Watershed Management Plan: Biodiversity Component

Non-native and Invasive Species Management: A Review of Policies and Practices

Serving the Battle River and Sounding Creek watersheds in Alberta

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Front Cover: Leafy spurge along the central reach of the Battle River

Back Cover: Leafy spurge management along the central reach of the Battle River

This report contains information that may be subject to future revisions. Persons wishing to use this information in any form may wish to contact the Battle River Watershed Alliance to ensure they have the most recent version.

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List of Acronyms

AAF	Alberta Agriculture and Forestry
AAFC	Agriculture and Agri-Food Canada
ABMI	Alberta Biodiversity Monitoring Institute
ACRCC	Asian Carp Regional Coordinating Committee
AEMERA	Alberta Environmental Monitoring, Evaluation and Reporting Agency
AIMS	Agricultural Infestation Management System
AIS	Aquatic Invasive Species
AISC/AIPC	Alberta Invasive Species Council (formerly Alberta Invasive Plants Council)
ALMS	Alberta Lake Management Society
AWC	Alberta Water Council
BRWA	Battle River Watershed Alliance
CFIA	Canadian Food Inspection Agency
CVC	Credit Valley Conservation
EDDMapS	Early Detection & Distribution Mapping System
EDDR	Early Detection and Rapid Response
EPA	United States Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
FOCA	Federation of Ontario Cottagers' Association
GBC	Government of British Columbia
GIS	Geographic Information System
GOA	Government of Alberta

GOC	Government of Canada
GOM	Government of Manitoba
GOS	Government of Saskatchewan
HF	Human Footprint
IMISWP	Inter-Ministry Invasive Species Working Group (British Columbia)
IPPC	International Plant Protection Convention
ISAP	Invading Species Awareness Program (Ontario)
ISC	Invasive Species Centre (Canada)
ISCBC	Invasive Species Council of British Columbia
ISCM	Invasive Species Council of Manitoba
NAPPO	North American Plant Protection Organization
OFAH	Ontario Federation of Anglers and Hunters
OIPC	Ontario Invasive Plant Council
OMNR(F)	Ontario Ministry of Natural Resources (and Forestry)
PNWER	Pacific NorthWest Economic Region
PSMFC	Pacific States Marine Fisheries Commission
WID	Watercraft Inspection and Decontamination
WMP	Watershed Management Planning (Process)

Legal Citations

S refers to Statutes and **RS** refers to Revised Statutes of a given province. For example, Statutes of Alberta is abbreviated to **SA** and Revised Statutes of Alberta is abbreviated to **RSA**. Manitoba uses the unique abbreviation of **CCSM**, which stands for Continuing Consolidation of the Statutes of Manitoba.

R or **Reg.** refers to regulations of a given province. For example, Alberta Regulation is abbreviated to **AR**. Consolidated Regulations of Canada is abbreviated to **CRC**.

1 Background

Under *Water for Life: Alberta's Strategy for Sustainability* (Government of Alberta [GOA], 2003), the Battle River Watershed Alliance (BRWA) is the Watershed Planning and Advisory Council for the Battle River and Sounding Creek watersheds within Alberta. Figure 1 shows a map of the BRWA's planning boundaries.

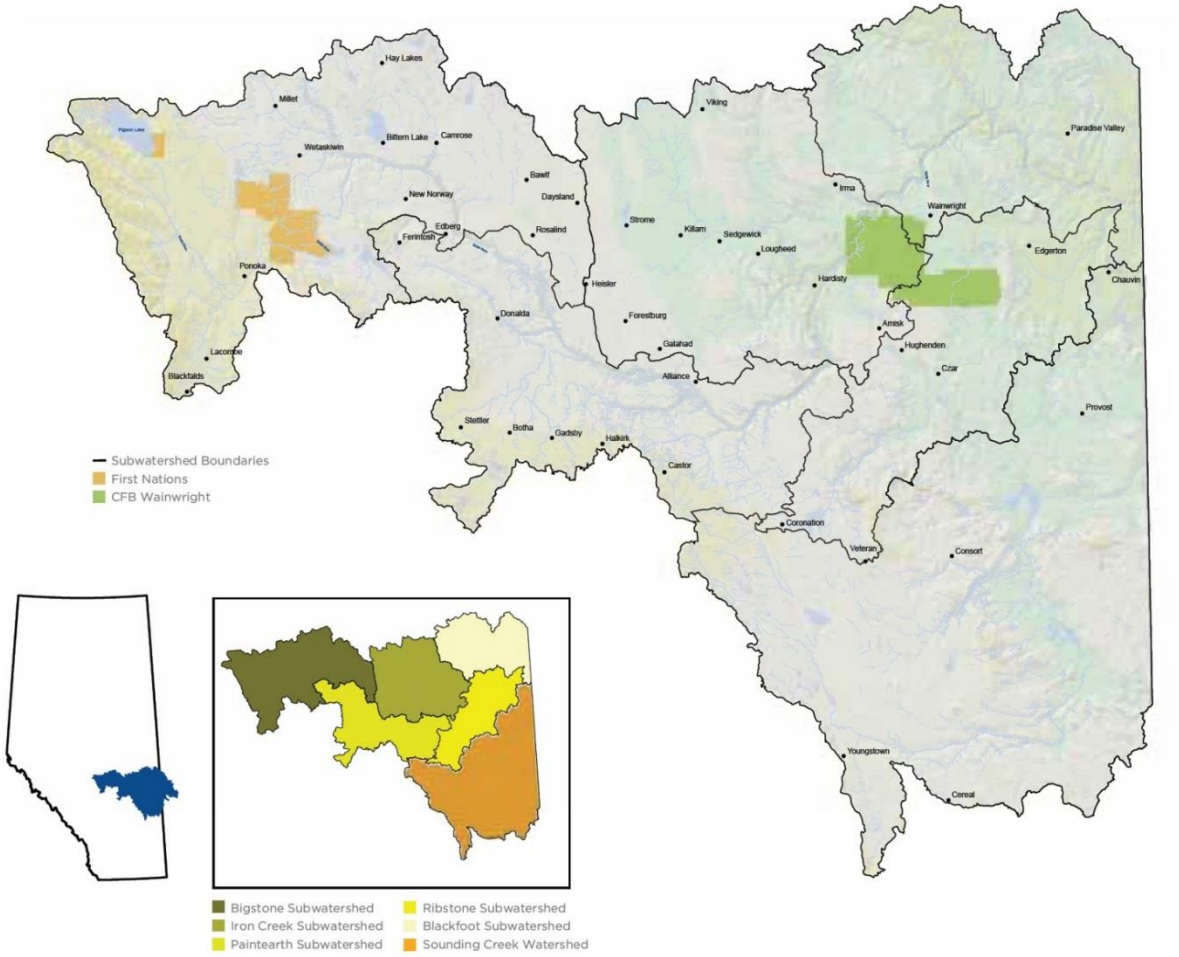

Figure 1. **Battle River and Sounding Creek Watersheds within Alberta (BRWA planning boundaries)**

In 2011, the BRWA completed its first State of the Watershed Report (BRWA, 2011). With the completion of this report, the BRWA has now shifted into its watershed management planning (WMP) process. This work is guided by the BRWA's WMP Terms of Reference (BRWA, 2012).

As outlined in the WMP Terms of Reference, various "watershed management components" have been identified as key issue areas to be addressed through the WMP process. These are outlined in Figure 2. Non-native and invasive species management has been identified as one of these components.

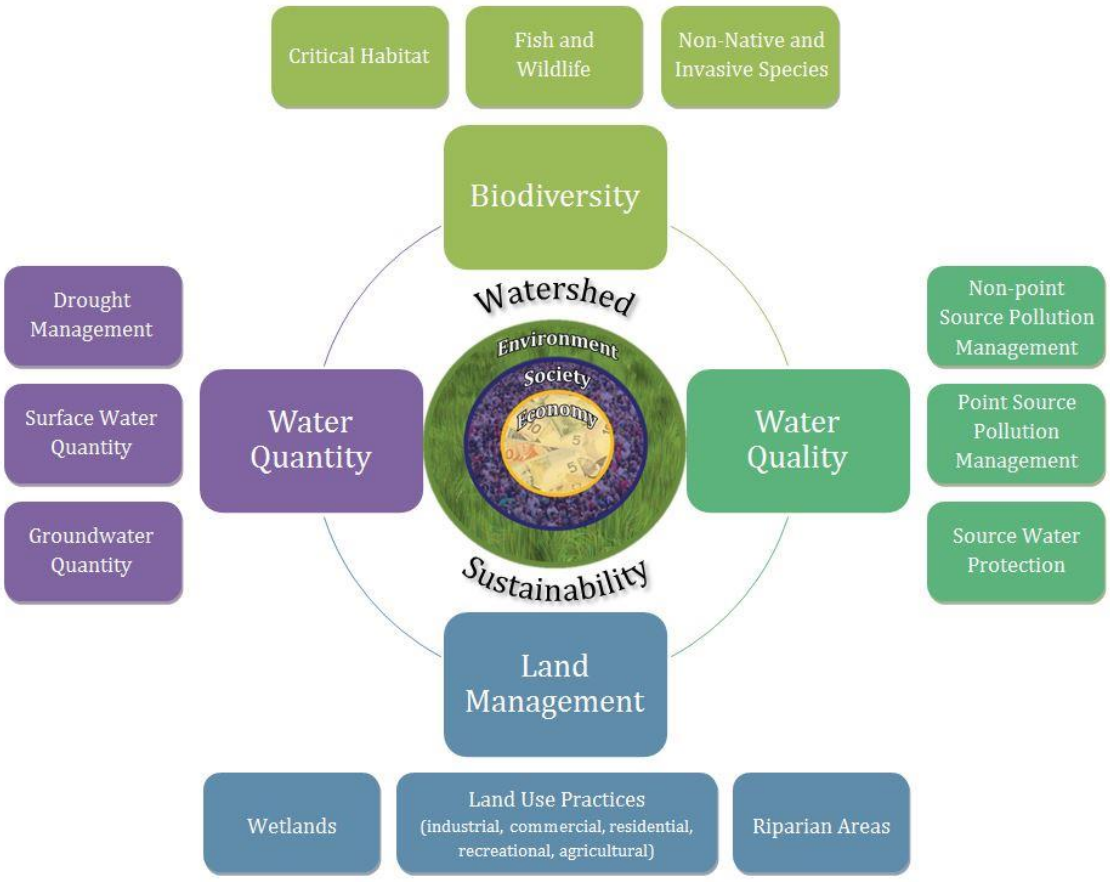

Figure 2. **Watershed management components of the BRWA's WMP process**

Figure 3 outlines the planning process the BRWA will undertake to develop management recommendations for each watershed management component. Key outcomes of this process include a background research report, policy advice, and implementation guidelines (BRWA, 2012).

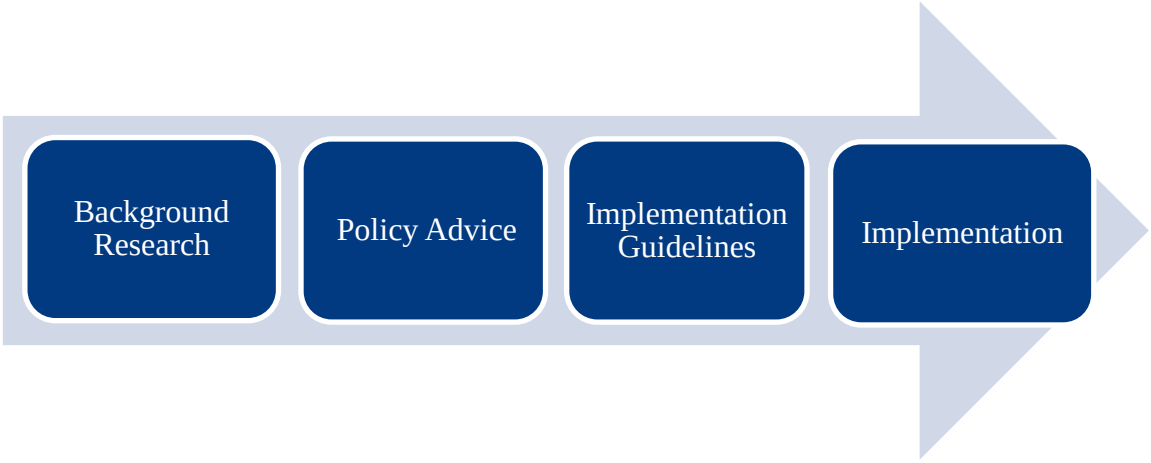

Figure 3. **Watershed management planning process for each watershed management component**

The purpose of this report is to outline the current knowledge base for non-native and invasive species management, the policy context in which it takes place in Alberta and Canada, and current and emerging management options. This research will then inform the development of non-native and invasive species management policy advice and implementation guidelines for the Battle River and Sounding Creek watersheds in Alberta.

