



TRCA Invasive Species Management Strategy 2020-2025

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INTRODUCTION

What Are Invasive Species?

The term “invasive” species has been used in different ways and often interchangeably with “alien”, “non-native”, “exotic”, and “introduced” in the literature (Richardson et al. 2000, Woods and Moriarty 2001, Blackburn et al. 2011, Carruthers et al. 2011). There are multiple frameworks available in literature that facilitates these terminologies and associated definitions. One of the widely adopted invasion framework is provided by Richardson et al. (2000) that views invasion as a series of barriers that a species navigates to establish itself so as to become naturalized or expand to become invasive (Emerton and Howard 2008, Blackburn et al. 2011). Thus, many official definitions distinguish the differences between these various terms and emphasize that “invasive” refers to the introduced or alien species that have the potential to cause significant changes to the ecosystems in which they are introduced.

The Global Invasive Species Programme and The World Conservation Union describes that the biological invasion occurs when a species enters a new environment, successfully establishes itself, changes the native species population and composition, and eventually disrupt the balance of plants and animal communities (Emerton and Howard 2008). Convention on Biological Diversity defines Invasive Alien Species (IAS) as species whose introduction and/or spread beyond their natural past or present distribution threatens biological diversity (Convention on Biological Diversity 2010). Government of Canada (2004) and Ontario Ministry of Natural Resources (2020) further elaborates that IAS are harmful non-native species, whose introduction or spread threatens the environment, economy, and/or society where their overall cost outweighs their beneficial aspect.

For the purposes of TRCA Invasive Species Management Strategy, IAS are defined as the non-native terrestrial and aquatic flora and fauna species and pathogens whose introduction and spread can pose significantly greater harm to the environment, economy and society compared to any potential benefit they might provide (Appendix 1 – *in progress*).

This Strategy also recognizes that not all non-native species are invasive, and that some native species can also show invasive characteristics. The latter are often perceived as less problematic and are attributed to the dynamic nature of ecosystems (DeLoach 1991, White et al. 1993). Box 1 provides a key difference between non-native and Invasive species. There is also an ongoing debate regarding what is considered native, including the reference time period used to make that judgement (Richardson et al. 2000, Guiasu 2016). More fulsome discussion on these debates are outside the scope of this Strategy and the reader are recommended to see Richardson et al. 2000 for more details.

Non-Native versus Invasive Species

Non-native: Any species whose presence in an ecosystem is due to intentional or accidental introduction as a result of human activity (synonyms: alien, exotic, non-indigenous).

Invasive: Any non-native species whose introduction and spread in an ecosystem can pose significantly greater harm to the environment, economy and society compared to any potential benefit they might provide

Impacts of IAS

IAS can have variety of direct and indirect environmental and socio-economic impacts. This Strategy acknowledges that most of IAS impacts are intertwined and are not separate entities, nevertheless for the purpose of discussion they are classified below as the ecological, economic, and societal impacts.

Ecological Impacts

IAS are considered a global threat to biodiversity and ecological stability (Simberloff 2000). A global assessment on biodiversity and ecosystem services identified that IAS is the fifth major driver for biodiversity loss globally (IPBES 2019). It highlighted that globally IAS has increased by 40% since 1980, mostly associated with increased trade and human population dynamics. It estimated that nearly one fifth of the Earth's surface is at risk from IAS impacting native species, ecosystem functions, and services that contribute human health and well-being. The rate of introduction of new IAS seems ever increasing with no signs of slowing, which may pose future threats to ecosystem and biodiversity (IPBES 2019). In Canada, about 24% of listed Species at Risk (e.g. American chestnut (*Castanea dentata*), eastern pondmussel (*Ligumia nasuta*) and American ginseng (*Panax quinquefolius*)) is estimated to be threatened with extinction due to IAS (Stronen 2002). In the Great Lakes there are about 160 IAS including sea lamprey (*Petromyzon marinus*) and zebra mussel (*Dreissena polymorpha*) that may have influenced the extinction of the native species such as deepwater cisco (*Coregonus johannae*) and native bivalve molluscs from some areas (Government of Canada 2004). Similar examples can be seen in urban areas where IAS such as emerald ash borer (*Agrilus planipennis*) and Asian long-horned beetle (*Anoplophora glabripennis*) have caused substantial damage to the various hardwood tree species (Government of Canada 2004).

In Toronto and region, there are anecdotal observations related to invasive species and wildlife impacts. For example, ovenbird (*Seiurus aurocapilla*), a ground-nesting forest bird, was observed in mature deciduous forest but disappeared when the understory became infested with dog-strangling vine (DSV) (*Vincetoxicum rossicum*). Similarly, historic populations of blue toadflax (*Nuttallanthus canadensis*), silverrod (*Solidago bicolor*) and the federally and provincially endangered bashful bulrush (*Trichophorum planifolium*) disappeared from sites when DSV infested the areas. When DSV infested a small milkweed (*Asclepias syriaca*) meadow, monarch butterfly (*Danaus plexippus*) that were previously recorded there were no longer found. Subsequently the DSV was managed, and milkweed and monarchs returned. Nevertheless, it is worth noting that anecdotally some urban-adapted species seem to benefit from some invasive plants. For example, American Robins (*Turdus migratorius*) readily eat the fruits from many exotic species, including European buckthorn (*Rhamnus cathartica*) and white mulberry (*Morus alba*) and in doing so assist in their spread.

