages the impacts of EAB, retains any incidental collections of aquatic species during other routine sampling, and manages invasive plant species at 13 of 62 conservation areas; however, there are many more opportunities for implementation of priority projects not only on CVC properties but throughout the watershed. Some examples where increased efforts would be beneficial include ensuring invasive species do not continue to impact newly constructed sites within or adjacent to natural areas. A way to ensure this could be for municipalities to require an invasive species management clause for construction projects and for CVC to include maintenance costs including invasive species management for all restoration projects.



ADVOCACY

Advocacy for changes to (or enforcement of) existing legislation, or the creation of new legislation, related to invasive species management can originate from a range of individuals or organizations. Typically, the lobbying of governments to improve legislation or to enact local by-laws starts at the local level as NGOs and public citizens push to facilitate change.

Table 6 summarizes current roles and jurisdictional responsibilities of key agencies and organizations, specifying whether they play a primary or supporting role in invasive species management. **Although there are two role types defined, there are many organizations who further support invasive species activities; however, Table 6 lists the ones that have specific roles identified in their legislated mandate, as either a primary or supportive role:**

- ☀ A primary role is held by an organization that has a direct responsibility to the role.
- ☀ A supportive role is held by an organization that will help fulfill the role, but they are not directly responsible.

Relevant administrative legislations and policies are also referenced for each agency where applicable.

Jurisdictional responsibility	Specific Roles							
	Legislation and Policy	Funding	Research/ Science/ Monitoring	Outreach and Education	Coordination	Enforcement/ Regulation	Site Level Management	Advocacy
Federal								
Environment and Climate Change Canada Administers the <i>Canadian Environmental Protection Act</i> , <i>Species at Risk Act</i> , <i>Canada Wildlife Act</i> , <i>Wild Animal & Plant Protection & Regulation of International and Interprovincial Trade Act</i> .	P	P		S		P		
Canada Border Services Inspect for invasive species at Canadian borders						S		
Department of Fisheries and Oceans Administers the <i>Fisheries Act</i> *currently these roles are related to Asian Carp	P	P	P	P*	P*	P	P*	
Canadian Food Inspection Agency Administers the <i>Plant Protection Act</i> , <i>Seeds Act</i> , <i>Pest Control Products Act</i> *these roles are related to specific forest pests such as ALHB	P	P	P	S	P*	P*	P*	
Natural Resources Canada Includes the Canadian Forest Service who administer the <i>Forestry Act</i>	S		S	S				
Canadian Council for Invasive Species				P				S
Provincial								
Ontario Ministry of Natural Resources and Forestry Administers the <i>Invasive Species Act</i> , <i>Fish and Wildlife Conservation Act</i> , <i>Forestry Act</i>	P	P	P	S	P	P	P	
Ontario Ministry of Agriculture, Food, and Rural Affairs Administers the <i>Weed Control Act</i>	P		S			S	S	
Invasive Species Centre			P	P	P		S	S
Ontario Invasive Plant Council			S	P	S		S	P
Ontario Federation of Anglers and Hunters Invading Species Awareness Program				P	P		S	P
Local								
Credit Valley Conservation Administers the <i>Conservation Authorities Act</i>		S	S	S	S		P	S
Municipalities Enact the provincial <i>Weed Control Act</i> and local by-laws including Property Standards	S		S	P		P	P	S
Local Non-Government Organizations e.g., local stewardship councils, naturalist clubs and others			S	S			S	P
Public/Landowners			S				P	P

Table 6. Invasive species management roles and jurisdictional responsibilities.

3.2 Program Gaps and Opportunities

Given the sheer number of agencies and organizations involved in invasive species management, there is a high risk for potential and actual duplication of efforts. There are many opportunities for improved collaboration and partnerships through knowledge transfer, combining resources, and overall improvements in resource efficiency.

Categories with gaps and/or duplications in jurisdictional roles and responsibilities include the following and are discussed in greater detail below:

- ☀ Research, Science and Monitoring,
- ☀ Outreach and Education,
- ☀ Coordination, and
- ☀ Site Level Management.

3.2.1 RESEARCH, SCIENCE, AND MONITORING

Agencies discussed above that undertake research, science, and monitoring initiatives share a responsibility to communicate their results to other organizations and to identify gaps in the current science. Beyond a need to standardize monitoring protocols so that all parties are using the same indicators and thresholds, there is a need to expand the EDRR program to include species that may be found elsewhere in Canada or Ontario, but are still new and a priority to a smaller jurisdictional area, such as a region or watershed. Although the Ontario EDRR pilot has proven effective in northern Ontario, the same can not be said for Southern Ontario.

For any EDRR to be successful, dedicated funds and formalized partners are essential to ensure on-the-ground action can and will take place. This would create greater support of EDRR within the Credit River Watershed and the rest of the province.

CVC's role in research and monitoring for invasive species is focused on CVC owned and managed lands; however, a more comprehensive and integrated approach is needed, particularly where aquatic species are concerned. There are significant gaps in monitoring related to the early detection of many invasive species on CVC conservation areas no less the remainder of the watershed. Currently, most new invasions are limited to incidental reports. For example, in 2015 the first report of Common Carp in Island Lake Conservation Area was an incidental report from CVC staff. Since that time, IWMP staff have caught Common Carp at monitoring stations downstream in the Credit River, indicating their population is spreading. Before this time Common Carp had been primarily found in the lower watershed due to the high numbers seen in Lake Ontario, but they were contained due to upstream dams, as seen in **Figure 12**. Due to the incidental report at ILCA, the source of the upper watershed Common Carp population was known; however, by the time they were observed the population was well established. CVC has started a pilot project to assess the effectiveness of carp removal; however, at the current level of effort and funding, management will be focused on control rather than eradication.

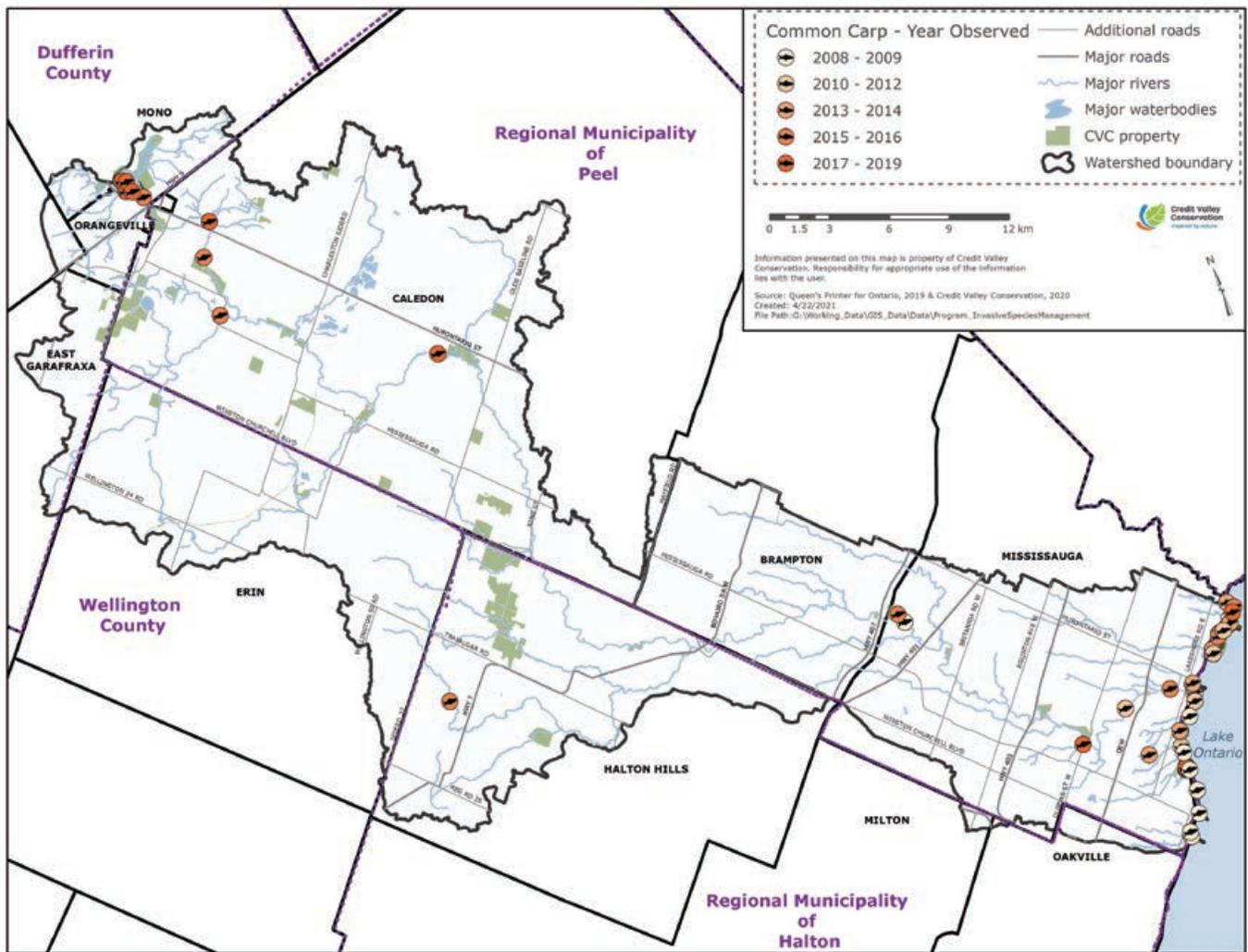


Figure 12. Locations and years Common Carp have been detected in the Credit River Watershed. Credit Valley Conservation, unpublished data (2008-2019).

3.2.2 OUTREACH AND EDUCATION

Numerous agencies and organizations conduct outreach and education activities related to invasive species management, and this can result in a duplication of efforts. Improved coordination is required to define the role of each organization and related target audiences. Federal and provincial programs tend to have a wider focus, while CVC, municipalities, and community-based NGOs are typically focused on more local audiences and would benefit from coordinating their efforts to meet shared objectives.