2 Non-native and Invasive Species: Defined

Non-native and invasive species have been variously defined by a number of regional, national and international organizations and governments. A recent report prepared for the Alberta Water Council (AWC) outlines definitions used in various jurisdictions in Canada and the United States (AWC, 2014, p. 12). For the purposes of this report and the associated management recommendations, non-native species are defined as any species that is alien to the local environment; in other words, the species has been introduced to an area outside of its natural, historic habitats, usually through direct or indirect human actions. Invasive species are defined as any species whose introduction or spread causes or may cause harm to the local environment, human health, society and economic activity. Not all non-native species are invasive, nor are all native species without invasive tendencies. As freshwater ecologist Julian Olden has stated, "not all non-native species are a problem, and not all problem species are non-native" (J. Olden, personal communication, October 29, 2015).

This report and associated recommendations focuses on aquatic and terrestrial species that are, or have the potential to become, invasive in the Battle River and Sounding Creek watersheds of Alberta. Diseases and insect pests that may affect native plant, fish and wildlife populations are out of scope, but may be addressed through future research and recommendations.

3 Non-native and Invasive Species: Media Coverage

In order to gain a greater understanding of how non-native and invasive species are portrayed in the media, the BRWA conducted a media scan to find articles of relevance to this topic. As a result of this media scan, 49 media articles were identified for the years 2002-2016. Descriptions of all these articles are available in the BRWA's non-native and invasive species information database (BRWA, 2016).

Based on this media scan, it was found that media articles related to non-native and invasive species focus on a number of topics, including invasive species threats, management, and education. Aquatic invasive species dominate the discourse around invasive species, with 40 of the 49 articles focusing on this topic. Quagga and zebra mussels are the focus of most of these articles (30 articles), though other invasive species such as Asian carp, bullhead catfish and goldfish have started making headlines recently (7 articles).

Table 1 outlines the various invasive species topics identified through the media scan.

Table 1. **Invasive Species Topics identified through Media Scan**

Topic	Number of Articles
Invasive Species Management	43
Invasive Species Threats	17
Invasive Species Education	7
Invasive Species Costs	3

4 Non-native and Invasive Species and Watershed Management

Non-native and invasive species may pose various threats to the social, economic, and ecological health of watersheds.

The main ecological risk posed by non-native and invasive species is that these species have no natural predators/competitors in the new environments in which they are introduced. This provides them with an advantage that enables them to out-compete native species (Saskatchewan Forage Council, 2011, p. 1). As such, non-native and invasive species pose a threat to the abundance and diversity of native species, which in turn can harm the overall resilience of terrestrial and aquatic ecosystems (AWC, 2014, p. 12). As highlighted by the Alberta Biodiversity Monitoring Institute, invasive species "are often cited as one of the top three causes of biodiversity loss" (Alberta Biodiversity Monitoring Institute (ABMI), 2015a, p. 1). In Canada, approximately 24% of species at risk are thought to be at risk in part due to the influence of invasive species. Freshwater ecosystems are particularly sensitive to invasive species, and aquatic invasive species (AIS) are a leading cause of native freshwater species such as fish and molluscs becoming threatened or endangered in the country (AWC, 2014, p. 4). In the Battle River watershed, fish and mollusc populations are already being threatened by current development pressures (Stevens & Council, 2008; University of Lethbridge, 2015). The presence of invasive species would likely contribute to further impacts on aquatic diversity in the watershed.

Invasive species also pose risks to the social and economic wellbeing of society. In Canada, annual losses to fisheries, agriculture and forestry sectors as a result of damage and control of just ten invasive species were calculated at $187 million (AWC, 2014, p. 4). In Alberta, the GOA estimates that it could cost about $75 million in annual losses if non-native mussels were to become established in the province's lakes and rivers. Costs may be associated with infrastructure damage (including water diversions and irrigation canals), losses to fisheries and tourism, and decreased property values, among other things (Derworiz, 2014, para. 4).

As stated by the ABMI, invasive species management strategies "will require increased coordination across jurisdictions, and should be formulated across wider geographic areas (regional perspectives) and over longer time frames" (Chai, Nixon, Zhang and Nielsen, 2014, p. 1). Non-native and invasive species management at the watershed-scale provides this broader regional perspective and encourages collaboration and coordination of efforts between all jurisdictions, organizations, and communities within the watershed.

4.1 Invasive Species and Watershed Functions

In addition to threatening the biodiversity of terrestrial and aquatic ecosystems, invasive species also pose threats to specific watershed functions, especially in riparian areas. Native plant species that thrive in riparian areas have deep-binding root systems that help hold banks and shorelines in place and limit erosion. Many non-native and invasive plants have shallower root systems, which can lead to greater bank and shoreline instability. See Figure 4 for an illustration of the differing root systems of native, non-native and invasive plant species. Invasive plants in riparian areas also reduce forage quality and quantity for wildlife and are readily spread downstream with water flows to infest new areas (GOA, 2014a, p. 1).

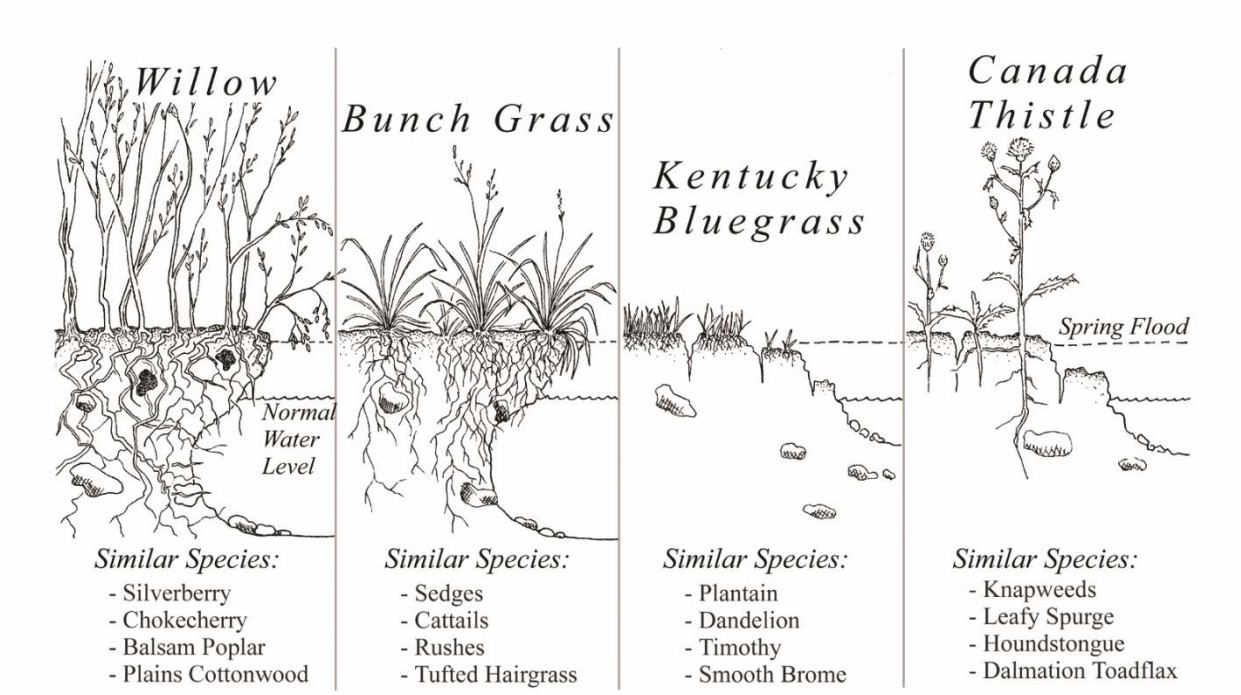

Figure 4. **Riparian function of native, non-native and invasive plant species (Cows and Fish, 2003, p. 26)**

5 Key Considerations for Invasive Species Management

The following sections outline considerations for aquatic and terrestrial invasive species management in Alberta.

5.1 Management Considerations for Aquatic Invasive Species (AIS)

For the purposes of this report and corresponding recommendations, consideration is given to all non-native and invasive plant, fish, and other aquatic species that may pose a threat to the ecological, social and economic health of the Battle River and Sounding Creek watersheds.

In 2014, the AWC undertook a literature review and jurisdictional scan to "summarize the state of AIS prevention, management, and communication strategies" (AWC, 2014, p. ii). This work highlights beneficial practices that may be used to enhance AIS management in the Battle River and Sounding Creek watershed. In general, they found that "while prevention should be the priority, it is inevitable that some AIS will still be introduced and spread. Consequently, a comprehensive management approach will require early detection, rapid response, and eradication, containment and control components. Public awareness and stakeholder engagement are critical at all stages of a strategic approach, because they can promote behavioural change that prevents the introduction and spread of AIS and can build public support for prevention and management initiatives" (AWC, 2014, p. 5). Key learnings are outlined below.

5.1.1 AIS Governance

Successful AIS management programs are most often coordinated by one lead agency, in collaboration with a wide range of other groups and stakeholders. In particular, many jurisdictions benefit from invasive species councils, "which provide direction on the AIS program and a formal structure to ensure participation by a wide range of stakeholders" (AWC, 2014, ii).

Effective AIS programs are often backed by strong legislation. This is usually a single dedicated piece of legislation that regulates a broad range of AIS through strong prohibitions on the import, possession, transport, trade and release of these species. Some pieces of AIS legislation contain additional provisions that enable jurisdictions to designate infested waterbodies, stop and inspect watercraft, and fine, seize, decontaminate, clean and quarantine infested watercraft or other AIS carriers.

Strong AIS programs are also typically supported by reliable long-term funding and resourcing, although many still struggle with limited capacity. Human resource requirements typically include several full-time staff, as well as seasonal staff to implement inspections, monitoring and public outreach. Some jurisdictions receive a portion of their funding through fines, fees and licenses.

5.1.2 AIS Prevention and Early Detection

An important first step in invasive species management is to determine which species have the potential to be invasive in a particular region; for example, which species may exhibit invasive tendencies if introduced into Alberta? In a recent report, the ABMI evaluated species invasiveness based on four attributes: ecological impact, biological characteristics, dispersal ability and feasibility of control (Chai et al., 2014, p. 1). This evaluation method may be useful in assessing future risks associated with AIS in Alberta as a whole, as well as the Battle River and Sounding Creek watersheds in particular.

A proactive approach to AIS management requires that work be done to prevent the introduction of AIS in the first place. AIS may enter new regions through various pathways. Historically, ballast water in ships arriving to Canada from abroad was the single largest source of AIS in Canada. More recently, pathways include live bait, live food fish, canals and water diversions, irrigation systems, and aquarium and water garden pathways. Boaters travelling between various water bodies for recreational purposes are a major pathway for the spread of AIS (AWC, 2014, p. 4).

Research may be conducted to determine key threats based on factors such as recreational boat movements, waterway connectivity, trade activity, and population density. Ecological niche modelling is one means of predicting the potential distribution of AIS into new areas based on information about a species' native range, environmental tolerances and sensitivities. Risk assessments may also be used to evaluate probabilities of AIS arrival, establishment, spread, and economic, social and ecological impacts. Modelling and risk assessments are useful tools for prioritizing management actions in areas that are particularly vulnerable to AIS introduction. (AWC, 2014, p. 5).

Ongoing monitoring is also essential to the prevention and early detection of new AIS. The earlier an AIS is detected, the greater the likelihood that it may be contained or eradicated altogether. These programs may be targeted at detection and identification of particular target species, or may take a more general approach to monitoring for a range of AIS. Various jurisdictions and organizations incorporate citizen science monitoring programs as a key component of their AIS monitoring efforts. By utilizing a volunteer network of citizens located across a particular geographic area, it may be possible to monitor a greater number of locations. Training volunteers in invasive species

identification and sampling protocols helps to ensure that citizen science monitoring programs are robust and defensible. Mandatory watercraft inspections that are enforced are another key strength of many AIS early detection and monitoring programs.

In cases where AIS are detected, it is important to have a rapid response plan in place and immediate access to the resources and funding required to address the issue and attempt to eradicate the species.

5.1.3 AIS Management

Long-term management is required when AIS have become established in an area and eradication is not possible. Management is then aimed at limiting the size and spread of the invasion, mitigating its effects and restoring damaged habitats where possible. This may include mechanical, chemical and biological control methods. An adaptive management approach is essential due to the rapidly evolving nature of AIS and ongoing research (AWC, 2014, p. 10).