Economic Impacts

Several studies have highlighted economic impacts of biological invasions indicating billions of dollars' worth of environmental damage caused by invasive species (Pimentel et al. 2001, Born et al. 2005, Pimentel et al. 2005, Colautti et al. 2006, Olson 2006, Lovell et al. 2006).

In Canada, the annual cost of IAS is broadly estimated to be as much as \$20 billion to the forest sector, \$7 billion for aquatic invasive species in the Great Lakes and \$2.2 billion for invasive plants alone in the agricultural sector (Environment Canada 2010). The cost of only 10 invasive species on fisheries, agriculture, and forestry is estimated to be \$187 million per year (Colautti et al. 2003).

In the Great Lakes it is estimated that the cumulative impact of zebra mussels (*Dreissena polymorpha*) ranges from \$3 billion to \$7.5 billion. The initial costs of zebra mussel control measures for Ontario Hydro alone were \$20 million, with an annual \$1 million in operating costs. In the prairies, a single invasive alien thistle species impacting a single crop, canola, is estimated to cost about \$320 million per year (Government of Canada 2004). Likewise, there are examples where intentionally introduced IAS creating massive economic costs such as kudzu vine (*Pueraria montana*), which was intentionally introduced into the southeastern United States to prevent soil erosion and has inadvertently caused millions of dollars of losses to timber productivity (Forseth and Innis 2004).

In Ontario, the direct cost of IAS control and management in natural areas by municipalities and conservation authorities are estimated to be \$50.8 million which does not include the indirect cost associated with habitat degradation, costs of restoration, loss of recreational values etc. (Vyn 2019)

Social Impacts

The social impacts of IAS are diverse and often complex. There are direct and indirect adverse impacts such as damage to private properties and infrastructure, loss of recreational and aesthetic value of natural areas, loss of traditional medicinal plants, clogging of water bodies preventing navigation access and angling, nuisance to landowners, as well as serious health risks such as allergies caused by giant hogweed (*Heracleum mantegazzianum*) and ragweed (*Ambrosia artemisiifolia*) (Cavin and Kull 2017). In addition, the IAS management often brings up societal uncertainties and controversies about social values, achievability, efficiency, social fairness, trade restrictions, and ethical implications (Crowley et al. 2017). This includes debate over use of chemical and biological control agents as well as large scale removal practices that may spark wide range of human interests and values.

For example, common reed or Phragmites (*Phragmites australis*) invaded the shoreline of Grenadier Pond in Toronto's High Park resulting in concerns from the local community regarding aesthetics about the pond being blocked from view. Subsequent efforts to manage Phragmites using pesticide application also resulted in concerns from the local community who oppose the use of pesticides. Boaters at Frenchman's Bay in Pickering have complained about Eurasian water-milfoil (*Myriophyllum spicatum*) where dense mats of the plant become tangled in boat propellers. A local community group approached the City requesting funding biocontrol (milfoil weevil *Euhrychiopsis lecontei*). The City agreed to partially fund the biocontrol program for 5 years but raised concerns about the cost and efficacy of the program over the long-term.

Rationale for IAS Management

The success of IAS often is attributed to their common characteristics of high dispersal ability, rapid reproduction and growth, and ability to adapt to and survive under wide range of environmental conditions (CBD 2010). When IAS are introduced to a new ecosystem, it may not have the natural predators and competitors present in its native environment that would normally control their populations (CBD 2010, Government of Canada 2017). IAS can create novel interactions with available biotic and abiotic elements of the ecosystem thereby altering habitats and affecting various ecosystem functions and services. This is especially pronounced in areas that are more disturbed (CBD 2010). As such, the overarching goal for IAS management is to prevent the undesirable impacts and ensure that the ecosystem function and services are resilient over long term.

Managing IAS in an Urban Context

The decisions and actions to manage IAS are extremely complex, especially in highly altered and continually disturbed ecosystems, such as urban ecosystems in the Toronto and region. In such systems, IAS are often widespread and persistent, available management resources are often limited, and opportunities for successfully managing invasive species are often restricted.

Urban areas are considered hotspots for invasive species as they possess characteristics that make them susceptible to biological invasion (Gaertner et al. 2017). Potgieter et al. (2020) identifies five major reasons for this. First, urban areas are hubs for the introduction of IAS, both intentionally and accidentally, mostly associated with human activities. Second, the availability of widespread and persistent seed source, especially for those IAS used for ornamental horticulture, aquaculture and the pet trade, increases the likelihood of their establishment and persistence (Pyšek 1998, Kowarik et al. 2013). Third, the variety of dispersal pathways and vectors in cities facilitate their rapid spread, both within urban core and into surrounding natural and semi-natural ecosystems (Alston and Richardson 2006, McLean et al. 2017, Padayachee et al. 2017). Fourth, altered disturbance regimes, complex physical structures, and increased resource availability associated with concentrated human activities create opportunities for the establishment, reproduction and proliferation of many alien species (Cadotte et al. 2017). Fifth, the alteration of biotic conditions, microclimatic conditions, hydrology, and soils are important mediators of the patterns and processes of biological invasions in urban ecosystems (Klotz and Kühn 2010). Accounting and managing for all these aspects of urban invasion are important for successful IAS management and requires a strategic approach with strong commitment in terms of financial and management resources over long term.