CVC provides technical support and education through site visits, presentations, specialized workshops, resources and materials (Figure 13), and participation on committees (OIPC, IAS Collaborative, etc.). Some of these approaches and materials are outdated and would benefit from being updated.

3.2.3 COORDINATION

Coordination for invasive species management is undertaken at many scales as identified in Table 6; however, jurisdictional roles are not always fulfilled. This results in a breakdown in chains of responsibilities, confusion in specific roles and mandates, and sometimes a lack of accountability. For example, forest pest monitoring at the federal level continues to be done strategically and rapid response measures have generally been effective. However, the coordination of the EDRR network for terrestrial plants within Ontario lacks accountability for on-the-ground management of new invasive species populations resulting in a failure of effective and rapid response measures.

CVC has the expertise to play a lead role in coordinating efforts for the early detection and management of terrestrial and wetland (priority) invasive species throughout the watershed but needs to be supported in this role by provincial agencies.



Figure 13. CVC uses a library of resources developed in collaboration with partners to share information about invasive species biology and management techniques.

3.2.4 SITE LEVEL MANAGEMENT

Roles and responsibilities for site-level management for terrestrial invasive species management tend to be clear as they typically fall under the responsibility of the landowner or land manager. Unless there is a regulated species or action, it is up to the landowner's discretion to manage the ecological health of their property. However, the interest or capacity to fulfill these commitments can be lacking even when species are listed as restricted under the provincial *Invasive Species Act*. This is understandable as not only do many landowners not have the technical knowledge

and/or skills to manage invasive species, but they may not have the interest or incentive to take on such labour intensive and costly efforts.

When invasive species management involves waterbodies, jurisdictions may overlap, and priorities may not be shared between various levels of governments, which can complicate management or eradication efforts. Since waterbodies are interconnected, the impacts of aquatic invasive species can rapidly extend far beyond the site, to a watershed-level and are therefore a priority to CVC.

Potential Aquatic Invasive Species Management: Round Goby in Hillsburgh

In 2013, CVC staff captured two Round Gobies in the West Credit River in Hillsburgh (Wellington County). Further sampling by OMNRF, CVC, and university researchers confirmed their presence in the two ponds downstream of the initial capture site and indicated that Round Goby were successfully reproducing. Concerns about related impacts included effects on native Brook Trout (*Salvelinus fontinalis*) upstream and downstream as well as concerns about downstream trout, salmon and benthic fish populations. OMNRF was the primary lead and developed a report outlining management options, including long-term suppression, containment, and eradication. OMNRF staff expressed interest in advancing this as a pilot project in support of the new Invasive Species Act and a means of testing the Rapid Response Framework for Invasive Species in the province. Ultimately, a decision was made not to move forward with efforts to manage the Round Goby at Hillsburgh. For the Credit River, this means there is a secondary source of further goby invasion located in the upper watershed posing a threat to native aquatic communities downstream.



ROUND GOBY IN HILLSBURGH POND



CLOSE UP OF A ROUND GOBY

4.0 Guiding Principles, Objectives and Actions

The preceding sections of this ISS described the current context of invasive species management within the Credit River Watershed, significant changes that have occurred over the past ten years, and jurisdictional roles and responsibilities. The manner in which CVC plans to respond to the increasing threat of invasive species over the next ten years is laid out in the following sections starting with the guiding principles, themes, objectives, and actions of this strategy (Figure 14). These were developed by the ISS steering committee with input from CVC staff and partners through internal and external workshops, meetings and draft reviews.

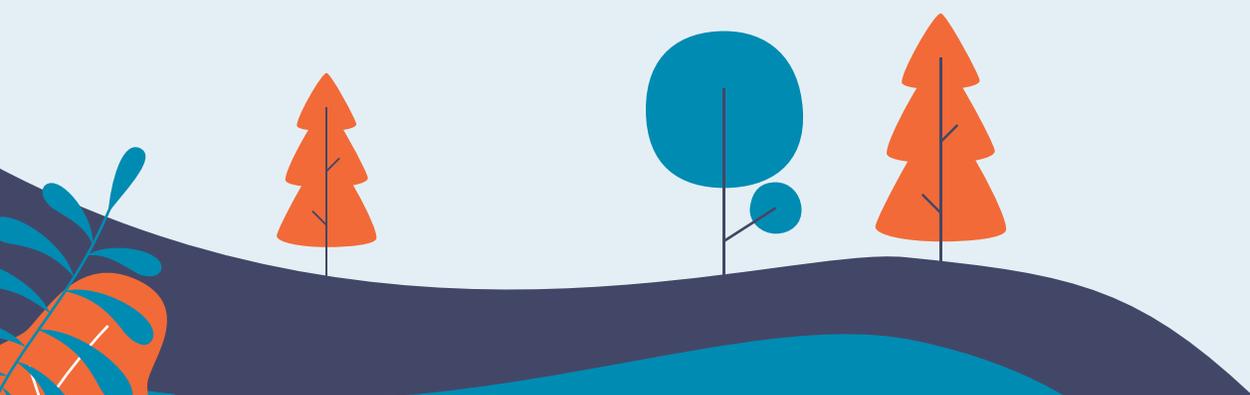


Figure 14. Organization of the ISS management direction.



4.1 Guiding Principles

The guiding principles of the ISS reflect implicit and explicit intentions that are inherent in the strategy's objectives and actions. They are intended to support relevant goals in CVC's strategic plan by defining the manner in which invasive species management work is conducted. The following guiding principles provide the broad approach and inform the implementation and future management decisions for the ISS:

- 1. Implement invasive species management practices that respond to the guidance set in Ontario.** Consistent with CVC's continued commitment to be a leader in invasive species management initiatives, the invasive species management activities will respond to the guidance set out in federal and provincial legislation, BMPs, and other technical documents.
- 2. Restore invasive species impacted habitats in a manner consistent with CVC restoration practices and guidelines.** CVC is committed to supporting the Ecological Restoration Strategy and Guidelines (CVC, 2020b). Monitoring and inventory data collected from the watershed will be used to guide the creation and update of restoration strategies and guidelines.
- 3. Use a science-based approach to a) develop invasive species priorities and b) guide invasive species management on CVC lands and within the watershed.** Using an integrated and transparent science-based priority setting process for invasive species management will enable CVC to clearly communicate priorities to staff, partners, and stakeholders, and will facilitate a rapid response to new invasive species invasions.
- 4. Employ Adaptive Management to continuously improve invasive species management and restoration of impacted native habitat.** The successful management of invasive species requires continued refinement of strategies and learning to implement the most effective and efficient approaches to invasive species management and restoration. Therefore, adaptive management is required to guide all invasive species management activities, ensuring that the methods and efforts employed will have a positive effect on the ecosystem of the Credit River Watershed.
- 5. Align this strategy with existing CVC, municipal, provincial, and federal strategies and plans.** The actions outlined in the ISS are not intended to be carried out in isolation; rather, they are intended to be aligned with objectives outlined in existing CVC strategies and plans, and those of CVC's agency partners.

4.2 Themes, Objectives and Actions

Three high-level themes connect through seven objectives and lead to 31 recommended actions for on-the-ground invasive species management. The three themes encompass ecology, connecting with others, and health and safety:

1	Protect and manage healthy ecosystems
2	Connect with local communities, stakeholders and the public
3	Ensure public health and safety

For each of the three themes, the following sections and accompanying tables outline the objectives of the ISS, and their corresponding actions and timelines for implementation. In addition, the status column indicates whether an action is:

- ☀ Ongoing (something CVC is already doing).
- ☀ Modify (CVC is proposing to adapt or improve on our current methods).
- ☀ New (something CVC feels is a priority and needs to be done/created).

Actions that require further elaboration are highlighted in the below tables and are discussed in detail in Section 5.

Actions will be undertaken in a collaborative manner with relevant staff to ensure that they support and enhance related programs within CVC, including the ISMP, IWMP, Outreach and Education, and Conservation Parks. It should be noted that most actions will continue beyond 2030, but it is anticipated that the ISS will be reviewed and updated at that time.

4.2.1 THEME 1: PROTECT AND MANAGE HEALTHY ECOSYSTEMS

CVC's commitment to protecting and managing a healthy watershed is highlighted throughout the strategic plan from planning for an environmentally sustainable future to managing a healthy, resilient environment and contributing to policy development. The ISS supports many of CVC's strategic goals and directions. **Table 7** outlines the objectives and actions which will be implemented to support protecting and managing healthy ecosystems in the Credit River Watershed, including the following:

- ☀ Predicting emerging threats to environmental health by monitoring for new invasive species entering Ontario and participating in rapid response mechanisms will ensure CVC has the most current information to make management decisions.
- ☀ Creating and using a transparent science-based priority setting process for new and existing populations of invasive species will ensure on-the-ground management is occurring where it will have the greatest impact.
- ☀ Regularly monitoring project success and invasive species management activities putting a primacy on ecological values.

Objectives and actions that deal with on the ground management of invasive species to protect significant ecological features and functions within the watershed.

OBJECTIVE	ACTION	TIMELINE	STATUS OF INITIATIVE
Objective 1- Prioritization Determine the status of invasive species in the watershed and prioritize species for management.	Action 1.1: Compile existing data on invasive species presence and extent in the watershed using internal and external resources. This includes incidental reports by staff and the general public and checking EDDMapS, fishing chat boards, and iNaturalist.	Ongoing	Ongoing
	Action 1.2: Assess invasive species presence data to determine which infestations could be eliminated (i.e. not fully established) and which infestations will be identified for ongoing management.	Ongoing	Ongoing
	Action 1.3: Develop a methodology to prioritize management of invasive species occurrences in the Credit River Watershed and create a layer within the watershed Restoration GeoBin application.	2022	New
	Action 1.4: Update CVC’s current Invasive species lists, including the addition of a management priority.	2021 and 2025	Modify
Objective 2- Prevention Prevent establishment of new invasive species populations in the watershed.	Action 2.1: Monitor reports of new invasive species entering Ontario from other provinces or the United States. This includes reviewing postings on EDDMapS, iNaturalist, fish chat boards, and reviewing the ISC and OIPC e-blasts.	2021-2030	Ongoing
	Action 2.2: Review existing CVC inventory, monitoring, and restoration performance monitoring programs and integrate invasive species monitoring where appropriate within the watershed.	2021 and 2025	Modify
	Action 2.3: Participate in rapid response initiatives to support control efforts of new invasive species occurrences on public and private properties.	2021-2030	Modify
	Action 2.4: Control new priority invasive species occurrences on CVC owned and managed lands.	2021-2030	Modify

Table 7. Protect and Manage Healthy Ecosystems: Objectives and Actions

Objectives and actions that deal with on the ground management of invasive species to protect significant ecological features and functions within the watershed.