Management of any given AIS typically involves: 1) identifying the invasive threat and extent of infestation, 2) assessing potential impacts and feasibility of management, 3) evaluating treatment options, 4) implementing treatment, and 5) monitoring and evaluating treatment success.

The greatest barriers to adequate AIS management are insufficient funding, lack of legislative authority, limited partner coordination, resistance to behavioural change, and lack of political will.

5.1.4 AIS Communication, Education and Engagement

As described by the AWC, "communication and engagement of stakeholders and the general public is key to creating broad scale support for [AIS] prevention and management programs, while at the same time helping to promote desired behaviors" (AWC, 2014, p. 7). Effective engagement programs and resources help to build awareness, knowledge and the skills required to manage invasive species.

Many successful programs focus on engaging specific target audiences that are most likely to come into contact with invasive species (for example, boaters and other water recreationalists). Young people and students are another primary target audience of many programs. Communication and education resources for the general public may help to garner more broad-based understanding and support for AIS management efforts.

Citizen science monitoring programs offer a unique opportunity to engage people, though this approach has not yet been widely used in AIS prevention and management. Such programs contribute to public knowledge and hands-on experience with AIS

management, while at the same time contributing to the gathering of valuable data (AWC, 2014, p. 8). Regular reporting on the progress, successes and challenges of AIS management programs is another means of keeping people informed and engaged.

5.1.5 AIS Species of Concern in Alberta

Quagga mussels (*Dreissena polymorpha*) and zebra mussels (*Dreissena bugensis*) are a key aquatic invasive species of concern in Alberta at the present time. However, there are a number of other species for which AIS prevention and management actions are being undertaken or considered.

The GOA is currently monitoring water bodies for the presence of spiny water flea (*Bythotrephes longimanus*), a tiny freshwater crustacean native to northern Europe and Asia that may threaten native plankton populations and compete for the food resources of larval/small fish and other aquatic organisms (Alberta Invasive Species Council, 2015a).

There are currently two invasive aquatic/shoreline plant species known to occur in Alberta: flowering rush (*Butomus umbellatus*) and invasive phragmites (*Phragmites australis* subspecies *australis*). However, the Alberta Lake Management Society (ALMS) and the Alberta Invasive Plants Council (AIPC, now the Alberta Invasive Species Council) have highlighted additional aquatic weeds of concern that have greatly impacted lakes through the United States and Canada: Eurasian water-milfoil (*Myriophyllum spicatum*), curly-leaf pondweed (*Potamogeton crispus*), hydrilla (*Hydrilla verticillata*), didymo (algae; *Didymosphenia geminata*), and Brazilian elodea (*Egeria densa*) (ALMS, 2016; AIPC, n.d.).

Fish species of concern include Prussian and Asian carp (including domesticated goldfish) and bullhead catfish (*Ameiurus* species). Particular species of concern include grass carp (*Ctenopharyngodon idella*), black carp (*Mylopharyngodon piceus*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), and koi/goldfish (*Carassius auratus*). Bighead and silver carp may be especially damaging to aquatic ecosystems due to the fact that they eat huge amounts of plankton, which is the foundation of aquatic food chains. Various other carp species, and invasive fish species in general, may limit the food supply of native fish, as they feed on native fish eggs, snails, plants and algae. They may also limit spawning grounds and habitat for other fish, increase water turbidity by stirring up sediment when feeding, and carry bacteria, parasites and disease that could affect native fish populations (Jarvie, 2016). A related concern is the newly discovered presence of whirling disease in Alberta. Section 6.2.1 provides additional details on this topic.

In addition, the Government of Saskatchewan has compiled a list of AIS found in the neighboring jurisdictions of Saskatchewan, Alberta, Manitoba, North Dakota and Montana (see Table 2; Government of Saskatchewan (GOS), n.d.). It is important to be aware of AIS in these jurisdictions, as their proximity increases the likelihood that species may spread into Alberta.

Table 2. **Aquatic Invasive Species in Saskatchewan, Alberta, Manitoba, North Dakota and Montana (GOS, n.d.)**

Saskatchewan	Alberta	Manitoba	North Dakota	Montana
Fish Common Carp Koi Goldfish/Prussian Carp	**Fish** Crucian Carp Mosquitofish Prussian Carp Smallmouth Bass Black Bullhead Threespine Stickleback	**Fish** Common Carp Feral Goldfish White Bass Rainbow Smelt	**Fish** Common Carp Grass Carp Silver Carp Tubenose Goby	**Fish** Common Carp
Plants Purple Loosestrife Salt Cedar Flowering Rush	**Plants** Flowering Rush Himilayan balsam Japanese Knotweed Pale Yellow Iris Plumeless Thistle Purple Loosestrife Salt Cedar/Tamarisk	**Plants** Eurasian watermilfoil Flowering Rush Invasive Common Reed Purple Loosestrife	**Plants** Curly Leaf Pondweed Eurasian Watermilfoil Didymo	
		Other Asian Tapeworm Freshwater Jellies Rusty Crayfish Spiny Waterflea Water Flea Zebra Mussel Koi Herpes Virus (KHV) Black Algae	**Other** Zebra Mussel	**Other** Asian Clam Quagga Mussel New Zealand Mudsnail Faucet Snail Fishhook Waterflea Spiny Waterflea Asian Tapeworm Infectious Hematopietic Cecrosis Virus Infectious Pancreatic Necrosis Virus Proliferative Kidney Disease Enteric redmouth disease Heterosporis parasite Whirling Disease

5.1.6 AWC Recommendations for AIS Management

The AWC Aquatic Invasive Species Project Team developed a number of recommendations for AIS management based on their 2014 report (AWC, 2014). They are summarized below.

The AWC recommends that the GOA:

- continue working with governments and national, regional and local partners to enhance the effectiveness of the provincial AIS program, focusing particularly on: prevention; increasing public awareness of AIS and their potential impacts,

targeting high-risk audiences; and supporting AIS-related stakeholder communication and coordination networks

- collaborate and support industry, non-government organizations, academia and governments to develop and disseminate effective AIS tracking and control options for long-term management
- work with its partners to communicate success stories of AIS management
- work with AEMERA [Alberta Environmental Monitoring, Evaluation and Reporting Agency; now the GOA's Environmental Monitoring and Science Division] to develop and begin implementing a provincial AIS monitoring plan for fish, invertebrates and aquatic plants, with assistance from stakeholders including citizen scientists
- maintain the mandatory watercraft inspections element of the AIS program and also begin inspecting other vectors of potential introduction. This should include working with stakeholders where inspections are planned to raise the profile of the issue and increase buy-in from the public
- have a protocol in place to ensure fishery officers and fishery guardians are educated and trained on their authority to enforce AIS legislation
- share information on enforcement activities and potential penalties with stakeholders and the public to raise the profile of the AIS issue (AWC, 2016)

5.2 Management Considerations for Terrestrial Invasive Species

For the purposes of this report and corresponding recommendations, non-native and invasive terrestrial plant species are the focus of management considerations. However, management of other non-native and invasive terrestrial species is also important to consider, and is briefly discussed in section 5.2.2.

The key management principles of prevention, early detection, rapid response, and long-term management discussed in sections 5.1.2 and 5.1.3 in relation to AIS are also applicable to terrestrial invasive species. The following sections outline additional considerations for terrestrial invasive species.

5.2.1 Invasive Plant Species

As discussed in section 3, invasive plant species pose a threat to watershed health because they are able to out-compete native species and agricultural crops for space, moisture and nutrients. They may also alter wildlife habitat, reduce local biodiversity, and alter soil and water cycles. This in turn can lead to increased soil erosion and

decreased water availability (ABMI, 2015b, p. 30). As a result, various watershed functions may be compromised.

The ABMI has undertaken monitoring and studies to better understand non-native plant distribution and abundance in Alberta, including measurement of species richness (number of species detected in a particular area) and identification of habitats where non-native plants are common. This information is important because it helps land and water managers "identify areas and habitats where special management of non-native plants may be required" (ABMI, 2015a, p. 1).

Figure 5 shows non-native plant species richness in various prairie/parkland habitats in Alberta. As one might expect, the fewest number of non-native plants were found in native habitats (areas where the predominant land cover was native vegetation). By comparison, there were more non-native plants in cultivated areas (including tame pasture), and substantially more in areas with industrial or urban development (ABMI, 2015a, p. 2).

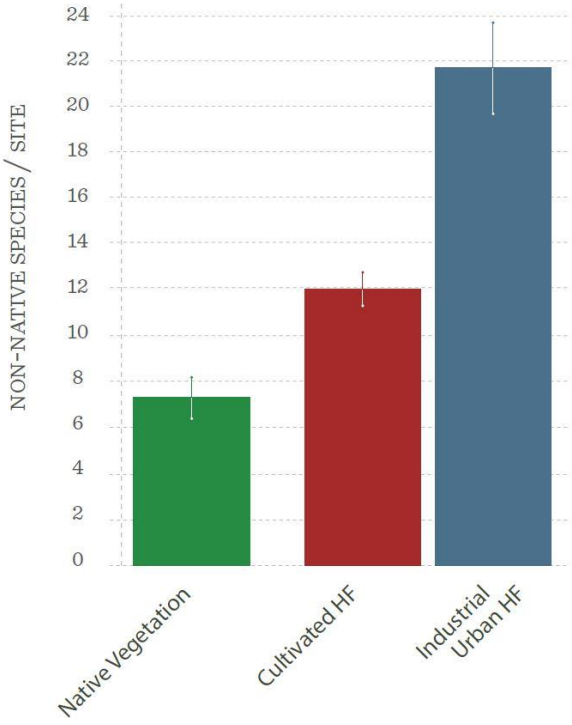

Figure 5. **Species richness in the Alberta prairies, comparing areas with native vegetation to areas with cultivated, industrial, and urban human footprint (HF) (ABMI, 2015a, p. 2)**

The ABMI study also looked at the impact of hard and soft linear developments on non-native species prevalence in Alberta. It was found that sites with soft linear development (road margins, pipelines, powerlines, seismic lines) had considerably more non-native plant species than sites with only native vegetation. Sites with hard linear development (roads, railways) caused less of an increase in non-native species than sites with soft linear development (ABMI, 2015a, p. 3). Figure 6 illustrates this point.

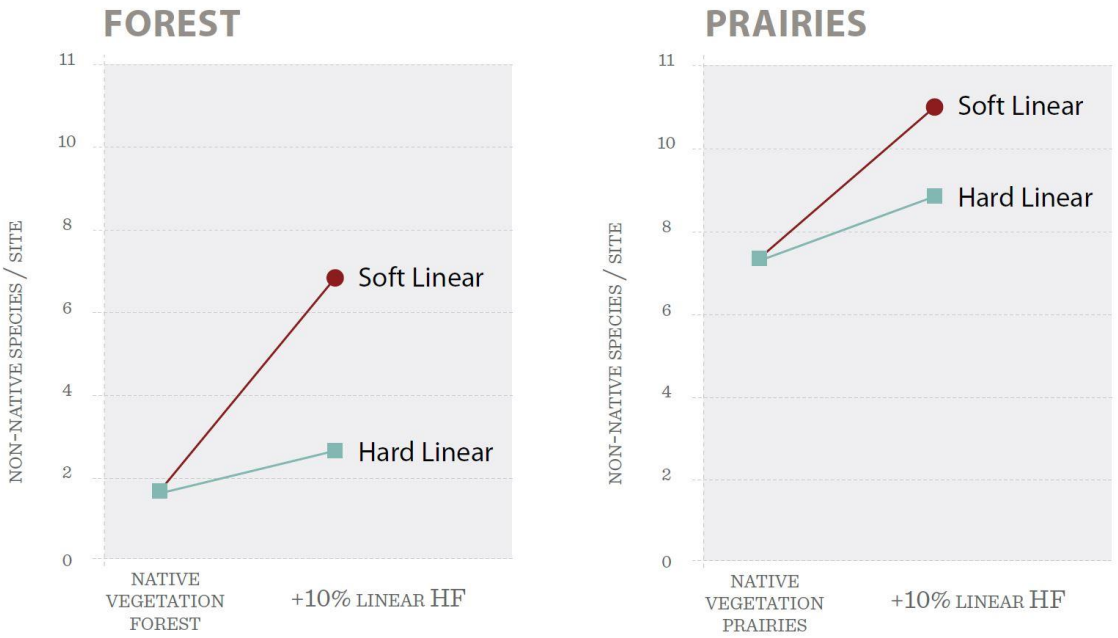

Figure 6. **Linear Human Footprint (HF) and Non-native Species Richness in Alberta's Forest and Prairie Regions (ABMI, 2015a, p. 3)**

Non-native plant species distribution is highly correlated with the percentage of a natural region covered by human footprint. As Figure 7 illustrates, the grassland and parkland natural regions have the greatest human footprint as well as the greatest occurrence of non-native species. However, it was also found that this correlation remained even for areas with low human footprint. This indicates that non-native species have spread beyond areas directly affected by human footprint, especially in the highly developed grassland and parkland natural regions of Alberta. Disturbance by grazing may be a factor in the presence of non-native plants in areas where human footprint is low.

