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Current Prevention and Management Approaches for Aquatic Invasive Species in Jurisdictions outside Alberta

Prepared for:	Alberta Water Council
In collaboration with:	Dr. Norman Yan
Project #:	140060
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4482 97 St. NW. Edmonton AB, T6E 5R9 | 587-773-4850

Hutchinson
Environmental Sciences Ltd.
4482 97 St. NW. Edmonton AB, T6E 5R9 | 587-773-4850
www.environmentalsciences.ca

October 31, 2014 HESL Project #: J140060

Andre Asselin
Senior Manager
Alberta Water Council
14th Floor, Petroleum Plaza South Tower
9915-108 Street
Edmonton, AB, T5K 2G8

Dear Mr. Asselin:

Re: Final Report: Current Prevention and Management Approaches for Aquatic Invasive Species in Jurisdictions outside Alberta

We are pleased to submit this final report for the project "Current Prevention and Management Approaches for Aquatic Invasive Species (AIS) in Jurisdictions outside Alberta" for review by the Aquatic Invasive Species Project Team. The report summarizes and synthesizes the information obtained from interviews with 10 representatives from six Canadian and U.S. jurisdictions. It is complemented by a literature review on most common and state-of-the art approaches to AIS management.

In the preparation of this final report we have addressed the comments of the AIS Project Team and have submitted a detailed response to the comments under separate cover.

Sincerely,
Hutchinson Environmental Sciences Ltd.

Dörte Köster, Ph.D.
Senior Aquatic Scientist
dorte.koster@environmentalsciences.ca

Executive Summary

The Alberta Water Council (AWC) has identified aquatic invasive species (AIS) as a priority issue of concern, and has charged AWC's Aquatic Invasive Species Project Team (AISPT) with identifying gaps in, and opportunities for, improving AIS prevention and management in Alberta. As part of this undertaking, the AISPT identified four main tasks, one of which was documenting the current prevention and management approaches for AIS in a selection of other North American jurisdictions. The following report presents the findings of this jurisdictional scan, complemented by a literature review summarizing the state of AIS prevention, management, and communication strategies.

Ten respondents from six jurisdictions (Ontario, Idaho, Minnesota, Oregon, Texas and Utah) were interviewed on a wide range of prevention, management and communication topics.

All reviewed jurisdictions have comprehensive AIS prevention and management systems in place, which focus on preventing the introduction of new AIS, but which also encompass managing existing AIS. Initiatives tend to be coordinated and led by one main government agency, which typically works with a diversity of other government and external partners. Several U. S. states 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.

All jurisdictions include public outreach in their AIS approach. Many jurisdictions target specific groups, such as those who might be at high risk for introducing or spreading AIS, either inadvertently or purposefully (e.g., anglers, boaters, aquarium owners). A focus on reaching the next generation, through elementary curriculum or school presentations, is also seen as an integral component of these AIS programs.

Risk assessments are an essential tool used by all jurisdictions to prioritize species, pathways and/or locations for monitoring, inspections, regulation and public awareness. Most jurisdictions have mandatory inspections for prohibited species targeted at high risk areas of entry and spread, such as highway border crossings, boat launches and bait retailers.

All jurisdictions have programs for the early detection and identification of new and localized invasions, through monitoring programs by both government and voluntary citizen scientists, the latter involving the general public. A variety of AIS are specifically targeted in these monitoring programs, including Asian carp species (bighead carp, *Hypophthalmichthys nobilis*; black carp, *Mylopharyngodon piceus*; grass carp, *Ctenopharyngodon idella*; and silver carp, *H. molitrix*), dreissenid mussels (quagga mussel, *Dreissena bugensis* and zebra mussel, *D. polymorpha*) and Eurasian water-milfoil (*Myriophyllum spicatum*). Alternatively, a more general approach is adopted, monitoring for any types of AIS that can be detected. Ongoing monitoring is generally recognized as a critically important precursor to a successful rapid response to biological invasions.

Some jurisdictions have rapid response plans established for specific threats, like Asian carp species, dreissenid mussels and *Spartina* species (*Spartina alterniflora*, *S. anglica*, *S. densiflora* and *S. patens*). The implementation of these plans is often led by the main agency responsible for the AIS program, with help from other levels of government, and sometimes landowners, contractors and volunteers. Eradication is attempted if the infestation is limited in extent, and a positive outcome is deemed possible.

Once AIS become established, jurisdictions switch to controlling and containing AIS, where possible. In general, most jurisdictions rely on a combination of mechanical, chemical and biological control options, depending on the AIS. Efforts to suppress populations and limit their spread occur at the smallest scale possible, which is usually an individual waterbody.