OBJECTIVE	ACTION	TIMELINE	STATUS OF INITIATIVE
Objective 3- Eradication Eradicate populations of newly established priority invasive species before they spread on CVC owned and managed lands.	Action 3.1: Remove targeted populations and restore the project area when necessary.	2021-2030	Ongoing
	Action 3.2: Review current species detection and restoration performance monitoring protocols and update as required.	2022 and ongoing	Modify
	Action 3.3: Formalize annual staff training for bait fish identification to ensure no aquatic invasive species are being sold as bait at conservation areas.	Annually	Modify
Objective 4- Management Prevent further population expansions of invasive species that are management priorities.	Action 4.1: Develop an integrated pest management framework to ensure there is a response mechanism in place for all types of invasive species.	2021	New
	Action 4.2: Follow established best management practices including clean equipment protocols throughout CVC operations to reduce the spread of invasive species (e.g., on equipment and uniforms).	2021-2030	Ongoing
	Action 4.3: Create prioritized workplan (based on Action 1.3) on invasive species populations for management on CVC owned and managed lands.	Annually	Ongoing
	Action 4.4: Implement project plans for top priority invasive species populations on CVC owned and managed lands.	2021-2030	Ongoing
	Action 4.5: Create project plans for top priority invasive species populations for landowners and public within the Credit River Watershed.	2021-2030	Ongoing
	Action 4.6: Implement project plans for top priority invasive species populations on private and public lands.	2021-2030	Ongoing
	Action 4.7: Monitor success of implementation through Restoration Performance Monitoring and feedback to adaptive management approach.	2021-2030	Ongoing

Table 7. Protect and Manage Healthy Ecosystems: Objectives and Actions



4.2.2 THEME 2: CONNECT WITH LOCAL COMMUNITIES, STAKEHOLDERS AND THE PUBLIC

Prevention, detection, management, and monitoring of invasive species within the entire watershed cannot be effectively completed by any single agency. Outreach and education to the public, landowners and policymakers, and partnerships with other agencies and organizations are essential to the implementation of the ISS. **Table 8** outlines the objectives and actions which will be implemented to support connecting with local communities, stakeholders, and the public, including the following:

- ☀ CVC will continue to work with partners, other conservation authorities, and government agencies to define opportunities for collaboration on similar projects to maximize impacts and the efficiency of our service delivery.

- ☀ An important part of collaboration is the development and distribution of materials to communicate scientific information to the general public. Privately owned lands comprise a significant portion of the watershed and promoting behavioral change and private landowner stewardship can lead to large scale changes across the landscape. Therefore, CVC will continue to promote education and management of invasive species within the watershed.
- ☀ Education and outreach programs will focus on prevention (e.g., increasing public awareness about pathways of invasion, removing invasive species from the horticultural trade), monitoring (e.g., promoting the use of EDDMapS and other tools to report invasive species), and control (e.g. educating landowners on what tools they have available to remove invasive species).

Sets out how CVC will collaborate with others who are interested and/or invested in dealing with the impacts of invasive species within the watershed.

OBJECTIVE	ACTION	TIMELINE	STATUS OF INITIATIVE
<p>Objective 5</p> <p>Facilitate public and landowner education and participation in invasive species management in public and private spaces through communications and awareness.</p>	<p>Action 5.1: Prepare a marketing and communications plan to ensure invasive species education and awareness is achieved.</p>	<p>2021</p>	<p>New</p>
	<p>Action 5.2: Disseminate up to date information and best management practices from invasive species professionals to the public.</p>	<p>2021-2030</p>	<p>Ongoing</p>
	<p>Action 5.3: Identify gaps in invasive species best management practices (BMPs) and contribute to the development of new BMPs where gaps exist.</p>	<p>2021-2030</p>	<p>Ongoing</p>
	<p>Action 5.4: Engage the public and local partners in hands-on removal of invasive species and related stewardship activities.</p>	<p>2021-2030</p>	<p>Ongoing</p>
	<p>Action 5.6: Engage, educate, and provide support to watershed landowners (private and public) in invasive species management.</p>	<p>2021-2030</p>	<p>Ongoing</p>
	<p>Action 5.7: Work with the private contractor industry and partners to develop a training program to increase landowner options for ecologically sound invasive species management on private and public lands.</p>	<p>2022 and then every few years depending on demand</p>	<p>New</p>
	<p>Action 5.8: Encourage watershed landowners and public agencies to engage in practices that incorporate invasive species management.</p>	<p>2021-2030</p>	<p>Ongoing</p>

Table 8. Connect with Local Communities, Stakeholders and the Public: Objectives and Actions

Sets out how CVC will collaborate with others who are interested and/or invested in dealing with the impacts of invasive species within the watershed.

OBJECTIVE	ACTION	TIMELINE	STATUS OF INITIATIVE
Objective 6 Collaborate with municipalities and other levels of government to maximize impacts.	Action 6.1: Connect with municipal and other partners to facilitate collaboration, reduce duplication, and use organizational strengths to improve invasive species management within the watershed.	At least annually, if collaborative project initiated, then as project dictates.	Modify
	Action 6.2: Support invasive species research through partnerships with government and educational institutions.	2021-2030	Ongoing
	Action 6.3: Support efforts to identify areas of overlap and gaps between jurisdictions of our government partners and adjust priorities to try to resolve.	2022-2030	Ongoing

Table 8. Connect with Local Communities, Stakeholders and the Public: Objectives and Actions



4.2.3 THEME 3: ENSURE PUBLIC HEALTH AND SAFETY

Invasive species can pose a direct threat to human health and property. For example, Quagga and Zebra Mussels can have a significant effect on infrastructure and facilities that use surface water, including but not limited to, water treatment plants. Invasive species that pose a direct health risk to humans include Giant Hogweed, Wild Parsnip (*Pastinaca sativa*), Wild Chervil (*Anthriscus sylvestris*), and Spreading Hedge Parsley (*Torilis arvensis*). These species can cause skin irritation or allergic reactions through direct contact. There are also situations where invasive species can pose indirect risks to human health or property as

seen with EAB and HWA, which kill trees creating potential safety hazards to conservation area users, CVC staff, and infrastructure. Therefore, management of invasive species occurrences where they threaten human health and property will be given a high priority by CVC. Hazards on CVC owned and managed lands will be addressed in a timely manner to ensure staff and visitor safety. Managing these indirect threats is aligned with priority actions in CVC’s SFMP, which identifies managing hazard trees as an objective (Credit Valley Conservation, 2020a). **Table 9** outlines the objectives and actions that will be implemented to ensure invasive species related risks and hazards are managed.

Ensure that CVC properties are managed for invasive species related risks and are safe for staff and visitors			
OBJECTIVE	ACTION	TIMELINE	STATUS OF INITIATIVE
Objective 7 Safeguard infrastructure and the public from impacts of invasive species on CVC owned and managed lands.	Action 7.1: Control invasive species on CVC owned and managed lands that pose a threat to human health through direct contact.	2021-2030	Ongoing
	Action 7.2: Control invasive species on CVC owned and managed lands that are a human health and/or safety hazard or can impact natural and capital (infrastructure) assets.	2021-2030	Ongoing
	Action 7.3: Control invasive species on CVC owned and managed lands that could result in harm to staff or conservation area users through indirect means such as the creation of hazard trees.	2021-2030	Ongoing

Table 9. Ensure Public Health and Safety: Objectives and Actions



5.0 Implementation of the ISS

Since CVC has been managing invasive species for over a decade, implementation of this strategy will largely be incorporated into existing programs. To achieve the seven objectives, the implementation of the identified actions will be grouped into two key approaches:

- ☀️ Actions that highlight the need for guidance or methodology. For example, “develop a methodology to prioritize management of invasive species occurrences in the Credit River Watershed...”. These actions are timebound and have a more specific deliverable; and,
- ☀️ Actions associated with site-level management activities, such as following best management practices to ensure that the intent of an objective is met. These actions are “routine” and ongoing.

While many of the objectives and actions outlined above are already incorporated into existing CVC programs (status of Initiative is “ongoing”), there are also many actions that are either not reflected in existing CVC programming or require adaptations of existing programming. To aid in implementation, Section 5.1 provides additional details regarding the intent and scope of each of these new or modified actions. Section 5.2 summarizes Next Steps in terms of implementing the ISS.



5.1 New or Significantly Modified Priority Actions

As stated above, highlighted actions within Tables 5 to 7 are either new or significantly modified. Additional detail follows to add clarity to the intent and scope of each of these actions.



Theme 1: Protect and Manage Healthy Ecosystems

CVC has been very active in on-the-ground invasive species management activities, with early detection at 197 sites on CVC properties and implementation of over 190 control projects. However, within this theme there are five Actions in **Table 7** that require further discussion:

Action 1.3 - Develop a methodology to prioritize management of invasive species occurrences in the Credit River Watershed and create a layer within the watershed Restoration GeoBin application.

As discussed in Section 2.2, CVC maintains lists of invasive species that are updated as their status in the watershed changes or as new science emerges pertaining to their management. For practical reasons, this strategy addresses the control of invasive species that have known feasible management techniques available, and for which CVC has the knowledge or capacity to identify, track, and establish baseline data. Since it is not feasible to manage every species across the entire watershed, the prioritization of species and sites is essential to ensure the most effective use of limited resources.