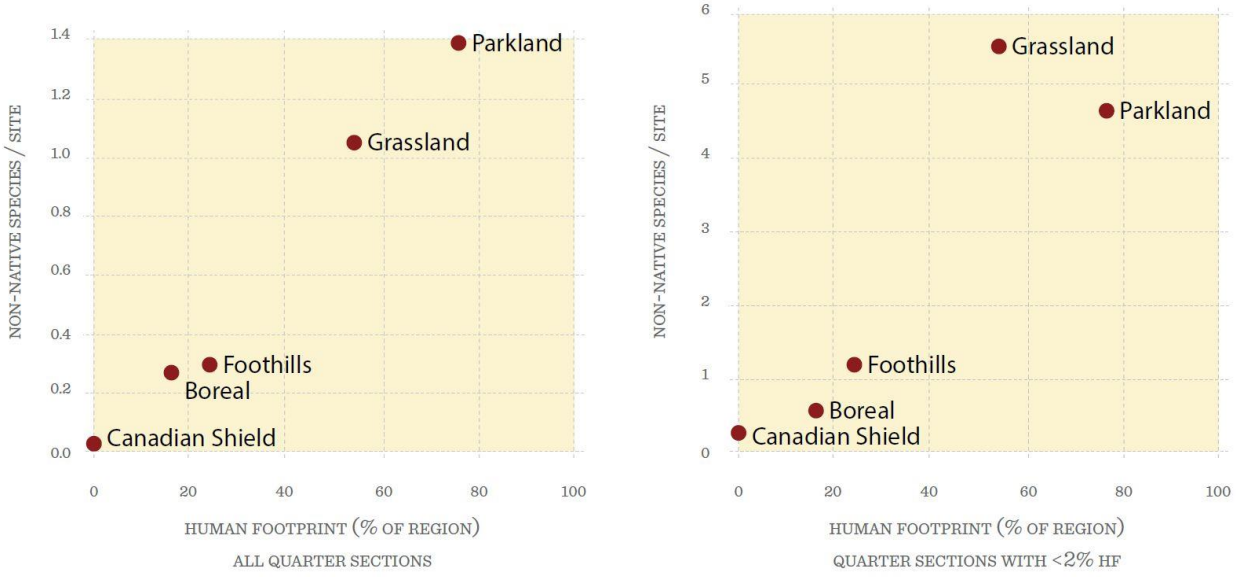

Figure 7. **Human Footprint and Non-native Species Richness (ABMI, 2015a, p. 3)**

ABMI summarizes their findings as follows: "The higher occurrence of non-native plants in the prairies was probably due to abundant agriculture and other human footprints being present there for more than a century and non-native plants spreading beyond these human disturbances. Given the wide distribution for many non-native plant species, and their close association with human development, it will be difficult to slow their spread in areas with abundant human development. Environmental management, especially on the prairies, needs to acknowledge that all ecosystems contain many non-native plants – eradication of these is not feasible. It will be more effective to focus management activities of non-native plants within large tracts of undisturbed vegetation because small areas will be continually 'invaded' from the perimeter" (ABMI, 2015a, p. 4).

It is also important to undertake monitoring to gauge if an introduced or disturbance-caused plant species becomes invasive. Monitoring data currently gathered by ABMI is a means of assessing the current level of invasion and detecting trends in invasion level over time (ABMI, 2015b, p. 30). Management actions may then be undertaken in a timely fashion if non-native plant species begin exhibiting invasive tendencies.

5.2.1.1 Invasive Plant Management in Riparian Areas

Special consideration must be given to invasive plant species management in riparian areas. These areas are particularly important to the maintenance of water quality in natural water bodies and waterways, and invasive species in close proximity to waterways may be readily spread by stream flows. Chemical control of invasive species in riparian areas may have water quality impacts. As such, the application of various

herbicides is restricted near water bodies. A number of alternative management practices may be employed.

The GOA has developed a fact sheet that identifies a number of recommendations for invasive plant management in riparian areas. These include:

- maintaining riparian areas in good condition to reduce the opportunities for invasive plants to establish,
- managing invasive plants in adjoining upland areas to prevent spread into the riparian zone,
- scouting riparian areas and taking action promptly when new infestations of invasive plants are found,
- distributing livestock evenly to avoid overgrazing riparian areas, and
- using rotational grazing to keep grazing pressure in balance with the productivity of forage.

If invasive species are found:

- Hand pulling can be used to control some invasive species with shallow roots and non-vegetative reproduction. Pulled invasive plants should be incinerated or bagged and sent to the landfill, never composted.
- Herbicides can be used judiciously for controlling invasive plants in riparian areas, but there are restrictions on herbicide use within 30 metres of any open body of water.
- Herbicide applications in undisturbed riparian vegetation must be conducted by a certified pesticide applicator.
- Biological control insects are available for some plant species such as leafy spurge, scentless chamomile and hound's-tongue (GOA, 2014a, p. 2).

In Canada, all biological control agents must be approved through the Plant Protection Act and reviewed by an advisory panel of experts before they may be used (Alberta Agriculture and Forestry [AAF], 2000; Government of British Columbia [GBC], n.d.(a)). Table 3 outlines several biological control agents that may be suitable for biological control of invasive plant species in Alberta.

Table 3. **Biological control agents that may be suitable for use in Alberta (AAF, 2000; GBC, n.d.(b); Watson, 1977)**

Invasive Plant Species	Biological Control Agent(s)	Availability
Canada thistle (*Cirsium arvense*)	Stem gall fly (*Urophora cardui*)	Limited
	Seed feeding weevil (*Larinus planus*)	Good
Cleavers (*Galium aparine*)	Gall forming mite (*Cecidophyes rouhallahi*)	Unknown
Diffuse and spotted knapweed (*Centaurea* species)	Seed feeding flies (*Urophora affinis* and *Urophora quadrifasciata*)	Good
	Root feeding beetle (*Sphenoptera jugoslavica*)	Good
	Root feeding weevil (*Cyphocleonus achates*)	Limited
	Seed feeding weevils (*Larinus minutus* and *Larinus obtusus*)	Good
	Root feeding moth (*Agapeta zoegana*)	Good
	Seed feeding moth (*Metzneria paucipunctella*)	Limited
Hound's-tongue (*Cynoglossum officinale*)	Root feeding weevil (*Mogulones crucifer*)	Good
Leafy spurge (*Euphorbia esula*)	Black dot spurge beetle (*Aphthona nigriscutis*)	Good
	Brown dot spurge beetle (*Aphthona cyparissiae*)	Good
	Brown-legged spurge beetle (*Aphthona lacertosa*)	Not currently available for distribution
	Black spurge beetle (*Aphthona czwalinae*)	Not currently available for distribution
	Defoliating moth (*Hyles euphorbiae*)	Not currently available for distribution

Invasive Plant Species	Biological Control Agent(s)	Availability
Nodding thistle (*Carduus nutans*)	Seed feeding weevils (*Rhinocyllus conicus, Larinus planus*)	Good
	Root feeding weevil (*Ceutorhynchidis horridis*)	Unknown
Purple loosestrife (*Lythrum salicaria*)	Foliar feeding beetles of the genus *Galerucella* (*Galerucella calmariensis, Galerucella pusilla*)	Good
Scentless chamomile (*Matricaria perforata*)	Seedhead feeding weevil (*Omphalapion hookeri*)	Limited
	Stem mining weevil (*Microplontus edentulus*)	Not currently available for distribution
	Gall forming midge (*Rhopalomyia tripleurospermi*)	Not currently available for distribution
Yellow toadflax (*Linaria vulgaris*)	Stem mining weevil (*Mecinus janthinus*)	Limited
	Seed feeding weevil (*Rhinusa neta*)	Good
	Seed feeding beetle (*Brachypterolus pulicarius*)	Good
	Foliar feeding moth (*Calophasia lunula*)	Limited
	Root mining moth (*Eteobalea serratella*)	Not currently available for distribution

In addition to biological control of invasive plant species through the use of insects, livestock may also be effective at managing these species through selective grazing. For example, Flagstaff County has had success in using goats to manage leafy spurge, which is considered a noxious weed in Alberta (Flagstaff County, 2016). The City of Calgary has also successfully used goats to control a range of weed species (Nerman, 2016).

Another important consideration in the management of riparian areas is the presence and potential impact of introduced and disturbance-caused plant species that may not be

considered invasive. Disturbance plant species are well adapted to areas of continual stress, such as degraded riparian areas where other more beneficial native plants may struggle. Introduced species are those that are not native to an area, but which do not pose the same threat as invasive species. Both disturbance and introduced species may be a concern in riparian areas, as they indicate an alteration to the normal, native plant community that would naturally occur in an area. In addition, disturbance and introduced plants tend to be more shallow-rooted than native riparian plants and are thus less able to perform important functions such as bank stabilization and water storage and filtration (see Figure 4; Cows and Fish, 2010, p. 12).

Figure 8 outlines the effectiveness of various vegetation types in stabilizing banks and shorelines. Effectiveness varies based on the type of waterbody or waterway in question.

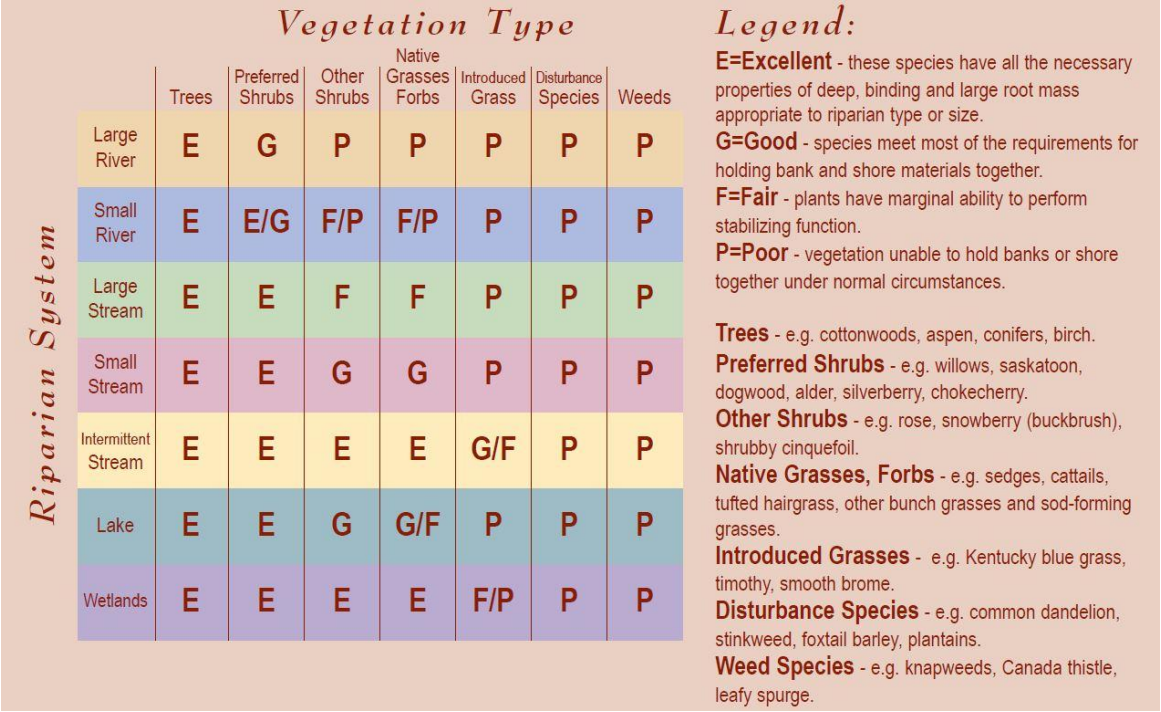

Figure 8. **Plant Effectiveness in Bank and Shoreline Stabilization (Cows and Fish, 2003, p. 26)**

5.2.2 Other Invasive Terrestrial Species

A number of other invasive species are present in Alberta, including Norway and Roof rats, wild boar, and several bird species. While the presence of these species may not directly impact key watershed functions, their presence may influence the overall health and integrity of the watershed through impacts to biodiversity, native habitats, and the socio-economic fabric of communities.