Another dimension of IAS in an urban context include the recognition that in highly altered areas with persistent disturbances (e.g. fragmented remnant forest patch in a densely populated urban core), IAS may provide and sustain some key ecosystem functions and services, which otherwise might not have been present (Elmqvist et al. 2008). These include urban heat island effect mitigation, providing accessible greenspace and recreation opportunity, soil stability, flood attenuation, erosion protection, and habitat (or stepping-stones within a fragmented area) for urban adapted species. In these situations, IAS management should consider a range of options, including adapting and managing for an altered state rather than focusing solely on control of invasive species, which may result in unintended consequences such as slope failures, increased flood risk, removal of an urban food source, decreased recreation opportunities etc. In addition, these consequences may spark social issues such as public opposition to management actions, especially if there are diversity of stakeholders who have different perceptions of IAS.

This underscores the complexity involved in IAS management within an urban context, where management

Invasive Species in an Urban Context

Urban areas often have IAS in their natural areas. The pervasiveness of these IAS may depend on multiple bio-physical and socio-economic factors including the extent of IAS management being undertaken. Given that the IAS impacts are largely negative, the management focus is on control and eradication of IAS. However, in highly altered areas with harsh bio-physical conditions, some of the established IAS may be the only source of desired ecosystem function and services (e.g. erosion control, thermal regulation). In such cases, the complexity involved in IAS management should be recognized and a wide range of management options should be considered including adapting to the altered state to avoid unintended consequences.

actions are expected to focus on achieving multiple objectives for both ecosystem health and human well-being. For effective invasive species management in urban landscapes, it is imperative to understand the costs and the benefits of various management actions and inactions. This requires a strategic invasive species management framework, which includes identification of priority areas and species of major significance for management (Lookingbill et al. 2014, Potgieter et al. 2018).

Managing IAS in TRCA context

IAS management is an important component for TRCA operations for both environmental (e.g. greenspace management) and socio-economic (e.g. responding to human health risks) reasons. TRCA and its partner municipalities have repeatedly expressed a strong commitment to healthy ecosystems that provide multiple ecosystem functions and services that are critical for human health and well-being. TRCA's *The Living City Policies, 2014* (LCP) highlights TRCA's mission to work with our partners to ensure that The Living City® is built on a natural foundation of healthy rivers and shorelines, greenspace and biodiversity, and sustainable communities. It acknowledges that the loss of native biodiversity and the proliferation of invasive species are a growing threat to local ecosystem function and that both land use and climate change are expected to exacerbate these issues. Accordingly, the LCP contains policies to recommend a natural approach to the landscaping adjacent to natural heritage systems with native, non-invasive and locally appropriate species.

The TRCA Strategic Plan (2018) includes several strategies, for which successful IAS management is a necessity. This includes managing our water resources for current and future generation (Strategy 2), rethinking greenspace to maximize its value (Strategy 3), foster sustainable citizenship (Strategy 5) and gather and share the best sustainability knowledge (Strategy 8). To achieve these, TRCA recognizes the need to enhance its ability to identify new and existing threats from IAS to strategically protect, manage, enhance and restore ecosystem functions and services, and promote public awareness and stewardship.

One of the key aspects of IAS management at TRCA is associated with it being one of the largest landowners in the GTA. TRCA and its partners operate its land holdings to serve several different purposes, including provision of nature-based recreational activities. Recreational activities are excellent ways to engage general public with nature, however they can also increase the risk of IAS spread. For example, recreational angling can result in the unintentional introduction of IAS (including pathogens) within a waterbody through live baits etc. Likewise, in some cases the public intentionally release IAS in water bodies to dispose of unwanted pets (e.g. red-eared sliders (*Trachemys scripta elegans*), goldfish (*Carassius auratus*)) or plant invasive horticultural plant species into natural areas or through "guerrilla" gardening. Improving education and awareness are key methods to address these issues, which can also be complemented by the creation and enforcement of specific policies (e.g. no live bait areas).

In addition, to fulfill its mandate to connect people with nature, TRCA is responsible for planning and implementing recreational trails in its properties. Well-planned and designed formal trails provide the public with safe access to nature, while allowing for conservation of ecosystem function and services). However, formal and informal trails can also introduce new pathways and vectors for IAS spread. The TRCA Trail Strategy (2019) includes "steward" as a guiding principle, which identifies the need to carefully plan new trail alignments and support stewardship of our natural resources. It also includes a number of strategic objectives and initiatives that reference the importance of sound planning, implementation, monitoring and adaptive management to help ensure ecosystem functions and services are protected and restored.

There are other programs under TRCA's mandate that may increase the risk of IAS introduction and spread in new areas. These are mostly associated with increased soil disturbance during forest management activities, the inland fill program, erosion control programs and even ecological restoration. TRCA recognizes that land management and land care practices must acknowledge IAS as a primary consideration before initiating such projects or programs and take steps to mitigate and restore over the long term. Best management practices such as species specific BMPs and the *Clean Equipment Protocol* (OIPC 2016) (Appendix 2) should become standard internal practices.