To date CVC has focused efforts on highly aggressive invasive species, particularly in high-quality habitats; however, as the demand for invasive species management efforts increases, a formal decision matrix is needed to narrow down the scope to operate within available resources.



For future program direction and implementation CVC is proposing a two-step process:

- 1** Apply invasive species project decision flowchart (**Figure 15**)
- 2** Apply project prioritization tool (to be created)

The invasive species project decision flowchart (**Figure 15**) is used to determine if the potential project meets the established criteria for CVC to play a primary or supporting role in invasive species

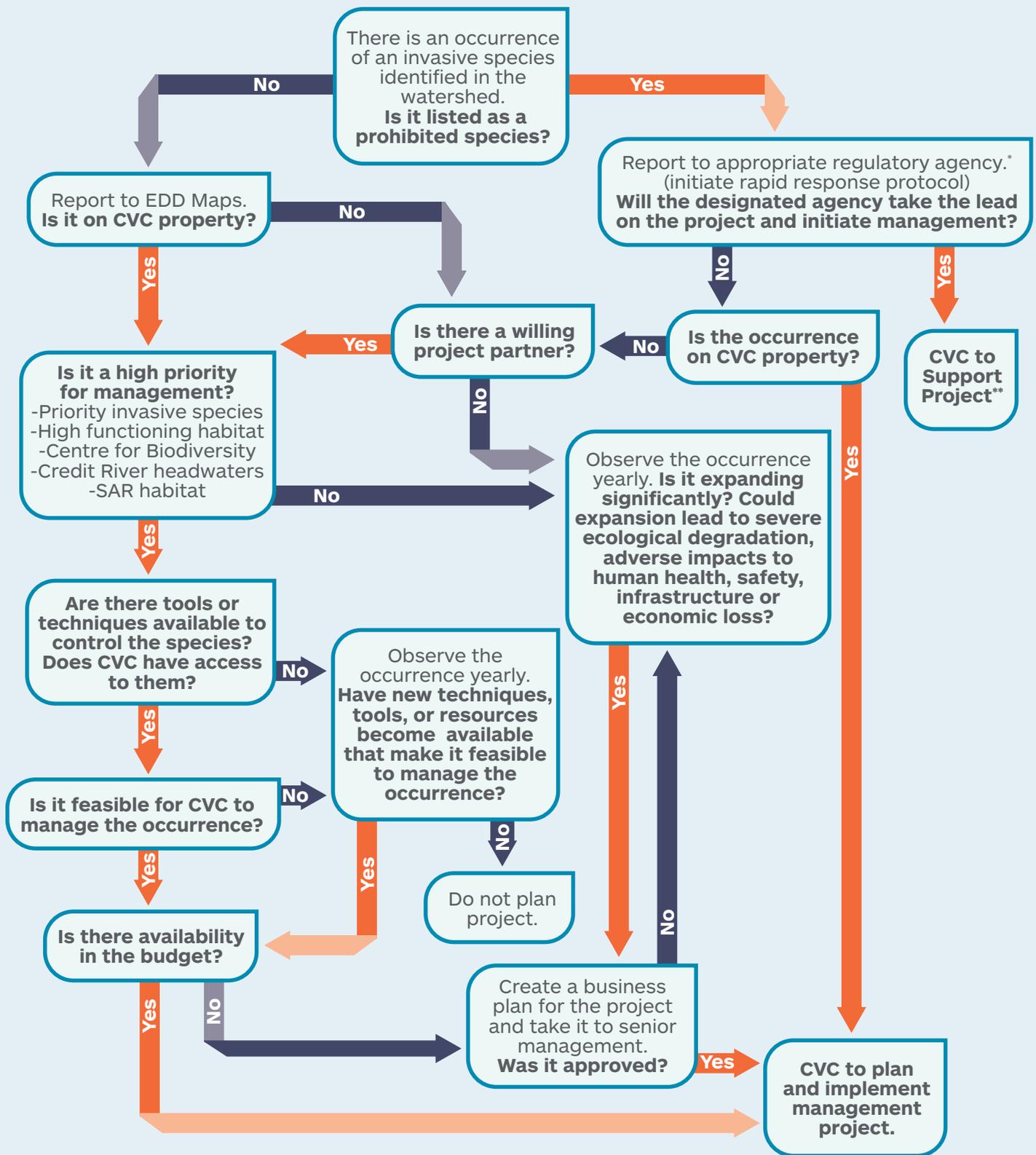


Figure 15. Invasive species project decision flowchart.

*Appropriate regulatory agencies include the Fisheries and Oceans Canada (DFO), the Ministry of Natural Resources and Forestry (MNRF), and the Canadian Food Inspection Agency (CFIA).

**Support to regulatory agencies may include personnel, equipment/supplies, public education and outreach, property access, and liaising with project partners.



management. CVC will play a primary role in managing priority projects on CVC conservation areas. Where potential projects involve lakes or watercourses (where jurisdictions overlap), CVC will manage aquatic projects on CVC conservation areas and share the responsibility with the lead agency(ies) for lakes and watercourses with invasive species that may impact CVC conservation areas.

If the outcome of the flowchart is that the project should be planned and implemented, then the project is to be screened by the project prioritization tool to determine the priority level of the project.

Action 2.2 - Review existing CVC inventory, monitoring, and restoration performance monitoring programs and integrate invasive species monitoring where appropriate within the watershed and Action 2.4 - Control new priority invasive species occurrences on CVC owned and managed lands especially with respect to management of aquatic invasive species.

To date, CVC's ISMP has focused more on terrestrial invasive plant management; however, greater cohesion into existing inventory and monitoring programs needs to be explored to ensure CVC is being fiscally responsible. As CVC continues to purchase

more lands, the amount of work required to monitor them for new invasive species occurrences increases. CVC needs to determine priority areas for monitoring and determine which teams are able to ensure these areas are monitored.

This is especially important for aquatic invasive species as currently there is no comprehensive monitoring program or routine management of aquatic invasive species due to a variety of factors including:

1. No high priority aquatic invasions within the watershed where CVC has had the primary role for management or the capacity to manage,
2. Outside of CVC's primary role, and
3. Detection and control efforts of aquatic species can be very complex for the following reasons:
 - a. permits are required to sample and detect aquatic fauna species,
 - b. species disperse easily and can move throughout the watercourse or waterbody,
 - c. many removal options can't guarantee complete eradication due to the continued movement of water,



- d. manual removal or water level manipulation are not always feasible and, in many circumstances, are most effective when done in combination with pesticide application, and
- e. limited options for pesticide use are currently available and ones that are available (e.g. rotenone) require a lengthy approval process.

There have been successful examples of implementing the management of aquatic invasive species through exclusion and/or removal in the watershed, including incidental removals during regular fish collection and the construction of control structures to exclude fish (and maintain water levels) in the wetlands at Jim Tovey Lakeview Conservation Area. However, there are also examples of missed opportunities for the management of aquatic invasive species, for example, the management of Round Goby and Yellow Floatingheart (*Nymphoides peltata*). In 2009 Yellow Floatingheart was identified in the lower Credit River, and in 2013 Round Goby was detected in the West Credit River. Removal of these species was not pursued due to a lack of defined leadership of the EDRR, uncertainties associated with control and approvals, agency leadership, and funding.

Currently, CVC does not have a formal monitoring program for aquatic invasive

species, so that new detections are typically found through incidental reports and other data sources. This approach can result in detections long after establishment (as seen with the Common Carp at Island Lake Conservation Area) which significantly compromises the ability to eradicate occurrences due to increased technical and financial feasibility.

Another challenge in the management of aquatic species is that the use of herbicides over water was prohibited in Canada until this year, making chemical control of aquatic plants nearly impossible without special exemptions and permits. However, currently only one herbicide has been approved and permitting is still required. CVC has yet to go through this process, but will be looking into the feasibility of it for some priority projects in the near future. Recent research into natural removal mechanisms and environmental half-life of common herbicides may lead to more herbicides being permitted for use over water in the coming years (Breckels & Kilgour, 2018). Herbicides and other chemical controls are an increasingly controversial subject, but they remain an effective and important tool in invasive species management and one CVC will continue to use. Rotenone has occasionally been used in Ontario for control of invasive fish, although permits are difficult to obtain. The use of rotenone and other chemicals for the control of invasive fish

may be explored further by CVC where management of invasive aquatic species is deemed a critical priority.

A more focused approach to aquatic invasive species management within the watershed and the integration of aquatic invasive species monitoring into existing CVC programs is needed. CVC will take the lead on the management of new priority invasive species on CVC conservation areas. The project area for aquatic species management (reach up and downstream) will be determined on a case-by-case basis depending on the species traits, stream characteristics, and extent of occurrence. In cases where the species are regulated by another agency such as DFO or OMNRF, CVC will follow the project decision flowchart outlined in **Figure 15** aiming to play a supporting role to responsible agencies. In cases where the species is on public or private property, CVC may play a supporting role dependant on CVC's prioritization of the infestation and available resources.

Action 2.3 - Participate in rapid response initiatives to support control efforts of new invasive species occurrences on public and private properties

A plan of action to deal with new invasive species recorded in the watershed is urgently needed; to date, the responses are seldom "rapid". The creation of a rapid response plan of action for new invasive species occurrences within the watershed is essential to allow CVC to respond to new threats as they emerge. CVC will work through the expanding EDRR network to develop a watershed-based rapid response plan.

CVC will take the lead on managing new invasive species on CVC conservation areas unless the species are regulated by another agency such as DFO or CFIA. In situations where the species is on public or private

property CVC may play a supporting role dependant on CVC's prioritization of the infestation and available resources.