Norway and Roof Rats

Alberta has a long history of rat control and management. Two species of rats have been reported in Alberta, Norway and Roof, but the predominant species of concern is the Norway rat. Norway rats were first discovered on Alberta's eastern border in 1950, followed shortly by their designation as a pest under the Agricultural Pests Act of Alberta (1942). This designation mandated rat control in the province, and an amendment to the Act in 1950 required that every municipality appoint a pest control inspector. Rural municipalities along the Alberta-Saskatchewan border carry the greatest responsibility for rat control in the province. The number of known rat infestations along the border dropped dramatically after 1959 (GOA, 2002). Although incidents of rat infestations are still reported periodically, procedures are in place to deal with these infestations and ensure that the vast majority of Alberta remains rat-free.

Wild Boar

The three prairie provinces of Alberta, Saskatchewan and Manitoba have been facing increasing challenges with wild boar populations. Wild boar were brought to the Canadian prairies from Europe in the late 1990s for the purposes of breeding and game farming. In Saskatchewan, 111 of the approximately 300 rural municipalities in the province have reported sightings of wild boar. In Alberta, the issue appears to be less widespread, but several counties have reported problems with boar that have escaped from farms or ranches and begun destroying crops. Wild boar may also cause damage to native habitat through their nesting, rooting and feeding habits. They make nests from cattails and other wetland grasses and eat native vegetation, salamanders, and duck and songbird eggs (Nature Conservancy of Canada, 2016; "Wild boars", 2002). There is also a concern that the boars may spread disease to domestic swine. Wild boar are aggressive by nature and prolific in terms of reproduction ("Wild boars", 2002). They live approximately 5-6 years in the wild, and an individual can produce 6-10 piglets twice a year (The Homestretch, 2016).

The GOA introduced a wild boar population control program in 2003, which includes a $50 bounty available to hunters for each boar killed. The program is ongoing and will be up for review in 2017 ("Alberta extends boar program", 2014). The Government of Manitoba recently amended its Exotic Animals Regulation to allow licensed gun owners to shoot and kill any wild boar roaming at large, and the Saskatchewan Crop Insurance Corporation administers a Feral Wild Boar Control Program in Saskatchewan (Government of Manitoba [GOM], n.d.(a); Saskatchewan Crop Insurance Corporation, n.d.). Although wild boar populations may be reduced through such programs, it was estimated in 2002 that 3% of Alberta's captive wild boars escape every year, resulting in an ongoing management issue. The Saskatchewan Wildlife Federation recently discussed

putting a resolution forward to the Government of Saskatchewan to ban wild boars as a game farm animal (The Homestretch, 2016). Several municipalities in Alberta have put bylaws in place to ban wild boar operations within their jurisdictions, and others are considering doing the same. In addition, the Government of Alberta has released "Minimum Containment Standards for Alberta Wild Boar Farms" in order to enhance efforts to contain wild boar in Alberta (GOA, 2015a).

Non-native Bird Species

Based on monitoring undertaken by ABMI, three non-native bird species were detected in the prairie region: European Starling (25% of ABMI sites), House Sparrow (20% of ABMI sites) and Ring-necked Pheasant (18% of ABMI sites) (ABMI, 2015b, p. 30). The Eurasian collared dove has also been detected in the province in recent years (Anderson, 2017). Adverse environmental impacts from non-native bird species may include damage to crops and outcompeting native hole-nesting bird species.

Feral Animals

The release of domesticated animals such as dogs, cats, rabbits, reptiles and amphibians may result in impacts to native species populations in cases where the released animals compete for similar habitats, food and other resources, or utilize native species as a food source. In addition, feral animal populations may grow rapidly due to the absence of natural predators. Ecosystem degradation may occur where feral animal populations exceed the carrying capacity of a particular area.

5.2.3 Terrestrial Invasive Species of Concern in Alberta

A recent ABMI study focused on prioritizing and mapping new potential threats to Alberta's biodiversity and predicting invasive plant response to climate change. The top three new potential terrestrial invasive plant threats identified through the study were giant knotweed (*Fallopia sachalinensis*), tamarisk (*Tamarix chinensis*), and alkali swainsonpea (*Sphaerophysa salsula*). These species "received the highest invasiveness score and showed the greatest increase in suitable high risk habitat in Alberta between current and future projected climate" (Chai et al., 2014, p. 1). Species invasiveness was evaluated based on ecological impact, biological characteristics, dispersal ability and feasibility of control. This evaluation method may be a useful tool for the ongoing evaluation of new potential invasive species threats in Alberta.

A number of other invasive plant species of particular concern for riparian areas in Alberta have been identified by the GOA and the Alberta Invasive Plants Council (GOA, 2014a; Alberta Invasive Plants Council, n.d.). These include:

- Canada thistle (*Cirsium arvense*)

- Common burdock (*Arctium minus*)
- Common tansy (*Tanacetum vulgare*)
- Flowering rush (*Butomus umbellatus*)
- Himalayan balsam (*Impatiens glandulifera*)
- Hound's-tongue (*Cynoglossum officinale*)
- Invasive phragmites (*Phragmites australis* subspecies *australis*)
- Knapweeds (*Centaurea* species)
- Leafy spurge (*Euphorbia esula*)
- Ox-eye daisy (*Leucanthemum vulgare*)
- Perennial sow-thistle (*Sonchus arvensis*)
- Purple loosestrife (*Lythrum salicaria*)
- Russian olive (*Elaeagnus angustifolia*)
- Salt cedar (*Tamarix* species)
- Scentless chamomile (*Matricaria perforata*)
- Tall buttercup (*Ranunculus acris*)
- Yellow flag iris (*Iris pseudacorus*)
- Yellow toadflax (*Linaria vulgaris*)

Invasive, disturbance and introduced species that have been identified through health assessments in riparian areas in the Battle River and Sounding Creek watersheds include (Cows and Fish, 2010, p. 32-41, 44-55):

Invasive

- Canada thistle (*Cirsium arvense*) ^*
- Common caragana (*Caragana arborescens*) ^*
- Common tansy (*Tanacetum vulgare*) ^*
- Leafy spurge (*Euphorbia esula*) ^*
- Perennial sow-thistle (*Sonchus arvensis*) ^*
- Scentless chamomile (*Matricaria perforata*) ^*
- Yellow toadflax (*Linaria vulgaris*) ^*
- Cleavers (*Galium aparine*) ^
- Hound's-tongue (*Cynoglossum officinale*) ^
- White cockle (*Silene pratensis*) ^
- Stork's-bill (*Erodium cicutarium*) *
- Tall buttercup (*Ranunculus acris*) *

^ Battle River and Driedmeat Lake

* Lakes and Tributaries

Disturbance

- Alsike clover (*Trifolium hybridum*) ^*
- Bluebur (*Lappula squarrosa*) ^*

- Common burdock (*Arctium minus*) ^*
- Common dandelion (*Taraxacum officinale*) ^*
- Common plantain (*Plantago major*) ^*
- Crested wheat grass (*Agropyron pectiniforme*) ^*
- Cultivated barley (*Hordeum volgare*) ^*
- Field mouse-ear chickweed (*Cerastium arvense*) ^*
- Flix weed; tansy mustard (*Descurainia sophia*) ^*
- Foxtail barley (*Hordeum jubatum*) ^*
- Green foxtail (*Setaria viridis*) ^*
- Hemp-nettle (*Galeopsis tetrahit*) ^*
- Kentucky bluegrass (*Poa pratensis*) ^*
- Lamb's-quarters (*Chenopodium album*) ^*
- Quack grass (*Agropyron repens*) ^*
- Red clover (*Trifolium pratense*) ^*
- Red-root pigweed (*Amaranthus retroflexus*) ^*
- Rough cinquefoil (*Potentilla norvegica*) ^*
- Shepherd's-purse (*Capsella bursa-pastoris*) ^*
- Silverweed (*Potentilla anserina*) ^*
- Small-leaved everlasting (*Antennaria parvifolia*) ^*
- Smooth brome (*Bromus inermis*) ^*
- Stinkweed (*Thlaspi arvense*) ^*
- Timothy (*Phleum pratense*) ^*
- White clover (*Trifolium repens*) ^*
- White sweet-clover (*Melilotus alba*) ^*
- Wild buckwheat (*Polygonum convolvulus*) ^*
- Wild oat (*Avena fatua*) ^*
- Wild strawberry (*Fragaria virginiana*) ^*
- Wormseed mustard (*Erysimum cheiranthoides*) ^*
- Yellow sweet-clover (*Melilotus officinalis*) ^*
- Annual hawk's-beard (*Crepis tectorum*) ^
- Annual sow-thistle (*Sonchus oleraceus*) ^
- Cultivated oat (*Avena sativa*) ^
- Spreading dogbane (*Apocynum androsaemifolium*) ^
- Wild morning-glory; hedge bindweed (*Convolvulus sepium*) ^
- Fowl bluegrass (*Poa palustris*) *
- Russian-thistle (*Salsola kali*) *

^ Battle River and Driedmeat Lake

* Lakes and Tributaries

- Sweet clover (*Melilotus* species) *

Introduced

- Absinthe wormwood (*Artemisia absinthium*) ^*
- Alfalfa (*Medicago sativa*) ^*
- Black medick (*Medicago lupulina*) ^*
- Bull thistle (*Cirsium vulgare*) ^*
- Common knotweed (*Polygonum arenastrum*) ^*
- Curled dock (*Rumex crispus*) ^*
- Orchard grass (*Dactylis glomerata*) ^*
- Pasture sagewort (*Artemisia frigida*) ^*
- Pineappleweed (*Matricaria matricarioides*) ^*
- Prairie sagewort (*Artemisia ludoviciana*) ^*
- Prickly annual sow-thistle (*Sonchus asper*) ^*
- Redtop (*Agrostis stolonifera*) ^*
- Western bluebur (*Lappula occidentalis*) ^*
- Chicory (*Cichorium intybus*) ^
- Meadow brome (*Bromus biebersteinii*) ^
- Prickly lettuce (*Lactuca serriola*) ^
- Rape (*Brassica napus*) ^
- Witch grass (*Panicum capillare*) ^
- Annual bluegrass (*Poa annua*) *
- Caraway (*Carum carvi*) *
- Common goat's-beard (*Tragopogon dubius*) *
- Common pepper-grass (*Lepidium densiflorum*) *
- Cotoneaster (*Cotoneaster* species) *
- Blue spruce (*Picea pungens*) *
- Bur oak (*Quercus macrocarpa*) *
- European mountain-ash (*Sorbus aucuparia*) *
- Green ash (*Fraxinus pennsylvanica*) *
- Oak (*Quercus* species) *
- Summer-cypress (*Kochia scoparia*) *
- Tufted vetch (*Vicia cracca*)

^ Battle River and Driedmeat Lake

* Lakes and Tributaries

Invasive plant species that are of particular concern to select municipalities in the Battle River and Sounding Creek watersheds include:

- Paintearth County: scentless chamomile, yellow toadflax, white cockle
- Municipal District of Wainwright: hoary alyssum, spotted knapweed, diffuse knapweed, nodding thistle, common baby's-breath, downy brome, great burdock & lesser burdock, scentless chamomile, yellow clematis, white cockle, oxeye daisy, leafy spurge, common tansy, Canada thistle, yellow toadflax, tall buttercup, orange hawkweed
- Flagstaff County: leafy spurge, scentless chamomile, white cockle, yellow toadflax, common tansy, Canada thistle
- Beaver County: Canada thistle, oxeye daisy, scentless chamomile, common tansy, leafy spurge, yellow toadflax, spotted knapweed

5.2.4 Climate Change and Non-native and Invasive Species Distribution

As climate change shifts natural regions and associated ecosystems and plant and animal communities, "some regions around the world are predicted to have a higher climate match to Alberta by the 2050s than they do presently, including Newfoundland and Labrador, Turkey, Asia and Russia" (Chai et al., 2014, p. 1). This, in turn, will increase the likelihood that species from these regions may become established in Alberta if they were ever to be transported here.

6 Current Management Context

6.1 Battle River and Sounding Creek Watersheds

Management of invasive plant species is led by municipalities across the watershed, who undertake weed inspection and control on public and private land within their jurisdiction. Most undertake roadside weed spraying programs on a regular basis as a means of noxious weed control. Some also offer spraying services to county residents, often at a subsidized cost. "No spray zone" policies are also common among municipalities. A shared philosophy is that early detection and rapid response is the most effective method of managing invasive plants.