Lastly, the Planning and Development and Environmental Assessment permitting processes regularly flag the need for IAS management. Nevertheless, the recommended course of actions and approaches vary by municipality, which often pose challenge for consistent IAS management. TRCA recognizes the need to foster collaboration and work in partnership with its municipal partners and other stakeholders to facilitate consistent IAS management across TRCA jurisdiction.

Examples of IAS Initiatives

As of 2017, IAS in Canada account for at least 27% of all vascular plants, 181 insects, 24 birds, 26 mammals, 2 reptiles, 4 amphibians, 55 freshwater fish, several fungi and molluscs, and an unknown number of species that have not yet been detected (BioDivCanada 2017a). At a national scale, an Invasive Alien Species Strategy for Canada (IASSC) was developed and approved by federal, provincial and territorial governments in 2004. It focuses on minimizing the risk of IAS to the environment, economy and society through a hierarchical approach that prioritizes prevention, early detection, rapid response and management (Environment Canada 2004). Subsequently the federal government committed \$85 million over five years (2005–2010) to initiate the implementation of the IASSC including formation of the Invasive Alien Species Partnership Program (IASPP). About 141 projects targeting 277 IAS have been funded by IASPP between 2005 and 2010. Most of the projects focused on increasing stakeholder engagement, increasing IAS understanding and awareness to minimize the IAS risk, expanding species inventories and monitoring to detect the presence of new IAS infestations and the development of management activities to reduce the impact of established IAS (Environment Canada 2010). Since then, the federal government has continued to identify IAS as a shared priority with provincial and territorial governments and a Federal-Provincial-Territorial IAS Task Force was formed in 2015 (BioDivCanada 2017b). Furthermore, the 2020 Biodiversity goals and targets for Canada include the target: "By 2020, pathways of invasive alien species introductions are identified, and risk-based intervention or management plans are in place for priority pathways and species." (Government of Canada 2017, BioDivCanada 2017a).

Nationally, the Invasive Species Centre (ISC) is a non-profit organization dedicated to the prevention and spread of high-risk IAS in Canada by connecting stakeholders with knowledge and technology. They work with experts and stakeholders to identify priorities and gaps in knowledge, tools and resources. Programs under the ISC include Forest Invasives Canada and Asian Carp Canada.

At the provincial scale, the *Ontario Invasive Species Strategic Plan* (2012) (OMNR 2012) provides direction on how Ontario will meet the goals outlined in the federal IAS strategy. In 2015, Ontario passed the *Ontario Invasive Species Act* (2015), which sets out regulations to prevent and control the spread of invasive species. Species regulated under the act pose a risk to Ontario's natural environment. Based on the biological characteristics, risk of harm to the natural environment, ability to disperse, and social and economic impacts,

the overall IAS risk was assessed to identify two classes of IAS to be regulated under the act: prohibited and restricted. Both classes include IAS that are illegal to import, deposit, release, breed/grow, buy, sell, lease or trade with some exceptions. In addition, it is also illegal to possess, and transport prohibited species (OMNRF 2020).

The Ontario Invasive Plant Council (OIPC) is a chapter of the Canadian Council on Invasive Species and the primary provincial coordinating body for invasive plant management in Ontario. This non-profit organization provides citizens and organizations with practical tools and information to mobilize and engage communities and agencies to undertake prevention and management activities. Programs under the OIPC include the Ontario Phragmites Working Group (OPWG) and the *Grow Me Instead* guide.

The Ontario Invading Species Awareness Program (ISAP) is a program of the Ontario Federation of Anglers and Hunters (OFAH) in partnership with the MNRF. Its objectives are to generate education and awareness of Ontario's aquatic and terrestrial IAS, address key pathways contributing to introduction and/or spread, and facilitate monitoring and early detection initiatives for IAS across Ontario. The ISAP also operates a toll-free hotline where the public can speak with an invasive species expert and report sightings.

EDDMapS (Early Detection and Distribution Mapping System) is a web-based mapping system for documenting IAS distribution developed by the Center for Invasive Species and Ecosystem Health at the University of Georgia. The system allows participants to submit their observations or view results through interactive queries into the EDDMapS database. All information is reviewed to ensure accuracy and, once verified, is made freely available. EDDMapS Ontario is a program specific to the province that was developed through support from the ISC, OFAH and MNRF.

At the municipal scale, there are multiple IAS management initiatives that support local policies, plans, programs, and projects. These include development of IAS management strategies (BiodivCanada 2017a), best management practices guidelines (OIPC), and targeted IAS control for various operational reasons such as habitat management, restoration projects, maintenance of recreational uses (for complete list see OIPC 2012). In addition, there are policies on IAS management in municipal Official Plans as well as TRCA's the LCP (TRCA 2014) to allow for a functioning ecosystem and communities across the region. Several of TRCA's partner municipalities either have invasive species strategies or consider invasive species management through the implementation of forestry, parks and other community programs and initiatives. For example, the City of Toronto's Biodiversity Strategy and Ravine Strategy both have regard for invasive species management.

TRCA has been actively managing invasive species for many years to protect and enhance ecological features and functions, to protect human health, and to engage and educate the public. These initiatives include monitoring, controlling, and treating invasive species, restoring invasive-dominated habitat on TRCA properties, and promoting public awareness. Some examples of this work include participation in the development of the Ontario Invasive Plant Council's *Grow Me Instead* guides (OIPC 2020), community-based IAS management (e.g. garlic mustard pull events), Asian long-horned beetle surveillance, sea lamprey control, buckthorn, dog-strangling vine and Phragmites management at select sites, and emerald ash borer hazard tree management (TRCA 2012).