Action 4.1: Develop an integrated pest management framework to ensure there is a response mechanism in place for all types of invasive species

With new introduced forest pests getting closer to the watershed (e.g. HWA and Oak Wilt), an IPM framework is essential for ensuring that CVC adaptively manages its conservation areas to detect and take action to eradicate new invasions. To date CVC, like many organizations, has been dealing with invasive species already present within the watershed that are causing the most harm either ecologically or to human safety. By the time the effects of most invasive pests are apparent, it is too late or very costly to manage the problem and eradication is difficult or even impossible to achieve. The formalization of an IPM framework, that expands CVC's current invasive species related efforts from primarily control and restoration performance monitoring to also include prevention and early detection, with clear roles and responsibilities of various teams within CVC, will ensure CVC is well situated to face the next significant invasion. It is conceivable that having such a program in place could have allowed for ash tree inoculations to occur earlier, likely saving additional ash trees from the impacts of EAB. When potential pest problems are identified through monitoring, pest population levels should be recorded and used to establish reasonable thresholds for treatment to reduce pest populations to acceptable levels. Equally important is evaluating the effectiveness of the treatments.

CVC is proposing to work with its partners to create and implement an IPM framework throughout the watershed, with CVC focusing its efforts on CVC conservation areas.



Theme 2: Connect with Local Communities, Stakeholders and the Public

CVC has been very active in working with local partners, community organizations, landowners and the public, and will continue to share knowledge and resources wherever possible. However, within this theme there are two Actions from **Table 8** that require further discussion:

Action 5.1 - Prepare a marketing and communications plan to ensure invasive species education and awareness is achieved.

As part of connecting with local communities, stakeholders and the public, CVC has been active in producing outreach and educational materials and resources in the last ten years. This has included maintaining information on CVC's website, posting social media content, providing presentations, and collaborating with partners in the creation of province-wide resources and factsheets. However, a strategic communications framework has never been created and many of CVC's materials and resources are now outdated.

Action 5.1 recommends reviewing existing communications products (including digital media, factsheets and brochures), creating a strategic communications framework, and determining the best tactics to support invasive species outreach and stewardship programming in both public and private spaces.

Action 5.8 - Encourage watershed landowners and public agencies to engage in practices that incorporate invasive species management.

There are many ways in which CVC can encourage landowners and land managers to manage their properties with invasive species in mind. However, there are two areas in which efforts could have significant impacts:

SALE OF INVASIVE SPECIES IN THE HORTICULTURE AND AQUARIUM TRADES

Many nurseries and aquarium suppliers sell invasive species, and this continues to be a major pathway of introduction for these species if they escape or are released into natural habitats in the watershed. CVC has been actively involved in outreach activities with these industries, including participating in the OIPC's Horticultural Outreach Collaborative and educating landowners on the benefits of using native plants in gardens and not releasing aquarium species into natural environments. However, it is an area that continues to require focus from an outreach and education standpoint.

MANAGEMENT OF INVASIVE SPECIES AT CONSTRUCTION AND RESTORATION SITES

As land development continues to expand throughout the watershed, the disturbance caused by construction sites creates optimal conditions for invasive species to spread from nearby sites or from equipment moving between sites. There are many examples where invasive plants such as European Reed move in following land development and take over any natural areas that may have been created or spread to the existing natural heritage system. This is also an ongoing challenge at many restoration sites where disturbance is intrinsic to the projects.



In addition to negatively affecting native biodiversity, the spread of invasive species can result in significant expenses to future and/or adjacent landowners if invasive species removal or re-planting with native species is required. To ensure that invasive species do not continue to impact newly constructed sites with or adjacent to natural

areas it is suggested that municipalities could require an invasive species management clause for a minimum of two to five years following construction. Furthermore, for CVC restoration projects, funds should be identified and allocated for maintenance including invasive species management for a minimum of five years.



Theme 3: Public Health and Safety

As safeguarding people, property and communities from hazards is priority for CVC, all the actions within this theme are ongoing (**Table 9**). This theme is in direct support of CVC's SFMP Action 15.1 (*Continue to develop and implement a Hazard Tree Program and review the current program to assess its effectiveness and make recommendations for improvement*) to ensure staff and park users are safe from hazards on CVC conservation

areas. Therefore, management of invasive species occurrences that directly or indirectly threaten human health and property are also given a high priority. As other invasive species that will kill or compromise the health of target trees, including HWA and Oak Wilt, move closer to the watershed, it is anticipated that there will be an increase in hazard trees on CVC properties.



5.2 Next Steps

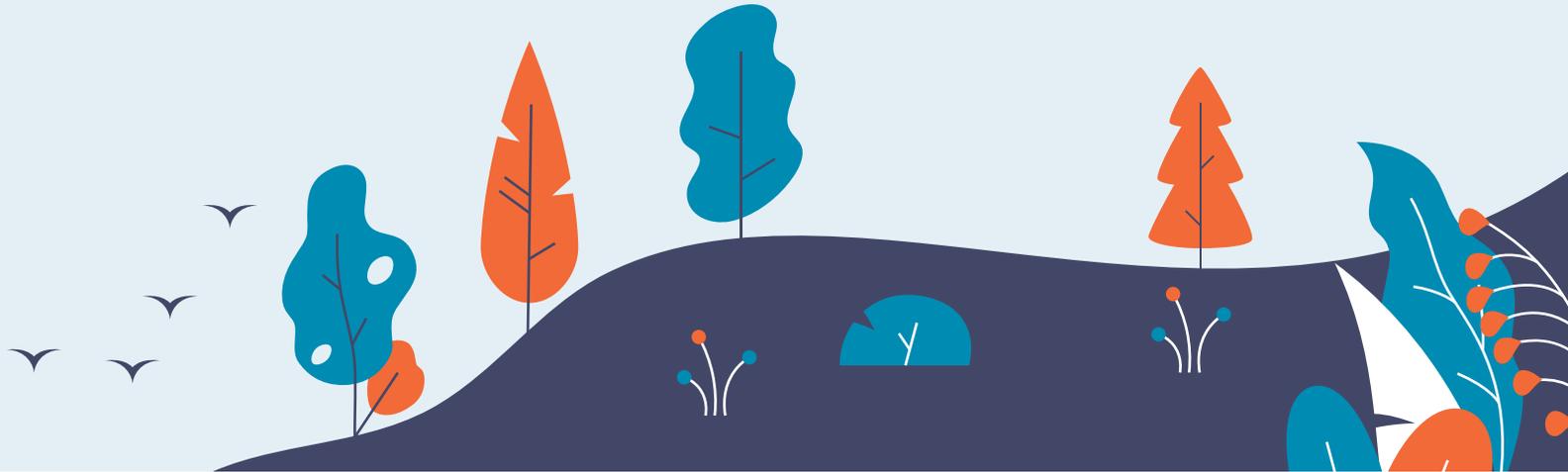
Although there are 31 actions with associated timelines outlined in Section 4, there are several immediate next steps for the successful implementation of the ISS:

- ☀️ Creation of tools to support prioritization of species and sites for management.
- ☀️ Formalization of an integrated pest management framework and early detection and rapid response program.
- ☀️ Review of existing CVC invasive species related protocols and outreach materials.
- ☀️ Increased collaboration and formalization of initiatives within CVC and with partners in early detection, site level management, outreach, and education.
- ☀️ Pursuit of funding opportunities to increase on-the-ground efforts and increase response times to new invasive species occurrences.

It will be the responsibility of the ISMP staff to administer and track the implementation of the suite of actions and to measure these, in order to track and report on objectives.

6.0 Conclusions

CVC's ongoing response to the threat of invasive species focuses on protecting and managing healthy ecosystems, connecting with partners and landowners, and ensuring the health and safety of public and staff.



There are currently 184 documented invasive species in the Credit River Watershed, with an additional 56 species on our doorstep. Some of these such as Asian carp and the forest pests (impacting beech, ash, oak, hemlock and maple) could have significant ecological and socio-economical impacts to our watershed. Although species that are at risk of arriving are of significant concern, there are also 72 currently present invasive species that are deemed management priorities.

To ensure that CVC can respond to new threats of invasive species from both an ecological and socio-economic perspective, the creation of an integrated pest management framework, a more comprehensive and integrated monitoring program, and a rapid response plan of action are needed. For any EDRR to be successful, dedicated funds and formalized partners are essential to ensure on-the-ground action can and will take place.

Managing current and potential invasive species is an objective shared with many of CVC's partners and exploring opportunities for leveraging resources and expertise with both municipalities and NGOs is mutually beneficial. CVC is well positioned to support municipal partners with on-the-ground invasive species monitoring and management. To ensure that invasive species do not continue to impact newly constructed sites with or adjacent to natural areas it is suggested that municipalities require an invasive species management clause following construction projects, and CVC restoration projects allocate funds for maintenance including invasive species management.

Numerous agencies and organizations conduct outreach and education activities related to invasive species management and would benefit from coordinating their efforts to meet shared objectives. CVC will continue



to support outreach and education activities to ensure residents are informed and aware of the impact invasive species have on the watershed and what can be done to manage them. The capacity of CVC to undertake invasive species management is directly related to legislation, corporate priorities, interagency collaboration, available funding, and human resources. However, many of the actions outlined in the ISS are underway and only require adaptive management.

As CVC continues to expand its property holdings, the amount of land requiring invasive species management will also increase. This will further CVC's need to prioritize efforts on CVC conservation areas, including safeguarding the health and safety of staff, visitors and property. The creation of a project prioritization process will ensure CVC uses its available resources to the best of its ability. The identification of dedicated funds to manage new invasive species on

both existing and new land holdings would allow CVC to respond more effectively to new infestations.

Achieving the objectives of the ISS will not happen overnight. Implementing the actions and acquiring the resources to do so will be an ongoing and challenging pursuit. CVC's continuing commitment to managing invasive species goes beyond the ten-year term of this strategy. By prioritizing and implementing the ISS over time, we are taking the necessary steps towards a healthier watershed, one that supports native species biodiversity and is better prepared for climate change. The reward will be a thriving environment that protects, connects and sustains us.