Several municipalities make use of the Agricultural Infestation Management System (AIMS) technology to assist them in maintaining an effective, long-term weed control program. The AIMS program enables municipalities to map and track infestations from year to year, provides a snapshot of affected areas within the county, and calculates increases and decreases in infestations. In addition to invasive plant management, municipalities play an important role in controlling rat populations in Alberta. In the Battle River watershed, the County of Vermilion River, the Municipal District of Wainwright and the Municipal District of Provost all undertake rat inspections along the Alberta-Saskatchewan border in an effort to prevent the movement and establishment of rats in Alberta. Alberta Agriculture and Forestry is responsible for rat inspections in the Special Areas of Alberta.

A number of other initiatives contribute to invasive species management in the Battle River and Sounding Creek watersheds. The North Saskatchewan River Basin Council (the BRWA's counterpart in Saskatchewan) has been involved in an initiative that uses black dot and brown dot spurge beetles to manage leafy spurge along the Battle River in Saskatchewan (Cairns, 2014). In recent years, Flagstaff County has undertaken a similar initiative along the banks of the Battle River, which involves the use of both flea beetles and goats to help manage the weed. Non-chemical weed control has also been utilized at Pigeon Lake, where concerned citizens have worked for many years to eradicate Himalayan balsam from the shoreline through handpicking. In 2014, ALMS developed an aquatic plant monitoring program, which involves conducting aquatic plant surveys on lakes across Alberta. To-date, surveys have been carried out on 10 lakes across Alberta (including Lacombe Lake, which is located in the Battle River watershed) (ALMS, n.d.). The GOA, municipalities and other partners have posted "Clean, Drain and Dry" signage at major recreational water bodies and waterways across Alberta, including locations in the Battle River watershed. This signage is part of a broader GOA program aimed at

ensuring that invasive aquatic species (such as mussels and plants) are not transported between water bodies by recreational watercraft.

Opportunities exist for enhanced aquatic species monitoring in the Battle River and Sounding Creek. For example, the BRWA has developed an "X-Stream Science" program, which focuses on water quality monitoring through hands-on citizen involvement. Invasive species monitoring may be incorporated into this program in the future. Municipalities may also contribute to AIS monitoring in their jurisdictions.

6.2 Canada

The following section outlines non-native and invasive species management actions currently taking place in Alberta, select provinces, and nation-wide. Policies, practices, programs and resources from other jurisdictions may be useful in enhancing invasive species management efforts in Alberta.

6.2.1 Alberta

The Alberta *Weed Control Act* (2008) forms the basis of invasive plant management in Alberta. The Act designates plant species that are considered prohibited noxious and noxious weeds in Alberta, and requires individuals to control noxious weeds and destroy prohibited noxious weeds found on land they own or occupy. Under the Act, municipalities are required to appoint inspectors to enforce and monitor compliance with the Act. Inspectors may conduct control programs for weeds they feel may have significant ecological or economic impact on lands within their municipality (Wheatland County, 2011). Many municipalities also utilize the Agricultural Infestation Management System (AIMS) or similar Geographic Information System (GIS) mapping technology to assist them in conducting effective long-term weed control programs by providing a snapshot of areas affected by weeds and enabling municipalities to map and track weed infestations from year to year (including increases and decreases in affected areas) (County of Wetaskiwin, n.d.).

Alberta's early detection and rapid response to prohibited noxious and noxious weeds is supported by the Alberta Weed Survey, which is conducted annually through the Alberta Weed Monitoring Network (GOA, 2015b). More detailed distribution and abundance surveys are conducted every ten years. The most recent detailed surveys were carried out in 2009 (for irrigated areas) and 2010 (for dryland areas) (Leeson, Neeser, Kimmel, & Vadnais, 2010; Leeson, Neeser, Kimmel, & Vadnais, 2012). Alberta Agriculture and Forestry has also developed a number of fact sheets related to invasive plant management in Alberta, including advice for aquatic systems, riparian areas, acreages, forages and hayland, native rangeland, urban areas, transportation of equipment, horticultural

activities, fencelines and road allowances, and more (GOA, 2014b). The Government of Alberta also has specific guidelines for non-native and invasive weed management during construction, operation and reclamation of industrial sites (Alberta Energy Regulator, 2003; Alberta Environment, 2003; GOA, 2011).

The Alberta Weed Regulation Advisory Committee was formed in 2010 and has the role of developing recommendations for the Minister of Agriculture and Forestry related to weed regulation in Alberta. They have developed a protocol to assess whether any given plant species should be regulated under the Alberta *Weed Control Act* (2008) (GOA, 2016a).

Many municipalities across the province have developed useful tools and programs to support invasive plant management in Alberta. Wheatland County created the *Alberta Invasive Plant Identification Guide* in 2011 to support individuals and municipalities in the identification and management of prohibited noxious and noxious weeds in Alberta. In 2012, Clearwater County released the *Clearwater County Invasive Plant Management Strategy* to guide its invasive plant management work (Clearwater County, 2012).

The Alberta Invasive Species Council (AISC) is a key organization working to raise public awareness and involvement in invasive species management in the province. They have developed various educational fact sheets and other print resources for both children and adults. Of particular note is their "Grow Me Instead" brochure, which highlights native and non-native plant alternatives to invasive plant species commonly used in horticulture and residential gardens (AISC, 2015b). They also initiated the "Spotters Network", which is a network of volunteers who help identify and report on locations where invasive terrestrial and aquatic species are found in Alberta. This program is supported by the Alberta EDDMapS app and associated online mapping system (Early Detection & Distribution Mapping System) (AISC, n.d.(a); AISC, 2016). A related initiative is the Alberta Weed Spotter app developed by Athabasca University, the GOA, and the City of Edmonton, which supports people to identify and report the locations of noxious and prohibited noxious weeds in the province (City of Edmonton, n.d.). AISC also recently became involved in the release and monitoring of biological control agents for invasive plant management. The biological control agents utilized are insects or pathogens that have been approved by the Government of Canada, and invasive plants currently targeted are hound's-tongue, dalmation toadflax, leafy spurge, diffuse knapweed and spotted knapweed (AISC, n.d.(b)).

In order to further engage Albertans in limiting the spread of invasive plant species in Alberta, the Alberta Conservation Association, AISC and GOA initiated the "Play, Clean, Go" campaign. Originally developed in Minnesota, the program now has over 200 partners across North America (AISC, n.d.(c)). The program's goal is to encourage

people to 1) make sure their gear and equipment are clean before they leave home, 2) stay on designated trails, and 3) make sure everything is clean again before leaving the trail ("Stop invasive species", n.d.).

In addition to invasive terrestrial plant management, Alberta has ramped up its efforts in aquatic invasive species management in recent years. Limited aquatic plant monitoring has been undertaken in the province. However, from 2014-2015 ALMS developed and implemented an aquatic plant monitoring program to survey several recreational lakes in Alberta for the presence of invasive aquatic plant species (ALMS, 2015). They also created an aquatic plant guide to aid people in identifying native and invasive species (ALMS, 2016).

Extensive work has been undertaken in recent years in the area of invasive mussel prevention and engagement efforts. In 2015, the GOA and partners monitored 76 lakes for veligers (larval form of molluscs), with the primary concern being zebra and quagga mussels (GOA, 2015c). No veligers were found. 40 inspectors at 12 stations across the province inspected over 21,000 boats for aquatic invasive species, with a primary focus on zebra and quagga mussels. 11 mussel-fouled boats were found, 3 with live mussels ("Aquatic Invasive Species Update", 2015; GOA, 2015c). Since 2013, 26 mussel-fouled boats have been intercepted in Alberta (GOA, 2015c). Figure 9 (see next page) provides a comprehensive overview of 2015-2016 AIS monitoring work in Alberta. The GOA's extensive and ongoing "Clean, Drain, Dry" educational campaign raises awareness among watercraft users about steps they can take to prevent the transport of AIS (GOA, 2016b; My Wild Alberta, 2013b). The GOA also has a toll-free hotline (1-855-336-BOAT) for reporting boats or water bodies where the presence of invasive species is suspected.

A joint Alberta-Montana Canine Mussel Detection Pilot was initiated in 2014, which utilizes sniffer dogs to aid the mussel inspection process ("Sniffer dogs", 2014). ALMS has developed an aquatic plant monitoring program, which has now been carried out on 10 lakes across Alberta. Bullhead catfish were eradicated from a pond near Fort McMurray where they had been illegally introduced. Several stormwater ponds were found to host populations of goldfish. These occurrences prompted the GOA to launch the "Don't Let It Loose" campaign to raise awareness about the potential damage caused by activities such as illegal stocking, aquarium and other live plant and fish releases, and ceremonial and cultural releases (GOA, 2016c). A variety of resources have been developed, including specific recommendations for aquarium owners and anglers, and fact sheets about Prussian carp and bullhead catfish (GOA, 2015d; GOA, 2015e; GOA, 2015f).

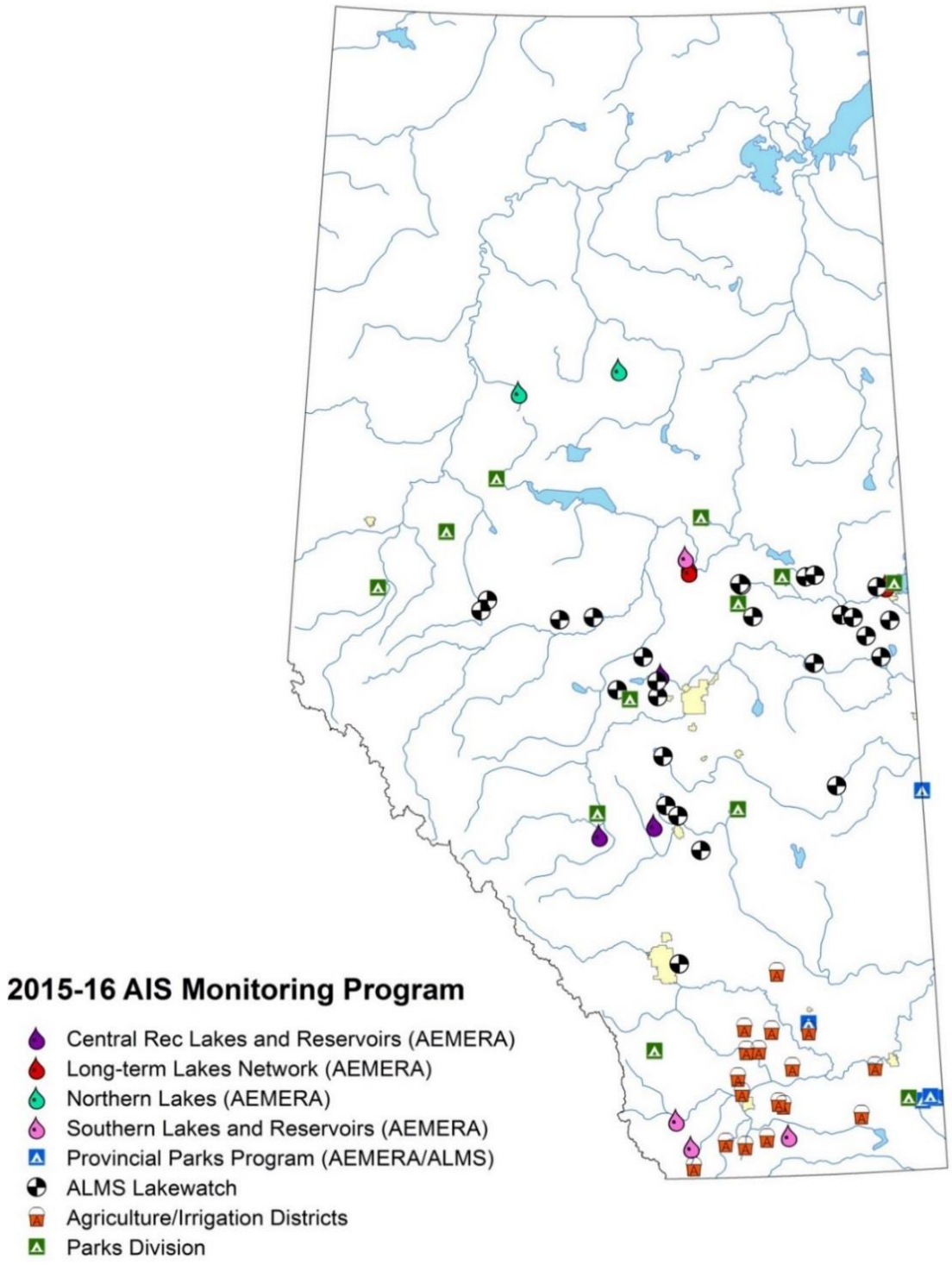

Figure 9. **2015-16 Aquatic Invasive Species Monitoring Program in Alberta (GOA, 2015b)**

Alberta's increased efforts in AIS management are tied to recent changes to the *Fisheries (Alberta) Act* (2000). An initial ministerial order in 2013 gave Fisheries officers the authority to stop, detain or seize a boat considered high risk. In March 2015, the *Fisheries (Alberta) Act* (2000) was amended to enable mandatory watercraft inspections and enhance the prohibited species list, increasing the number of listed species from 2 to 52, including 16 plants, 11 invertebrates, and 25 fish (GOA, 2015c; Ma, 2015). It is now illegal to import, sell, transport or possess these species in Alberta. The province is also currently developing Early Detection Rapid Response Plans for AIS and mussels, to be put into action in the event that any of these species are found in Alberta (Derworiz, 2014, para. 25; GOA, 2015c). In addition, the AWC has developed a number of recommendations to further advance AIS awareness, prevention and management in the province (see section 5.1.5 of this report; AWC, 2016).