GUIDING PRINCIPLES, GOAL, AND OBJECTIVES

Guiding Principles

TRCA strives to protect and enhance ecosystem health and community well-being through various plans, programs, projects, and initiatives. This includes undertaking various initiatives and actions that is focused on invasive species management, especially if it is strategic and effective in achieving TRCA goals and objectives related to ecosystem function and services. The TRCA ISM Strategy has established the following five guiding principles to inform TRCA actions that relate to invasive species management directly or indirectly.

1. TRCA will strive to ensure that its **actions do not exacerbate the spread** of invasive species while balancing the other objectives of TRCA and its municipal partners.
2. TRCA staff will **stay up to date on science and best practices** related to invasive species management.
3. TRCA will **continuously test, evaluate, and refine** our ecosystem management practices adapting to changing conditions and incorporating updated information.
4. TRCA will **recognize that in human dominated areas invasive species may provide ecosystem functions** and services that are important for community well-being that otherwise would not be present and will account for these in decision-making.
5. TRCA will **recognize that partnerships, collaboration and cooperation** with municipalities, other Conservation Authorities, stakeholders, and other organizations are crucial for successful and strategic invasive species management.

Goal and Objectives

The TRCA ISM Strategy provides a systematic, consistent, and coordinated framework that outlines TRCA's goal and four objectives for managing IAS and provides guidance on appropriate actions at both local and regional scales.

Goal

TRCA's goal for IAS management is to protect and, where possible, enhance terrestrial and aquatic ecosystem function and services on TRCA-owned lands and other public lands to ensure ecosystem health and community well-being. The strategy also has regard for IAS recommendations on private lands as part of the planning and development process.

Objectives

The four objectives outlined below provide a comprehensive approach to achieving TRCAs goal. The actions outlined in section three are organized around each of these objectives.

1. **Prevention, early detection, and rapid response**
2. **Eradication, containment, and control**
3. **Protection of high priority areas**
4. **Coordination, knowledge transfer and building awareness**

The goal and objectives align well with the general invasion curve and framework for invasive species management illustrated in Figure 1. The figure summarizes the various stages of invasion and the appropriate and realistic objectives for management within the context of the time and effort required.

In early phases of invasion, when there is no or low coverage of invasive species the objective might be to prevent or eradicate problematic species, respectively. As time progresses, areal coverage of the invasive species may be larger and the objective may be to protect strategic assets such as areas important for ecosystem function or service, rather than complete eradication. The TRCA ISM Strategy recognizes this context-dependency and acknowledges that the target objective for invasive management may, and often should, differ to increase the prospects of success. In addition, the importance of coordination, collaboration, and partnerships with various stakeholders at multiple scales in all stages of invasive species management is underscored throughout the TRCA ISM Strategy.

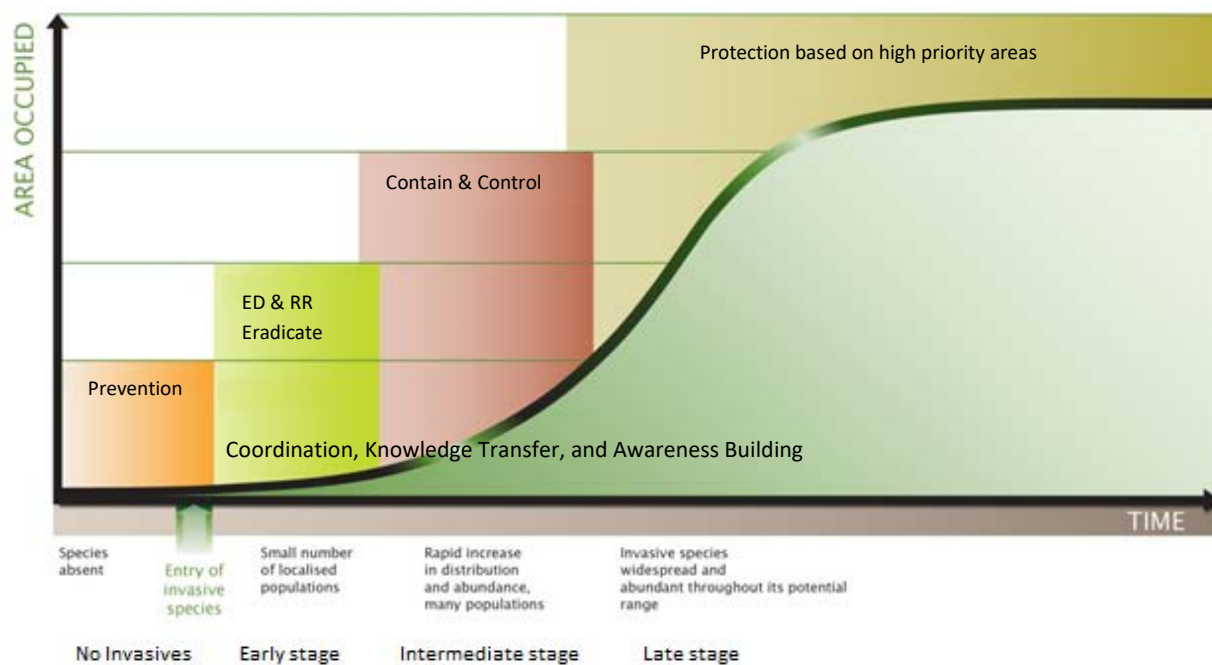


Figure 1: General invasion curve showing different objectives for management actions corresponding to the invasion stages and area occupied (spread) of invasive species. These include (i) Prevention, early detection and rapid response (ED & RR), (ii) Eradicate, contain, control, (iii) Protection of high priority areas, and (iv) Coordination, knowledge transfer, and awareness building (Adapted from: Harris et al., 2018)