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APPENDIX A: SUMMARY OF ISMP ACTIVITIES (2008-2019)

	NUMBER BY YEAR										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
CONTROL PROJECTS											
Conservation Areas	5	23	42	46	35	42	46	52	48	50	40
Private Landowners		3	4	5	8	10	28	20	22	22	25
Public Lands				2	2	2	2	2	3	2	5
Restoration Performance Monitoring Sites		4	6	8	8	8	8	10	9	6	10
Project Area Managed (ha)	0.07	8.88	14.89	91.32	91.8	94.56	146.59	168.55	117.64	97.61	108.42
Technical Site Visits		4	5	6	11	16	59	27	69	30	39
OUTREACH AND EDUCATION											
Speaking Events		1	9	4	3	11	7	7	8	5	3
Technical Workshops		1	1	2	1	1	2	2	4	4	1
Volunteer Workdays		11	11	17	8	8	6	10	9	8	3
EMERALD ASH BORER											
Trail Assessments (km)					1	47.4	22.4	0	5	14.5	20.6
TreeAzin Injections						118	128	77	70	72	47
Hazard Ash Trees Removed						739	1395	2258	2764	995	1984
Trees and Shrubs Planted						941	3903	470	185	2655	0
Hazard Ash Removal Monitoring Sites					1	1	2	6	2	6	2
Invasive Species Control Projects in ash removal zones						1	4	7	4	7	7
DETECTION MONITORING SITES											
Emerald Ash Borer					74	11					
Hemlock Woolly Adelgid										17	95

Invasive Species Management Program

ISMP was established in 2007 and is the primary group responsible for implementing the ISS, prioritizing management of species and sites, monitoring the status of invasive plants in the watershed and providing technical advice to other CVC staff, agencies and the public about invasive species.

In addition to directly managing invasive species, ISMP delivers workshops in partnership with other teams within CVC or with external partners such as other conservation authorities, the OIPC, and local NGOs. ISMP helped establish working groups such as the Horticultural Outreach Collaborative (now part of OIPC) and the Invasive Alien Species (IAS) Collaborative. ISMP also helped establish the EDRR program for Ontario (now administered by ISC and OIPC). ISMP is an active member of OIPC and currently sits on the Horticultural Outreach Collaborative and the Ontario Phragmites Working Group.

Since 2013, a substantial portion of the ISMP's operating budget has been focused on management of the impacts of Emerald Ash Borer (e.g. monitoring, trail assessments, tree removal, TreeAzin injections). The majority of EAB- management activities were completed in late 2020, allowing for the ISMP to focus efforts on the implementation of ISS priority actions. Specific tasks and projects will depend on funding, organizational priorities and organizational structure.

Other CVC Teams and Programs

- ☀️ **Conservation Youth Corps (CYC) and Branch Out** engage high school students in conservation activities across the watershed, which includes invasive species removal and monitoring. CYC provides volunteer support to ISMP and other programs for invasive species management projects throughout the watershed, providing approximately 20 days of volunteer work per year.
- ☀️ The **Community Outreach** team organizes community and corporate events which have included invasive species removal on CVC properties in partnership with ISMP, and on public lands throughout the watershed.
- ☀️ The **Rural Landowner Outreach** team administers the Landowner Action Fund, a grant program for private landowners, which can bring funding to invasive species management projects on rural properties.
- ☀️ The **Urban Outreach** team holds workshops and gives presentations about invasive species in the urban landscape and in horticulture.
- ☀️ The **Forest Management** team leads hazard tree management for EAB in the watershed, supports ISMP on certain invasive species control projects, and conducts some invasive species management during regular forest

management activities, such as plantation thinning. CVC's Sustainable Forest Management Plan (2020) identifies the ISS as the strategy to be followed for invasive species management on CVC-owned woodlands.

☀️ The **Aquatic and Wetland Restoration and Management (AWRM)** team works with ISMP and other staff to manage invasive species on CVC lands, including removals, monitoring and restoration. In partnership with ISMP, AWRM employs licensed pesticide applicators who conduct European Reed management activities on private properties associated with existing wetland and aquatic restoration projects. AWRM has conducted removals of aquatic invasive species and maintains fencing to help exclude larger invasive Common Carp from restored portions of Rattray Marsh.

☀️ The **Lands Planning and Management (LPM)** team regularly monitors CVC trails and has undertaken invasive species management activities with guidance from ISMP. LPM produces monitoring reports for conservation areas, which provide information about invasive species concerns. LPM and other programs (e.g. Rural Landowner Outreach and Conservation Parks) have conducted one-off invasive species removal projects over the past decade.

☀️ The **Natural Heritage Management (NHM)** team have removed Common Carp at Island Lake Conservation Area. In addition, Island Lake Conservation Area staff have implemented an external bait ban and boat checking protocols at events. The NHM team develops management plans, tools and strategies to guide environmental protection, ecological restoration and land development within the CVC watershed. The team is in the process of reviewing all relevant CVC strategies, including the ISS, and incorporating them into a new Watershed Plan. The team has also created the Ecological Restoration Strategy and Guidelines, of which invasive species management is a significant component.

☀️ The **Natural Heritage Inventory (NHI)** team conducts detailed surveys of flora and fauna across the watershed and provides detailed mapping of invasive species to ISMP in the form of geographic information system (GIS) shapefiles. NHI determines the abundance of invasive species in vegetation communities within CVC properties, but provides less detail for non-CVC properties.

☀️ The **Integrated Watershed Monitoring** team conducts long-term monitoring throughout the watershed that can identify trends in invasive species distributions, emerging invasive species and ecosystem responses to invasive species.

Aquatic Invasive Species & Fish Diseases

Rank #	Ecological Rank Definitions
1	This category includes species that are either new to the watershed or new to a particular portion of the watershed (such as a new spatial occurrence in a priority location). These species have the potential to disrupt entire aquatic communities.
2	This category includes species that are already established in Lake Ontario or the watershed. These species have the potential to disrupt entire aquatic communities.
3	This category includes species with low or localized impacts on the surrounding aquatic community or those in which the potential threat is uncertain.
*	These species are not yet present in the watershed. These are on a 'watch list' of species that have the potential to impose significant impacts on aquatic systems should they be introduced.
Rank #	Management Rank Definitions
1	This category includes species whose distribution and occurrence is such that efforts to eradicate may prove successful if undertaken in a timely manner. Tools or techniques are available to enable management. Rapid response to detection is advisable on any new reports.
2	This category includes species whose characteristics of dispersal and introduction to new areas of the watershed is such that containment over the long term is not likely feasible. Efforts should focus on actively monitoring, reducing dispersal, and keeping the species out of high quality habitats and sensitive areas.
3	This category includes species that have already spread throughout the watershed or there are no tools and techniques available to contain or slow the spread. Efforts should focus on monitoring and opportunistic removal.

APPENDIX C: CVC 2020 INVASIVE SPECIES LISTS

Aquatic Invasive Species & Fish Diseases			
Common Name	Latin Name	Ecological Rank	Management Rank
Common Carp	<i>Cyprinus carpio</i>	1	2
Frog Virus 3 (FV3) (type species of Ranavirus genus)		1	2
Quagga Mussel	<i>Dreissena rostriformis bugensis</i>	1	3
Round Goby	<i>Neogobius melanostomus</i>	1	1
Rudd	<i>Scardinius erythrophthalmus</i>	1	1
Sea Lamprey	<i>Petromyzon marinus</i>	1	1
Zebra Mussel	<i>Dreissena polymorpha</i>	1	3
Banded Mystery Snail	<i>Viviparus georgianus</i>	2	3
Goldfish	<i>Carassius auratus</i>	2	2
Oriental Mystery Snail	<i>Cipangopaludina chinensis</i>	2	3
Amur Carp (Koi)	<i>Cyprinus rubrofuscus</i>	3	2
Red-eared Slider Turtle	<i>Trachemys scripta elegans</i>	3	3
Allegheny Crayfish	<i>Faxonius obscurus</i>	1*	3
Bighead Carp	<i>Hypophthalmichthys nobilis</i>	1*	1
Black Carp	<i>Mylopharyngodon piceus</i>	1*	1
Didymo Algae (rock snot)	<i>Didymosphenia geminata</i>	1*	2
Grass Carp	<i>Ctenopharyngodon idella</i>	1*	1
Louisiana Crayfish	<i>Procambarus clarkii</i>	1*	3
Marbled Crayfish	<i>Procambarus virginalis</i>	1*	3
Ruffe	<i>Gymnocephalus cernuus</i>	1*	1
Rusty Crayfish	<i>Faxonius rusticus</i>	1*	3
Silver Carp	<i>Hypophthalmichthys molitrix</i>	1*	1
Snakehead	Genera <i>Channa</i> and <i>Parachanna</i>	1*	1
Tench	<i>Tinca tinca</i>	1*	1
VHS (Viral Hemorrhagic septicaemia)		1*	2
Bloody-red Mysid	<i>Hemimysis anomala</i>	2*	3
Fishhook Waterflea	<i>Cercopagis pengoi</i>	2*	3
Spiny Waterflea	<i>Bythotrephes longimanus</i>	2*	3
Tubenose Goby	<i>Proterorhinus semilunaris</i>	2*	1
Mosquito Fish	<i>Gambusia affinis</i>	3*	1

Forest Pests & Diseases List	
Rank #	Ecological Rank Definitions
1	This category includes species that are rapid colonizers with the potential to overwhelm forest ecosystems at a watershed scale, and to transform the character and composition of native forests indefinitely. Successful establishment of these species within the watershed is associated with significant ecological, social and economic impacts.
2	This category includes species with the potential to impact forest ecosystems on a watershed scale. These species are more specialized, often targeting specific communities or non-dominant species. Successful establishment of these species is associated with ecological, social, and economic impacts however, natural systems may be able to recover over time.
3	This category includes species with the potential to impact forests at a community level. Localized impacts of these species may be significant but they are often self-regulated by environmental conditions.
*	These species are not yet present in the watershed. These are on a 'watch list' of species that have the potential to impose significant impacts on forest systems should they be introduced.
Rank #	Management Rank Definitions
1	This category includes species whose distribution and occurrence is such that efforts to eradicate new infestations may prove successful if undertaken in a timely manner. Tools or techniques are available to enable management of small, newly established occurrences. Rapid response to detection is advisable on any new reports.
2	This category includes species with established populations in the watershed. Species may be controlled with management actions, however these options are costly and are only utilized where and when appropriate.
3	This category includes species that have already spread throughout the watershed or there are no tools and techniques available to contain or slow the spread. Ongoing management options are limited and these species continue to alter the composition and character of forested landscapes.