A new consideration for aquatic species management in Alberta is the recent discovery of whirling disease in the province. Whirling disease is an infectious disease that affects various salmonid fish species, including trout, salmon and whitefish (Canadian Food Inspection Agency [CFIA], 2016a; GOA, 2016d; GOA, 2016e). As of December 2016, the Canadian Food Inspection Agency had confirmed several locations where the disease was detected, including Banff National Park, Wheatland County, Foothills Municipal District, City of Calgary, Rocky View County, Municipal District of Bighorn, Stoney Nakoda First Nation, and commercial aquaculture facilities licensed by the Government of Alberta (CFIA, 2016b). In response, the Canadian Food Inspection Agency, Parks Canada and Alberta Environment and Parks are working together to determine appropriate steps to control the disease, including a sampling program to investigate the extent of whirling disease in the province (CFIA, 2016b; GOA, 2016d; GOA, 2016e). Alberta Environment and Parks has developed a three-pronged Whirling Disease Action Plan that involves emergency response and early detection, education, and mitigation (GOA, 2016d, GOA, 2016e). As part of the action plan, they have issued a Ministerial Order to quarantine all commercial fish culture operations until fish farms and hatcheries licensed for salmonids are tested for the presence of whirling disease (Ministerial Order 52/2016). Parks Canada and the GOA have also outlined best practices for anglers, boaters and recreational water users that can help reduce the risk of spreading whirling disease (GOC, 2016a; GOA, 2016e).

In addition to terrestrial weed management and aquatic invasive species management, the Government of Alberta also regulates other terrestrial pests and nuisance species through the Agricultural Pests Act and Pest and Nuisance Control Regulation. Inspectors appointed under the Act are responsible for monitoring and controlling the following disease and pests in Alberta:

- Dutch elm disease (*Ophiostoma ulmi* and *Ophiostoma nova-ulmi*);
- Norway rat and any other rat species or strain derived from the genus *Rattus*;
- Wild boar (*Sus scrofa*) (only considered to be a pest where it is at large in Alberta) (GOA, 2016f).

The Government of Alberta has also developed minimum containment standards for farmed wild boar in Alberta to better prevent boar from escaping and becoming established in the province (GOA, 2016f). Several municipalities are considering bylaws to completely ban wild boar farms in their jurisdictions.

6.2.2 British Columbia

A collaborative initiative led by the Invasive Species Council of British Columbia resulted in the development of an *Invasive Species Strategy for British Columbia* in 2012 (Invasive Species Council of British Columbia [ISCBC], 2012). In 2014, the Government of British Columbia released the *Invasive Species Early Detection and Rapid Response Plan for British Columbia*, which outlines a six-step process for responding to the introduction of new invasive species in the province (Inter-Ministry Invasive Species Working Group [IMISWP], 2014). This process may then be used for developing early detection and rapid response plans for particular invasive species of concern. The province has already developed an early detection and rapid response plan for zebra and quagga mussels, and is also signatory to the *Columbia River Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other* Dreissenid *Species* (IMISWG, 2015a; Heimowitz & Phillips, 2008). The Columbia River Basin plan covers the entirety of the basin in Canada and the United States, and partners include the U.S. Fish and Wildlife Service and the Pacific States Marine Fisheries Commission.

British Columbia has run a Watercraft Inspection Program since 2015, and it is mandatory for all watercraft to stop at roadside inspection stations. Inspection efforts are focused along the United States and Alberta borders. Residents are encouraged to report invasive species through the Report-Invasives BC and Report-A-Weed BC apps and online mapping tool (GBC, n.d.(c)). The Government of British Columbia has developed survey protocols for both terrestrial and aquatic invasive species monitoring (GBC, 2010; IMISWG, 2015b).

Through its Invasive Alien Plant Program, the province has developed an extensive Reference Guide, which includes information on invasive plant prevention, management and treatment options, monitoring and inventory methods, and how to enter data into the program's database and utilize the associated mapping system (GBC, 2010). The Invasive Species Council of British Columbia and its partners have created a number of invasive species resources, including fact sheets, curriculum-based teaching resources, identification guides for aquatic and terrestrial invasive species, best management practices for various industries, and tools for local government (ISCBC, 2014a; ISCBC, 2014b; ISCBC & IMISWG, 2014; ISCBC & GBC, 2015; ISCBC, 2014c; ISCBC, 2014d).

The Government of British Columbia has done extensive work in the area of biological control of invasive plants. An online database lists biological control agents available or currently being tested in the province (GBC, n.d.(d)). The province has created a *Field Guide to the Biological Control of Weeds in British Columbia*, as well as a number of species-specific operational field guides for select biocontrol agents (GBC, 1994; GBC, n.d.(e)). British Columbia has a number of invasive species programs that are similar to those offered in Alberta, including "PlantWise" (similar to "Grow Me Instead"), "Don't Let It Loose", "Clean Drain Dry", "Play Clean Go" and the "Spotters Network". See section 6.2.1 for more information about these programs. British Columbia also raises awareness about the transport of non-native insects in firewood through its "Buy it Where you Burn it" program.

6.2.3 Manitoba

Zebra mussels were discovered in the south basin of Lake Winnipeg in October 2013. In the spring of 2014, the Government of Manitoba attempted to eradicate the mussels using a treatment of liquid potash, concentrating efforts in four harbours. These efforts initially appeared to be effective at killing the mussels, but mussel larvae and adults were later discovered in other parts of the lake (Duckworth, 2014). Zebra mussels have since been found in Cedar Lake, the Manitoba portion of the Red River, and the north basin of Lake Winnipeg (GOM, 2015a).

Changes to the provincial *Water Protection Act* in 2015 have enhanced AIS management in the province, including making watercraft inspections mandatory at control stations and establishing control zones in areas where AIS are already present (GOM, n.d.(b); GOM, 2015b). Special decontamination requirements apply to watercraft, water-related equipment, motor vehicles and aircraft in these zones (GOM, n.d.(c)). Spiny water flea, zebra mussels, and black algae are the species currently being targeted for management in the province's control zones. Ongoing sampling for mussel larvae and adults is being

undertaken by the Government of Manitoba and partners such as the Lake Winnipeg Research Consortium and Manitoba Hydro (GOM, 2015). The government has also ramped up its education and outreach efforts, including fact sheets about spiny water flea, zebra mussels, and the legal requirements of watercraft users in the province (GOM, n.d.(d); GOM, 2016).

The Invasive Species Council of Manitoba has developed a number of useful resources, including *Invasive Species in Manitoba: River, Lake and Wetland Invaders, A Pocket Field Guide by the Invasive Species Council of Manitoba* and *Best Management Practices for Industry: Top Invasive Plant Concerns for Rights-of-Way* (Invasive Species Council of Manitoba (ISCM), 2013; ISCM, 2010). They have also developed a Weed Management Plan Template and associated resources. Various agencies have carried out targeted research and management efforts for specific weed species such as leafy spurge and purple loosestrife (Rural Development Institute, 2010; Lindgren, 2000; Henne, Lindgren, Gabor, Murkin, & Roughley, 2005).

6.2.4 Ontario

A number of invasive species management initiatives are underway in Ontario. The Ontario Invasive Species Strategic Plan was released in 2012 (Ontario Ministry of Natural Resources, 2012). Several Ministries of the Government of Ontario are involved in the implementation of this plan, including Natural Resources and Forestry; Agriculture, Food, and Rural Affairs; Environment and Climate Change; and Transportation. While the Government of Ontario has regulations in place that ban the trade of listed live invasive fish species, watercraft inspections for AIS are not mandatory (AWC, 2014).

The Ontario Invasive Plant Council provides leadership in the area of invasive plant management in the province (Ontario Invasive Plant Council [OIPC], 2016a). They have developed a number of useful resources, including technical documents and beneficial management practices for a number of invasive plants found in Ontario (OIPC, 2016b). They also run a "Look Before You Leave" program similar to Alberta's "Play, Clean, Go" program (OIPC, 2016c). An Early Detection & Rapid Response (EDRR) Network Ontario led by the Ontario Invasive Plant Council and the Invasive Species Centre strives to enhance efforts to detect, track, and respond to invasive species occurrences in the province (EDRR, 2015). The two groups have also collaborated in the development of a guide for municipalities interested in creating an Invasive Plant Management Strategy (Sherman, 2015).

Ontario's Invading Species Awareness Program (a joint initiative of the Ontario Federation of Anglers and Hunters and the Ontario Ministry of Natural Resources and

Forestry) focuses on invasive species education and awareness, addressing key pathways through which species are introduced and spread, and facilitating monitoring and tracking initiatives (Invading Species Awareness Program [ISAP], n.d.). Curriculum guides for grade 4 and 6 have been developed to support the incorporation of invasive species topics into the classroom (ISAP, Ontario Federation of Anglers and Hunters [OFAH], & Ontario Ministry of Natural Resources [OMNR], n.d.(a); ISAP, OFAH, & OMNR, n.d.(b)). The Government of Ontario has created a number of fact sheets outlining steps various groups (such as boaters, anglers, hikers, gardeners, and cottagers) can take to prevent the spread of invasive species (Government of Ontario, 2016). They also run the Invading Species Watch Program, which is a volunteer-based lake monitoring program. EDDMapS Ontario is widely used as a method of reporting invasive species occurrences in the province (EDDMapS Ontario, 2017).

The Federation of Ontario Cottagers' Association also has an active Aquatic Invasive Species Prevention & Monitoring Program, which strengthens their existing water monitoring and citizen science programs (Federation of Ontario Cottagers' Association [FOCA], n.d.(a)). Their website also houses a number of AIS identification guides, tips for various types of water users, and other resources (FOCA, n.d.(b)).

Fisheries and Oceans Canada (DFO) and the Ontario Ministry of Natural Resources and Forestry (OMNRF) partnered to develop an Asian Carp Response Plan, which outlines how DFO, OMNRF and their partners will respond if Asian carps are found in the Great Lakes or if there is a release in any Canadian water basin (Invasive Species Centre [ISC], n.d.(a)).

A number of resources have been developed to support invasive species awareness and management in Ontario, including invasive species identification guides for both aquatic species and terrestrial plants (OMNR, 2010; Credit Valley Conservation [CVC], n.d.). Multiple organizations also collaborated to develop "A Landowner's Guide to Managing and Controlling Invasive Plants in Ontario", which includes guidance on developing an Invasive Plant Management Plan (OMNR, OFAH, ISAP, OIPC, & CVC, n.d.).

6.2.7 Canada-Wide

Prior to 2015, Canada lacked a consistent and comprehensive national regulatory framework to prohibit the import, possession, trade, transport and release of live AIS (AWC, 2014, p. 6; Government of Canada [GOC], 2015). In 2015, the Government of Canada enacted the *Aquatic Invasive Species Regulations* (2015) under the federal *Fisheries Act* (1985), which prohibit the importation, possession, transportation, and release of four species of Asian carp (silver, black, bighead, and grass) across Canada. The importation of zebra and quagga mussels is prohibited across Canada (with the

exception of waters in Ontario and Quebec where these species are already present). Possession, transportation and release of zebra and quagga mussels is prohibited in British Columbia, Alberta, Saskatchewan and Manitoba. The regulations also enable designated federal and provincial authorities to authorize the deposit of approved deleterious substances or the use of fishing measures to control AIS.

With regards to the possession, transportation and release of triploid (sterile) grass carp, persons holding a cultured fish licence issued under the *Fisheries (Alberta) Act* (2000) are exempt from the federal AIS regulations. The grass carp must be confirmed to be triploid grass carp and may only be released for the purpose of vegetation control in a body of water on privately owned land. The body of water must be isolated from other bodies of water in a manner that ensures that the grass carp will not adversely affect fish, fish habitat, or the use of fish in other bodies of water. With regards to the possession of diploid grass carp, Alberta Agriculture and Forestry and the Aquaculture Centre of Excellence at Lethbridge College are also exempt from the federal AIS regulations, where a fish research licence issued under the *Fisheries (Alberta) Act* (2000) is held and the diploid grass carp are possessed for the purpose of culturing triploid grass carp.