Throughout the various stages of invasion curve, a multitude of management actions are needed to achieve the objectives identified above. However, to ensure success there are certain pre-requisites for each project to consider, such as adequate funding and commitment of funds for the entire duration required for successful control. Appendix 1 provides a broad self-assessment framework that highlights some of the major parameters to consider before undertaking ISM projects to ensure success.

OBJECTIVES, ACTIONS, AND SUCCESS CRITERIA

The TRCA ISM Strategy highlights four objectives and 10 actions that are important to realize the overall goal. Each action contains specific recommended tasks that are necessary to achieve them. Given that most of these tasks apply to multiple actions, they are summarized in Section 4, Table 1.

To facilitate effective implementation and tracking, high-level success criteria are also provided for each objective. This ensures that ultimate outcome can be measured to evaluate the successful implementation of the strategy.

Objective 1: Prevention, Early Detection and Rapid Response

Action 1: Promote and undertake strategic monitoring and use other external data sources to identify threats and risks to ecosystem function from emerging IAS in the jurisdiction or new infestation of established *high priority invasive species* (Appendix 2) in natural areas across TRCA's jurisdiction. Regularly review monitoring data to assess changes in invasive species extent/density over time.

Action 2: Promote and undertake activities to prevent introduction of all new *high priority invasive species* in natural areas across TRCA's jurisdiction, as appropriate.

Action 3: Initiate rapid response activities in areas where early detection of a *high priority invasive species* is confirmed.

Success Criteria

- a. Establishment of monitoring sites and monitoring plan for emerging *high priority invasive species* in key natural areas across TRCA's jurisdiction.
- b. Data collection on new (previously absent) *high priority invasive species* in natural areas across TRCA's jurisdiction.
- c. Prevention of identified *high priority invasive species* from being established in natural areas owned and/or managed by TRCA.

Objective 2: Eradication, Containment, and Control

Action 4: Use remote sensing, citizen science and where necessary strategic monitoring to identify threats and risks to ecosystem function from established *high priority invasive species* in natural areas owned and/or managed by TRCA.

Action 5: Undertake strategic and targeted management of established *high priority invasive species* with other agencies and partners to eradicate, contain, and/or control in natural areas owned and/or managed by TRCA, as appropriate.

Success Criteria

- a. Establishment of monitoring sites and monitoring plan for established *high priority invasive species* in key natural areas owned and/or managed by TRCA.
- b. Data collection on established *high priority invasive species* in natural areas owned and/or managed by TRCA.
- c. Decrease in IAS richness and extent within the properties owned and/or managed by TRCA.

Objective 3: Protection of High Priority Areas

Action 6: Undertake systematic monitoring to identify threats and risks to ecosystem function from *high priority invasive species* in *high priority areas* for ISM.

Action 7: Undertake actions to prevent introduction of all new and established *high priority invasive species* in *high priority areas*.

Success Criteria

- a. Establishment of monitoring sites and monitoring plans for all *high priority invasive species* in all *high priority areas*.
- b. Data collection on all *high priority invasive species* in all *high priority areas*.
- c. Decrease in invasive species richness and extent in *high priority areas*.
- d. Maintain or increase in the number of hectares of *high priority areas* managed annually by TRCA.

Objective 4: Coordination, Knowledge Transfer and Awareness Building

Action 8: Facilitate collaboration among partners in coordinating ISM efforts.

Action 9: Contribute to the development of best management practices (see Appendix) through partnerships with local and international researchers, regulators, and practitioners.

Action 10: Engage and educate community members and other partners in stewardship activities that prevent the introduction and spread of invasive species and protect ecological functions and services.

Action 11: Achieve comprehensive internal awareness of invasive species implications for ecosystems and the availability of best management practices.

Success Criteria

- a. Development of comprehensive data on ISM projects and locations in natural areas across TRCA jurisdiction including *high priority areas*.
- b. Increased communication, engagement, and coordination among partners (municipalities, provincial and federal governments, researchers, community groups) including increased awareness of respective projects and work plans, research partnerships and sharing of resources.
- c. Attendance and presentations at conferences and other forums (e.g. webinars).
- d. Membership and leadership roles when applicable in invasive species organizations (e.g. OIPC).
- e. Community participation in invasive species education programs and stewardship activities and follow up monitoring for effectiveness.
- f. Increased number of TRCA projects that incorporate invasive species considerations.
- g. Completion of ISM training for all TRCA staff involved in ecosystem management or any fieldwork.