APPENDIX C: CVC 2020 INVASIVE SPECIES LISTS

Forest Pests & Diseases List			
Common Name	Latin Name	Ecological Rank	Management Rank
Beech Bark Disease (scale)	<i>Cryptococcus fagisuga</i> (scale) <i>Neonectria faginata</i> (fungus)	1	3
Emerald Ash Borer	<i>Agrilus planipennis</i>	1	3
Butternut Canker	<i>Sirococcus clavigignenti-juglandacearum</i>	2	3
Dutch Elm Disease	<i>Ophiostoma ulmi</i> , <i>O. himal-ulmi</i> , <i>O. novo-ulmi</i>	2	3
LDD	<i>Lymantria dispar dispar</i>	2	2
Imported Willow Leaf Beetle	<i>Popillia japonica</i>	3	2
Japanese Beetle	<i>Cronartium ribicola</i>	3	3
Large Pine Weevil	<i>Hylobius abietis</i>	3	2
Pine Shoot Beetle	<i>Tomicus piniperda</i> (L.)	3	2
Satin Moth	<i>Plagiodera versicolora</i>	3	2
Sirex Wood Wasp	<i>Sirex noctilio</i> (F.)	3	2
White Pine Blister Rust	<i>Leucoma salicis</i>	3	2
Asian Long-horned Beetle	<i>Anoplophora glabripennis</i>	1*	1
Hemlock Woolly Adelgid	<i>Adelges tsugae</i>	1*	1
Oak Wilt	<i>Bretziella fagacearum</i>	1*	1
Spotted Lanternfly	<i>Lycorma delicatula</i>	1*	2
Beech Leaf Disease		2*	3

Invasive Plants	
Rank #	Ecological Rank Definitions
1	This category includes 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.
2	This category includes 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.
3	This category includes species that are moderately invasive but can become locally dominant given certain conditions (eg. Soils, recreational impacts, or disturbances).
4	This category includes 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.
5	This category includes species that 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.
*	These species are not yet present in the watershed. These are on a 'watch list' of species that have the potential to impose significant impacts on natural systems should they be introduced.
Rank #	Management Rank Definitions
1	This category includes species where management is high priority but control may be difficult to achieve. Upon detection, immediate removal is recommended. Potential for spread into other areas must also be controlled.
2	This category includes species where management is recommended for high quality habitats and habitat for species at risk to limit spread.
3	This category includes species where management is recommended if it falls into an existing management area to limit spread and prevent it from becoming locally dominant.
4	This category includes species where management is recommended but not a priority. It may be difficult to differentiate from native species too pervasive or impossible to track.

APPENDIX C: CVC 2020 INVASIVE SPECIES LISTS

Invasive Plants			
Common Name	Latin Name	Ecological Rank	Management Rank
Amur Silvergrass	<i>Miscanthus sacchariflorus</i>	1	2
Black Swallowwort	<i>Vincetoxicum nigrum</i>	1	1
Chinese Silvergrass	<i>Miscanthus sinensis</i>	1	2
Curly-leaved Pondweed	<i>Potamogeton crispus</i>	1	2
Dog-strangling Vine/European Swallowwort	<i>Vincetoxicum rossicum</i>	1	1
Dwarf Honeysuckle	<i>Lonicera xylosteum</i>	1	2
Eurasian Water-milfoil	<i>Myriophyllum spicatum</i>	1	2
European Black Alder	<i>Alnus glutinosa</i>	1	2
European Buckthorn	<i>Rhamnus cathartica</i>	1	2
European Reed	<i>Phragmites australis</i> <i>ssp. australis</i>	1	1
Garlic Mustard	<i>Alliaria petiolata</i>	1	2
Giant Hogweed	<i>Heracleum mantegazzianum</i>	1	1
Glossy Buckthorn	<i>Frangula alnus</i>	1	2
Goutweed	<i>Aegopodium podagraria</i>	1	2
Hybrid Cattail	<i>Typha x glauca</i>	1	4
Japanese Knotweed	<i>Reynoutria japonica</i>	1	1
Maack's Honeysuckle	<i>Lonicera maackii</i>	1	2
Morrow's Honeysuckle	<i>Lonicera morrowii</i>	1	2
Multiflora Rose	<i>Rosa multiflora</i>	1	2
Narrow-leaved Cattail	<i>Typha angustifolia</i>	1	4
Norway Maple	<i>Acer platanoides</i>	1	2
Oriental Bittersweet	<i>Celastrus orbiculatus</i>	1	1
Purple Loosestrife	<i>Lythrum salicaria</i>	1	2
Rough Mannagrass	<i>Glyceria maxima</i>	1	2
Showy Fly Honeysuckle	<i>Lonicera x bella</i>	1	2
Tatarian Honeysuckle	<i>Lonicera tatarica</i>	1	2
Yellow Floatingheart	<i>Nymphoides peltata</i>	1	1
Amur Maple	<i>Acer tataricum ssp. ginnala</i>	2	2
Autumn Olive	<i>Elaeagnus umbellata</i>	2	2
Black Locust	<i>Robinia pseudoacacia</i>	2	2
English Hawthorn	<i>Crataegus monogyna</i>	2	4
English Ivy	<i>Hedera helix</i>	2	2
Erect Hedge-parsley	<i>Torilis japonica</i>	2	2

APPENDIX C: CVC 2020 INVASIVE SPECIES LISTS

Invasive Plants			
Common Name	Latin Name	Ecological Rank	Management Rank
European Euonymus	<i>Euonymus europaeus</i>	2	2
European Lily-of-the-valley	<i>Convallaria majalis</i>	2	2
European Privet	<i>Ligustrum vulgare</i>	2	2
Fig-root Buttercup	<i>Ficaria verna</i>	2	2
Flowering-rush	<i>Butomus umbellatus</i>	2	2
Japanese Honeysuckle	<i>Lonicera japonica</i>	2	2
Periwinkle	<i>Vinca minor</i>	2	2
Purple Crown-vetch	<i>Securigera varia</i>	2	2
Purple Jewelweed	<i>Impatiens glandulifera</i>	2	2
Purple Willow	<i>Salix purpurea</i>	2	2
Scots Pine	<i>Pinus sylvestris</i>	2	2
Sea Buckthorn	<i>Hippophae rhamnoides</i>	2	1
Siberian Elm	<i>Ulmus pumila</i>	2	2
Spreading Hedge-parsley	<i>Torilis arvensis</i>	2	2
Sycamore Maple	<i>Acer pseudoplatanus</i>	2	2
Tree-of-heaven	<i>Ailanthus altissima</i>	2	2
White Mulberry	<i>Morus alba</i>	2	2
White Poplar	<i>Populus alba</i>	2	2
Wild Chervil	<i>Anthriscus sylvestris</i>	2	2
Winged Euonymus	<i>Euonymus alatus</i>	2	2
Yellow Iris	<i>Iris pseudacorus</i>	2	2
Alsike Clover	<i>Trifolium hybridum</i>	3	
Amur Corktree	<i>Phellodendron amurense</i>	3	2
Bitter Wintercress	<i>Barbarea vulgaris</i>	3	
Bittersweet Nightshade	<i>Solanum dulcamara</i>	3	3
Black Jetbead	<i>Rhodotypos scandens</i>	3	4
Black Knapweed	<i>Centaurea nigra</i>	3	
Bouncing-bet	<i>Saponaria officinalis</i>	3	
Brown Knapweed	<i>Centaurea jacea</i>	3	
Chinese Wisteria	<i>Wisteria sinensis</i>	3	2
Climbing Euonymus	<i>Euonymus fortunei</i>	3	2
Coltsfoot	<i>Tussilago farfara</i>	3	
Common Barberry	<i>Berberis vulgaris</i>	3	2
Common Kochia	<i>Bassia scoparia</i>	3	
Common Lilac	<i>Syringa vulgaris</i>	3	3
Common Tansy	<i>Tanacetum vulgare</i>	3	

APPENDIX C: CVC 2020 INVASIVE SPECIES LISTS

Invasive Plants			
Common Name	Latin Name	Ecological Rank	Management Rank
Common Teasel	<i>Dipsacus fullonum</i>	3	3
Crack Willow	<i>Salix euxina</i>	3	
Cranberry Viburnum	<i>Viburnum opulus ssp. opulus</i>	3	
Creeping Bellflower	<i>Campanula rapunculoides</i>	3	
Creeping Bentgrass	<i>Agrostis stolonifera</i>	3	4
Creeping Bugleweed	<i>Ajuga reptans</i>	3	
Creeping Buttercup	<i>Ranunculus repens</i>	3	
Creeping Thistle	<i>Cirsium arvense</i>	3	3
Creeping Thyme	<i>Thymus praecox</i>	3	3
Creeping Yellow Loosestrife	<i>Lysimachia nummularia</i>	3	
Dame's Rocket	<i>Hesperis matronalis</i>	3	3
English Violet	<i>Viola odorata</i>	3	
Eurasian Woodland Bluegrass	<i>Poa nemoralis</i>	3	4
European Mountain-ash	<i>Sorbus aucuparia</i>	3	
European Red Currant	<i>Ribes rubrum</i>	3	
European Stinging Nettle	<i>Urtica dioica ssp. Dioica</i>	3	
European Water-horehound	<i>Lycopus europaeus</i>	3	
False Spiraea	<i>Sorbaria sorbifolia</i>	3	
Field Bindweed	<i>Convolvulus arvensis</i>	3	
Five-leaved Aralia	<i>Eleutherococcus sieboldianus</i>	3	2
Garden Bird's-foot Trefoil	<i>Lotus corniculatus</i>	3	3
Greater Celandine	<i>Chelidonium majus</i>	3	3
Ground-ivy	<i>Glechoma hederacea</i>	3	
Hoary Alyssum	<i>Berteroa incana</i>	3	
Hybrid Crack Willow	<i>Salix x fragilis</i>	3	
Japanese Barberry	<i>Berberis thunbergii</i>	3	2
Japanese Hop	<i>Humulus japonicus</i>	3	
Japanese Tree Lilac	<i>Syringa reticulata</i>	3	3
Japanese-spurge	<i>Pachysandra terminalis</i>	3	2
Kentucky Bluegrass	<i>Poa pratensis ssp. pratensis</i>	3	4
Mahaleb Cherry	<i>Prunus mahaleb</i>	3	
Meadow Knapweed	<i>Centaurea x moncktonii</i>	3	
Mossy Stonecrop	<i>Sedum acre</i>	3	3
Narrow-leaved Bittercress	<i>Cardamine impatiens</i>	3	
Orange Daylily	<i>Hemerocallis fulva</i>	3	3
Orchard Grass	<i>Dactylis glomerata</i>	3	4