Fisheries and Oceans Canada houses the Centre of Expertise for Aquatic Risk Assessment, which aims to develop a national standard for AIS risk assessments and a process for determining national priorities for risk assessments (GOC, 2016b). In 2013, a risk assessment for three *Dreissenid* mussels was completed (Fisheries and Oceans Canada, 2013). *Dreissenid* refers to a particular category of freshwater bivalve mollusc species.

At the regional level, the provinces of Alberta, British Columbia, Saskatchewan and Manitoba and the Yukon Territory have signed an Inter-Provincial Territorial Agreement for Coordinated Regional Defence Against Invasive Species to encourage the sharing of resources and ensure a coordinated response to invasive species in Western Canada (GOA, 2016g).

The Canadian Food Inspection Agency (CFIA) acts as Canada's national plant protection organization. In this role, it regulates the import, sale and movement of plants into and within Canada, monitors imports to prevent entry of invasive plants, and conducts surveillance to determine if an invasive plant is present, or to confirm that an area is free of a specific invasive plant (GOC, 2016c). An Invasive Plants Policy has been created to guide this work (CFIA, 2012a). CFIA has also developed Interim Phytosanitary Requirements to help ensure that weed species are not introduced to Canada through in-transit shipments (shipments from a foreign country moving through Canada en route to another foreign country) (CFIA, 2016c). Invasive plants regulated under the federal *Plant Protection Act* (1990) are included in the *List of Pests Regulated by Canada* (GOC,

2016c), and invasive plants regulated under the *Seeds Act* (1985) are listed in the *Weed Seeds Order* (2016). The *Seeds Act* (1985) also regulates inspection, testing, quality and sale of seeds in Canada, which is key to ensuring that new invasive species are not imported to Canada in the form of seeds (GOA, 2014c). The Government of Canada regulates the use of biological control agents in Canada through the *Plant Protection Act* (1990), and Agriculture and Agri-Food Canada (AAFC) has developed a "Guide for the Importation and Release of Arthropod Biological Control Agents" (De Clerck-Floate et al., 2006).

Canada is a signatory party to the *International Plant Protection Convention* (Food and Agriculture Organization of the United Nations [FAO], 1997) and the *Convention on Biological Diversity* (United Nations, 1992). As a result, CFIA is responsible for administering a plant health program that includes addressing invasive species threats (CFIA, 2008). As part of this work, CFIA conducts weed risk analyses for species not currently found or not widely distributed in Canada. These analyses follow the international guidelines for pest risk analysis established by the IPPC, and include: 1) evaluating the probability of species entering, becoming established, and spreading in Canada, 2) determining risks posed to the Canadian economy and environment by these species, and 3) assessing options that may reduce the risk of their introduction, establishment and spread (CFIA, 2016d). CFIA has also developed an Invasive Plant Field Guide to aid people in identifying and reporting weed species of concern (CFIA, 2012b).

The Government of Canada has developed several strategies and plans to support invasive species management, including:

- *An Invasive Alien Species Strategy for Canada* (GOC, 2004),
- *A Canadian Action Plan to Address the Threat of Aquatic Invasive Species* (Canadian Council of Fisheries and Aquaculture Ministers, 2004),
- *Action Plan for Invasive Alien Terrestrial Plants and Plant Pests* (GOC, 2008),
- *Canadian Invasive Plant Framework* (GOC, n.d.), and
- *A Canadian Rapid Response Framework for Aquatic Invasive Species* (Fisheries and Oceans Canada, 2011).

Coordination and collaboration with provincial and territorial partners is promoted through the Federal-Provincial-Territorial Invasive Alien Species Task Force, which was formed in 2015. From 2005 to 2012, Environment Canada also ran an Invasive Alien Species Partnership Program, which provided funding for organizations taking action to prevent, detect and manage invasive alien species in Canada (GOC, 2012).

Several invasive species organizations operate at the national level. The Invasive Species Centre is an Ontario-based organization focused on natural and applied science, policy research, outreach and education to promote invasive species management in Canada (ISC, n.d.(b)). Associated programs include Asian Carp Canada and Forest Invasives Canada. The Canadian Aquatic Invasive Species Network was established in 2006 as a nation-wide network of researchers, partner universities, and federal laboratories. Initial research topics included investigation of the various pathways through which AIS enter Canada, determination of factors that affect establishment success of AIS, and development of risk assessment methods for AIS. Further research has focused on the themes of early detection, rapid response, AIS as one of multiple stressors influencing ecosystems, and means of reducing uncertainty in prediction and management of AIS (Canadian Aquatic Invasive Species Network, n.d.). One other prominent organization is the Canadian Council on Invasive Species. This federal society was formed by invasive species councils, committees and coalitions from across Canada as a means of supporting collaborative efforts and information sharing across jurisdictional boundaries (Canadian Council on Invasive Species, 2014). Many provinces have developed similar educational resources to one another, including invasive species fact sheets and "Grow Me Instead" brochures, to raise awareness about invasive plant species and provide people with management techniques and safe alternatives for gardening and horticulture purposes. Table 4 provides an overview of the lead invasive species organizations and policy frameworks in place for select provinces and territories of Canada.

Table 4. **Invasive Species Governance in Select Provinces of Canada**

Province	Invasive Species Council	Invasive Species Plans, Policies, and Legislation
Alberta	Alberta Invasive Species Council www.abinvasives.ca	Fisheries (Alberta) Act (RSA 2000 cF-16) Weed Control Act (SA 2008 cW-5.1) Agricultural Pests Act (RSA 2000 cA-8) and Pest and Nuisance Control Regulation (AR 184/2001) DRAFT Alberta Invasive Species Management Framework (2010)
Yukon Territory	Yukon Invasive Species Council www.yukoninvasives.com	Fisheries Act (RSC 1985 cF-14) and Yukon Territory Fishery Regulations (CRC c854)

Province	Invasive Species Council	Invasive Species Plans, Policies, and Legislation
British Columbia	Invasive Species Council of British Columbia www.bcinvasives.ca	Wildlife Act (RSBC 1996 c488) and Controlled Alien Species Regulation (BC Reg. 94/2009) Weed Control Act (RSBC 1996 c487) and Regulation (BC Reg. 66/85) Integrated Pest Management Act (SBC 2003 c58) and Regulation (BC Reg. 604/2004) Forest and Range Practices Act (SBC 2002 c69) Community Charter Act (SBC 2003 c26) Invasive Species Strategy for British Columbia (2012) Invasive Species Early Detection and Rapid Response Plan for British Columbia (2014)
Saskatchewan	Saskatchewan Invasive Species Council www.saskinvasives.ca	The Weed Control Act (SS 2010 cW-11.1) The Pest Control Act (RSS 1978 cP-7) The Forest Resources Management Act (SS 1996 cF-19.1) The Fisheries Regulations (SR 1995 cF-16.1 Reg 1) The Captive Wildlife Regulations (SR 1982 cW-13.1 Reg 13)
Manitoba	Invasive Species Council of Manitoba www.invasivespeciesmanitoba.com	The Noxious Weeds Act (CCSM cN110) The Water Protection Act (CCSM cW65)

Province	Invasive Species Council	Invasive Species Plans, Policies, and Legislation
Ontario	Ontario Invasive Plant Council www.ontarioinvasiveplants.ca	Fisheries Act (RSC 1985 cF-14) and Ontario Fishery Regulations (SOR 237/2007) Invasive Species Act (SO 2015 c22) Weed Control Act (RSO 1990 cW5) Ontario Invasive Species Strategic Plan (2012)
Prince Edward Island	PEI Invasive Species Council www.peiinvasives.ca	Weed Control Act (RSPEI 1988 cW-2.1) Fisheries Act (RSPEI 1988 cF-13.01)
Nova Scotia	Invasive Species Alliance of Nova Scotia www.invasivespeciesns.ca	Weed Control Act (RSNS 1989 C501) Fisheries and Coastal Resources Act (SNS 1996 c25) Stepping Up: Planning for the Challenges of Invasive Alien Species in Nova Scotia (2008)

6.3 International

It is beyond the scope of this report to provide an in-depth review of international policies related to non-native and invasive species management. However, the following sections provide a few examples of international policies and resources that may be applicable to Alberta.

6.3.1 United States

Alberta works collaboratively with several states in the northwest United States that are currently free of invasive mussels, including Washington, Oregon, Idaho and Wyoming. Montana is also an important partner, although invasive mussel veligers (larvae) were discovered in the state in the fall of 2016 (Montana Fish, Wildlife and Parks, 2016). All these states have mandatory watercraft inspections and follow similar watercraft inspection protocols to Alberta, which provides multiple barriers to the passage of invasive mussels through the region (Zabjek, 2015). An interactive online map provides

details on watercraft inspection stations currently active in the western United States and Canada (Pacific States Marine Fisheries Commission [PSMFC], 2016). Washington, Oregon and Idaho have developed *Dreissenid* mussel response plans (DeBruyckere, 2014; Draheim, Boatner, Dolphin, & DeBruyckere, 2013; Idaho State Department of Agriculture, 2015). Washington, Oregon, Idaho, and Montana are also signatories to the *Columbia River Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other* Dreissenid *Species* (IMISWG, 2015).

Much invasive species work in the eastern United States focuses on Asian carp monitoring, response and action. Several plans have been developed to guide this work:

- *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover, Simmonds, & Whalen, 2007),
- *2016 Asian Carp Action Plan* and *2017 Asian Carp Action Plan* (Asian Carp Regional Coordinating Committee [ACRCC], 2016; ACRCC, 2017),
- *Monitoring and Response Plan for Asian carp in the Upper Illinois River and Chicago Area Water System* (Finney et al., 2016), and
- *Monitoring and Response Plan for Asian carp in the Mississippi River Basin* (Mississippi Interstate Cooperative Resource Association, 2015).

6.3.2 International Efforts

Canada is a signatory party to the *International Plant Protection Convention* of the Food and Agriculture Organization of the United Nations (FAO, 1997). The IPPC is an international treaty that provides a common global framework for managing plant pests and preventing their introduction and spread (CFIA, 2016e). A key focus of the IPPC is the development of International Standards for Phytosanitary Measures, which seek to limit the spread of plant pests through international trade shipments. Measures developed by the IPPC provide the basis for phytosanitary measures applied in trade by members of the World Trade Organization (FAO, n.d.).

Canada is also a member of the North American Plant Protection Organization (NAPPO), which was formed in 1976 under the IPPC. NAPPO's goal is to facilitate trade between Canada, the United States, and Mexico, while ensuring that science-based standards are in place that protect agricultural, forest and other plant resources against regulated plant pests. This work includes the development of Regional Standards for Phytosanitary Measures (CFIA, 2016e).

The Western Regional Panel on Aquatic Nuisance Species and the 100th Meridian Initiative are two cooperative efforts between various local, state, provincial and federal agencies in Canada and the United States that focus on limiting the introduction, spread

and impacts of aquatic nuisance species in the western region of North America. In support of this work, the Pacific States Marine Fisheries Commission has outlined uniform minimum protocols and standards for watercraft inspection and decontamination (WID) programs for invasive mussels in the western United States (Elwell & Phillips, 2016). Another key report discusses model legislative provisions and guidance to encourage consistency and alignment of WID programs across multiple jurisdictions in the western region of North America (Otts & Nanjappa, 2014). A companion report identified commonalities, differences, and gaps among WID programs in various states (Otts & Janasie, 2014).

Another regional initiative involving international partners is the Invasive Species Working Group of the Pacific NorthWest Economic Region (PNWER) organization. Members of this non-profit include the states of Alaska, Idaho, Oregon, Montana, and Washington, the Canadian provinces of British Columbia, Alberta, Saskatchewan, and the Yukon and Northwest Territories. The mission of the PNWER is "to increase the economic well-being and quality of life for all citizens of the region, while maintaining and enhancing our natural environment" (PNWER, n.d.). Two key reports developed with the support of PNWER and partner organizations are the *Invasive Mussel Prevention Framework for Western Canada* and *Advancing a Regional Defense Against Dreissenids in the Pacific Northwest* (PNWER, 2016; PNWER & PSMFC, 2015).

The Global Invasive Species Information Network provides an online platform for sharing invasive species information and resources on a global scale.

7 Next Steps

This report has provided on overview of the current context and considerations for non-native and invasive species management in Alberta and Canada. The BRWA will use this information to develop policy advice and implementation guidelines for non-native and invasive species management in the Battle River and Sounding Creek watersheds of Alberta.

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This is our battle: the watershed we all share, and the fight to maintain to maintain a healthy environment, vibrant communities and a stable economy.

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