TASK LIST FOR SUCCESSFUL IMPLEMENTATION OF ISM STRATEGY

Table 1 below identified specific tasks required to achieve the four objectives and 10 actions of the TRCA ISM Strategy. Completing these tasks will involve working collaboratively with TRCA partners to identify needs and achieve multiple benefits. Timelines will vary in length and some have already been initiated as indicated. Priority of tasks has not included but will come about as partnerships, partner objectives and projects arise.

Table 1. Task list aligned with the 10 actions identified in the TRCA ISM Strategy

Required Tasks (not in the order of priority)	Description	Linked to the 10 Actions	Status
1. Form a working group of internal staff and external partners for ISM.	To facilitate a coordinated approach to ISM including monitoring efforts and sharing data	All	Ongoing
2. Identify emerging and established high priority invasive species list.	To direct the strategic monitoring and ISM	All	Ongoing Estimated completion - December 2020
3. Establish study design, plan, and tools for monitoring new and established high priority invasive species.	To facilitate a systematic monitoring of invasive species.	All	TBD
4. Develop a coordinated early detection and rapid response framework.	To help ensure new high priority species are identified and effectively addressed.	A1, A2, A3	TBD
5. Identify high priority areas for ISM.	To direct strategic protection of high priority areas from invasive species	A5, A6	Ongoing Estimated completion - December 2020
6. Develop site and/or species-specific management plans (Invasive Species Management Plans ISMPs)	To direct on the ground control and public awareness and stewardship efforts	A1, A3, A5, A10	Ongoing
7. Establish experimental sites for active ISM by TRCA.	To monitor and evaluate management effectiveness and aid adaptive management.	A3, A4	Ongoing

8. Develop database of TRCA managed invasive project and locations.	To communicate, coordinate, and monitor the effectiveness of the management actions.	A7	Ongoing TRCA Iceberg Database
9. Stay up to date on BMPs and contribute to BMP updates locally and globally.	To ensure TRCA is using the most effective approaches / techniques to manage invasive species.	A4, A6, A7, A8	Ongoing
10. Develop applied research partnerships with leading academic partners.	To address gaps in knowledge and inform best management practices.	A6, A7	Ongoing
11. Identify and secure additional and long-term funding from other sources.	To help ensure the sustainability and effectiveness of the TRCA invasive species program.	A5, A6	Ongoing
12. Develop engagement, outreach, communication, and education programs and tools (e.g. website, citizen science monitoring tools)	To engage public, community groups, and other stakeholders on the issue of invasive species and actions they can take to help.	A7, A8	Ongoing
13. Develop and deploy an invasive species online training module for all staff and field staff.	To ensure TRCA staff are up to date in ISM in all TRCA work and implement best practices in daily activities.	A8	TBD
14. Attain and/or maintain membership on the board of relevant organizations.	To help ensure coordination across TRCA jurisdiction and beyond.	A5, A6	Complete
15. Attend and present at influential conferences.	To stay up-to-date on the ISM and knowledge exchange.	A6	Ongoing
16. Develop a set of recommended policy statements for The Living City Polices and internal guidance.	To facilitate incorporation of ISM in all of TRCA operations.	A6, A8	TBD

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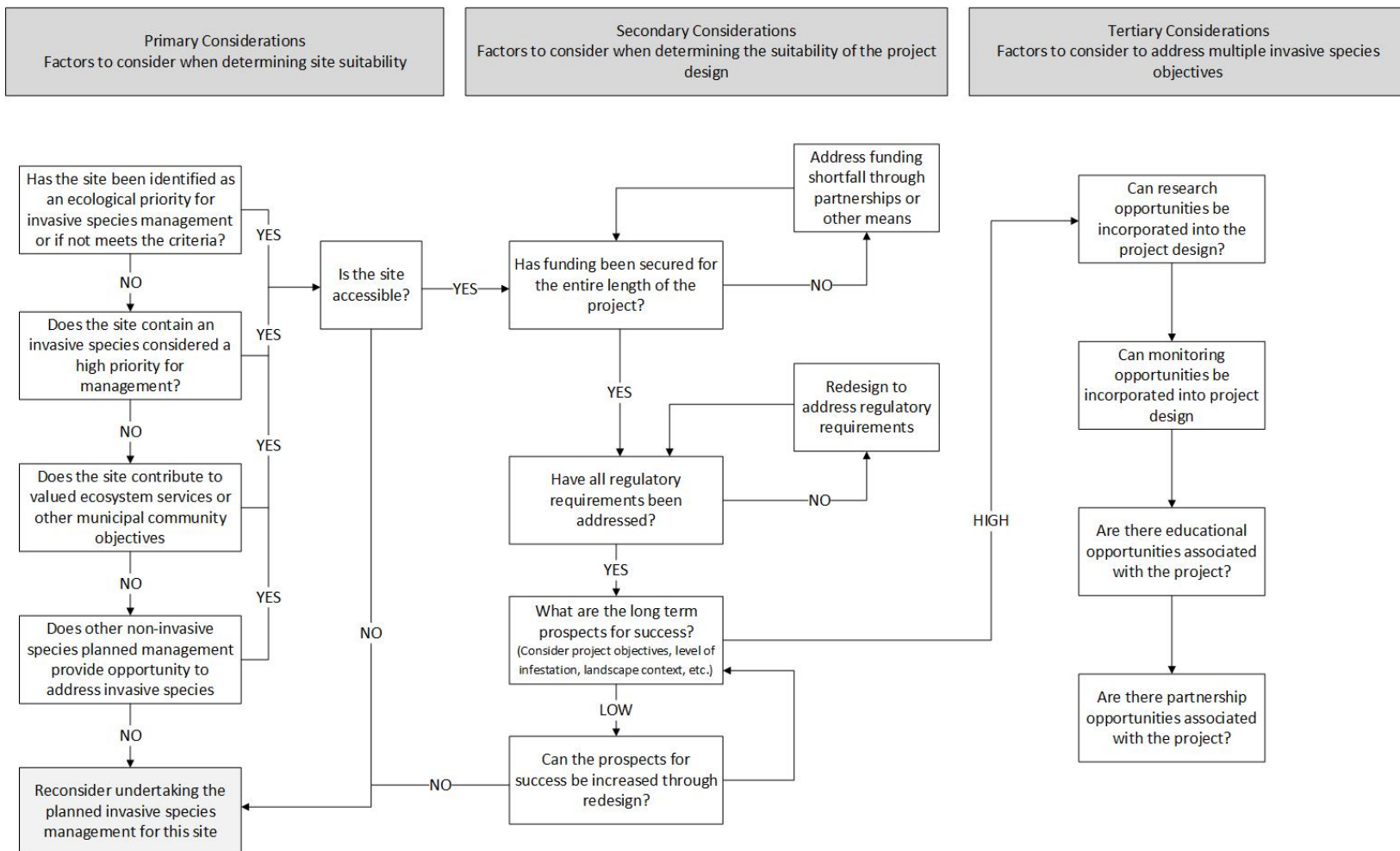
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APPENDIX 1: DECISION SUPPORT FLOWCHART FOR SUCCESSFUL IAS MANAGEMENT