APPENDIX C: CVC 2020 INVASIVE SPECIES LISTS

Invasive Plants			
Common Name	Latin Name	Ecological Rank	Management Rank
Peppermint	<i>Mentha x piperita</i>	3	
Perennial Ryegrass	<i>Lolium perenne</i>	3	4
Purple Dead-nettle	<i>Lamium purpureum</i>	3	3
Quackgrass	<i>Elymus repens</i>	3	4
Red Clover	<i>Trifolium pratense</i>	3	
Russian Olive	<i>Elaeagnus angustifolia</i>	3	2
Short-fringed Knapweed	<i>Centaurea nigrescens</i>	3	
Siberian Squill	<i>Scilla siberica</i>	3	3
Smooth Bedstraw	<i>Galium mollugo</i>	3	
Smooth Brome	<i>Bromus inermis</i>	3	4
Spiked Sedge	<i>Carex spicata</i>	3	
Spotted Knapweed	<i>Centaurea stoebe</i>	3	
Tall Ryegrass	<i>Lolium arundinaceum</i>	3	4
True Forget-me-not	<i>Myosotis scorpioides</i>	3	3
Tufted Vetch	<i>Vicia cracca</i>	3	
Wayfaring Viburnum	<i>Viburnum lantana</i>	3	4
Weeping Birch	<i>Betula pendula</i>	3	
White Clover	<i>Trifolium repens</i>	3	
White Sweet-clover	<i>Melilotus albus</i>	3	3
White Willow	<i>Salix alba</i>	3	
Wild Carrot	<i>Daucus carota</i>	3	4
Wild Parsnip	<i>Pastinaca sativa</i>	3	2
Winter Aconite	<i>Eranthis hyemalis</i>	3	2
Wood Avens	<i>Geum urbanum</i>	3	4
Woodland Angelica	<i>Angelica sylvestris</i>	3	
Yellow Archangel	<i>Lamium galeobdolon</i>	3	3
Yellow Sweet-clover	<i>Melilotus officinalis</i>	3	
Absinthe Wormwood	<i>Artemisia absinthium</i>	4	4
Basil Thyme	<i>Clinopodium acinos</i>	4	4
Bull Thistle	<i>Cirsium vulgare</i>	4	4
Canada Bluegrass	<i>Poa compressa</i>	4	4
Canada Poplar	<i>Populus x canadensis</i>	4	4
Common Burdock	<i>Arctium minus</i>	4	4
Common Mullein	<i>Verbascum thapsus</i>	4	4
Common Vetch	<i>Vicia sativa</i>	4	4
Common Wormwood	<i>Artemisia vulgaris</i>	4	4

APPENDIX C: CVC 2020 INVASIVE SPECIES LISTS

Invasive Plants			
Common Name	Latin Name	Ecological Rank	Management Rank
Downy Brome	<i>Bromus tectorum</i>	4	4
Elecampane	<i>Inula helenium</i>	4	4
European Ash	<i>Fraxinus excelsior</i>	4	4
Four-seed Vetch	<i>Vicia tetrasperma</i>	4	4
Green-stemmed Forsythia	<i>Forsythia viridissima</i>	4	4
Little-leaved Linden	<i>Tilia cordata</i>	4	4
Oxeye Daisy	<i>Leucanthemum vulgare</i>	4	4
Redtop	<i>Agrostis gigantea</i>	4	4
Smooth-leaved Snowberry	<i>Symphoricarpos albus</i> <i>var. laevigatus</i>	4	4
Velvetleaf	<i>Abutilon theophrasti</i>	4	4
Weeping Forsythia	<i>Forsythia suspensa</i>	4	4
Wild Marjoram	<i>Origanum vulgare</i>	4	4
Yellow Bedstraw	<i>Galium verum</i>	4	4
Yellow Daylily	<i>Heemerocallis lilioasphodelus</i>	4	4
Black Medick	<i>Medicago lupulina</i>	5	
Butter-and-eggs	<i>Linaria vulgaris</i>	5	
Catnip	<i>Nepeta cataria</i>	5	
Common Hawkweed	<i>Hieracium vulgatum</i>	5	
Common Nipplewort	<i>Lapsana communis</i>	5	
Common St. John's-wort	<i>Hypericum perforatum</i>	5	
Common Water-hyacinth	<i>Eichhornia crassipes</i>	5	
Cypress Spurge	<i>Euphorbia cyparissias</i>	5	
February Daphne	<i>Daphne mezereum</i>	5	
Field Forget-me-not	<i>Myosotis arvensis</i>	5	
Foxtail species	<i>Setaria sp.</i>	5	
Garden Yellow Loosestrife	<i>Lysimachia vulgaris</i>	5	
Giant Foxtail	<i>Setaria faberi</i>	5	
Goat Willow	<i>Salix caprea</i>	5	
Great Burdock	<i>Arctium lappa</i>	5	4
Green Foxtail	<i>Setaria viridis</i>	5	
Heath Sedge	<i>Carex flacca</i>	5	
Horse Chestnut	<i>Aesculus hippocastanum</i>	5	
Italian Foxtail	<i>Setaria italica</i>	5	
Japanese Snowball	<i>Viburnum plicatum</i>	5	
Leafy Spurge	<i>Euphorbia virgata</i>	5	

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Invasive Plants			
Common Name	Latin Name	Ecological Rank	Management Rank
Musk Mallow	<i>Malva moschata</i>	5	
Nodding Thistle	<i>Carduus nutans ssp. nutans</i>	5	
Queen-of-the-meadow	<i>Filipendula ulmaria</i>	5	
Rabbit's-foot Clover	<i>Trifolium arvense</i>	5	
Rusty Willow	<i>Salix atrocinnerea</i>	5	
Scarlet Firethorn	<i>Pyracantha coccinea</i>	5	
Scotch Elm	<i>Ulmus glabra</i>	5	
Slender False Brome	<i>Brachypodium sylvaticum</i>	5	
Sweet Cherry	<i>Prunus avium</i>	5	
Tatarian Dogwood	<i>Cornus alba</i>	5	
Upright Forget-me-not	<i>Myosotis stricta</i>	5	
White Willow	<i>Salix cinerea</i>	5	
Woodland Forget-me-not	<i>Myosotis sylvatica</i>	5	
Yellow-and-blue Forget-me-not	<i>Myosotis discolor</i>	5	
Bohemian Knotweed	<i>Reynoutria x bohemica</i>	1*	1
Brazilian Water-milfoil	<i>Myriophyllum aquaticum</i>	1*	1
Brazilian Waterweed	<i>Egeria densa</i>	1*	1
Carolina Fanwort	<i>Cabomba caroliniana</i>	1*	1
Empress Tree	<i>Paulownia tomentosa</i>	1*	1
European Frogbit	<i>Hydrocharis morsus-ranae</i>	1*	1
Giant Knotweed	<i>Reynoutria sachalinensis</i>	1*	1
Himalayan Knotweed	<i>Koenigia polystachya</i>	1*	1
Hydrilla	<i>Hydrilla verticillata</i>	1*	1
Japanese Chaff Flower	<i>Achyranthes japonica</i>	1*	1
Japanese Stiltgrass	<i>Microstegium vimineum</i>	1*	1
Kobus Magnolia	<i>Magnolia kobus</i>	1*	1
Kudzu	<i>Pueraria montana</i>	1*	1
Porcelain-berry	<i>Ampelopsis brevipedunculata</i>	1*	1
Starry Stonewort	<i>Nitellopsis obtusa</i>	1*	1
Swollen Bladderwort	<i>Utricularia inflata</i>	1*	1
Water Chestnut	<i>Trapa natans</i>	1*	1
Water Lettuce	<i>Pistia stratiotes</i>	1*	1
Water Soldier	<i>Stratiotes aloides</i>	1*	1
Callery Pear	<i>Pyrus calleryana</i>	2*	1
Chinese Privet	<i>Ligustrum sinense</i>	2*	1
Japanese Angelica-tree	<i>Aralia elata</i>	2*	1

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Invasive Plants			
Common Name	Latin Name	Ecological Rank	Management Rank
Oval-leaved Privet	<i>Ligustrum obtusifolium</i>	2*	1
Small Carpetgrass	<i>Arthraxon hispidus</i>	2*	1
Small-flowered Jewelweed	<i>Impatiens parviflora</i>	2*	1
Wineberry	<i>Rubus phoenicolasius</i>	2*	1
Cut-leaved Teasel	<i>Dipsacus laciniatus</i>	3*	1
Diffuse Knapweed	<i>Centaurea diffusa</i>	3*	1
Great Yellowcress	<i>Rorippa amphibia</i>	3*	1
Japanese Virgin's Bower	<i>Clematis terniflora</i>	3*	1
Japanese Wisteria	<i>Wisteria floribunda</i>	3*	1
Siebold Viburnum	<i>Viburnum sieboldii</i>	3*	1
Tansy Ragwort	<i>Jacobaea vulgaris</i>	4*	1

Please direct comments and inquiries to:

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**Credit Valley
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