On the ground management of invasive species is led by Restoration and Infrastructure and Development and Engineering Services (for aquatic fauna), however other divisions may also undertake site-specific or program-specific initiatives including Parks and Culture, and Education and Training. In addition, the invasive species management may be recommended or initiated through other organizational needs such as through development and infrastructure planning and permitting processes or special projects or watershed planning processes. The following decision support flowchart provides a high-level guidance and considerations for initiating and sustaining site level invasive management.



APPENDIX 2: BEST MANAGEMENT PRACTICES, TECHNICAL BULLETINS & MANAGEMENT PLANS

This Appendix is a living document and will be updated regularly as new content becomes available.

General

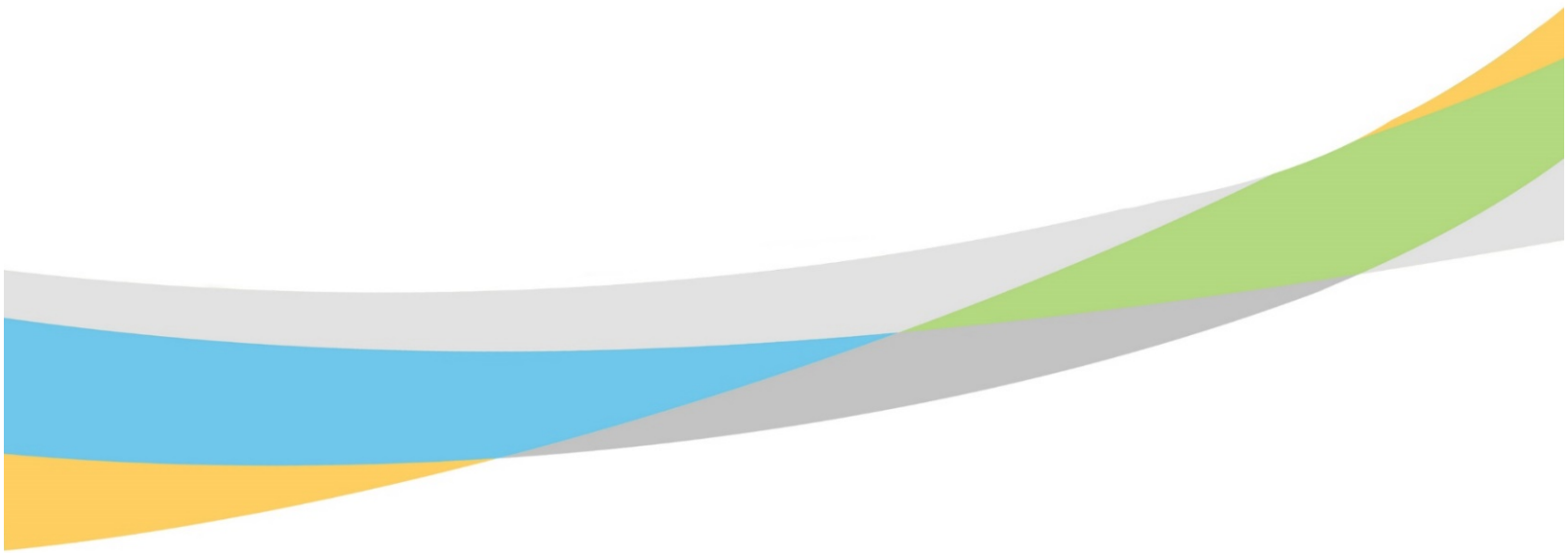
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