Several jurisdictions have a single dedicated piece of legislation on AIS to support their prevention and management program. Many states regulate a large number of AIS through a wide range of prohibitions (e.g., import, possession, transport, propagation, trade, release). These restrictions may be further bolstered by additional powers, such as the ability to designate infested waterbodies, and the ability to stop and inspect any boat. Jurisdictions with strong legislation back this up with strong enforcement tools, such as the ability to fine, seize, decontaminate, clean and quarantine.

All jurisdictions rely on several (or many) full-time staff to implement the AIS program; some also employ seasonal staff to help with inspections, monitoring and public outreach. Many jurisdictions have mandatory and regular reporting built into the AIS program (e.g., required annual or biennial reports to the state legislature), and this ensures that success is measured on a consistent basis.

All jurisdictions have some level of dedicated consistent funding available for their AIS programs (and in some cases, the budget for invasive species keeps rising while budgets for other government programs keep falling), but funding is never enough for the work that needs to be accomplished. A number of jurisdictions receive a portion of their funding through fines, fees and licenses.

Amongst the large number of indicated individual approaches, methods, structures and strategies, a few stand out that have been tested and proven effective for AIS prevention or management in a number of jurisdictions, as indicated by their adoption by the large majority of jurisdictions and by their citation as a barrier to effective management when missing. These include:

- Focus on prevention,
- One lead agency, collaborating with a large range of other groups and stakeholder,
- Mandatory inspections that are enforced,
- Outreach targeted to specific groups,
- Risk assessments to inform program priorities and allocate efforts to the right species, pathways, and location,
- Readiness for active, rapid response,
- A single piece of legislation with a wide range of prohibitions, and
- Reliable sources of funding, including operational government and user-fee derived funds.

The most important barriers to a successful AIS program were repeatedly cited as insufficient funding, personnel, legislative and legal authority, and insufficient partner coordination, while resistance to behavioural changes and lack of political will were also mentioned. These results clearly demonstrate that the technical components of AIS management are well known and developed, but that the resources, strategies and structures to implement them are limiting program success.

Some jurisdictions, such as Oregon and Idaho, have so far prevented invasion of dreissenid mussels within their borders and have reduced the impact of existing aquatic invasive plants. This provides reassurance that, despite the general perception that invasions cannot be halted, success is possible to a certain degree with an effective AIS program.

A large number of the reviewed and proven approaches could be useful in an Alberta Strategy to prevent and manage AIS. Utah and Idaho are most similar to Alberta in terms of geographical exposure to aquatic invasive species. Their AIS management systems with a focus on preventing dreissenid invasion through watercraft inspection and decontamination, ongoing monitoring, established rapid response, extensive public outreach and dedicated legislation are therefore exemplary for Alberta. While the Canadian regulatory context is different from that in the U.S., possibly limiting the adoption of some of the reviewed regulatory and enforcement tools in Alberta, there are a large number of universally applicable approaches, methods and tools that build an effective AIS program. Learning from the experience in other places was an essential part of all reviewed jurisdictions' programs; showing that this study is one step in the right direction for Alberta's AIS program.

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List of Acronyms

Table 1. List of Acronyms

Acronym	Meaning
AIS	aquatic invasive species
AISPT	Aquatic Invasive Species Project Team
AWC	Alberta Water Council
BMPs	best management practices
CCFAM	Canadian Council of Fisheries and Aquaculture Ministers
CO	conservation officer
COA	Canada-Ontario Agreement
CRB	100th Meridian Initiative Columbia River Basin Team
DNR	Department of Natural Resources (Minnesota)
DWR	Division of Wildlife Resources (Utah)
EDDMapS	early detection and distribution mapping system
EDRR	early detection and rapid response
eDNA	environmental DNA
EPA	U.S. Environmental Protection Agency
FWCA	Fish and Wildlife Conservation Act (Ontario)
GPS	global positioning system
HACCP	Hazard Analysis and Critical Control Point Program
IISC	Idaho Invasive Species Council
IS	invasive species
ISAP	Invading Species Awareness Program (Ontario)
ISDA	Idaho State Department of Agriculture
ISCBC	Invasive Species Council of British Columbia
MDA	Minnesota Department of Agriculture
MNR	Ministry of Natural Resources (Ontario; previous name of MNRF)
MNRF	Ministry of Natural Resources and Forestry (Ontario)
MOECC	Ministry of the Environment and Climate Change (Ontario)
NGO	non-governmental organization
ODA	Oregon Department of Agriculture

Acronym	Meaning
ODFW	Oregon Department of Fish and Wildlife
OFAH	Ontario Federation of Anglers and Hunters
OFR	Ontario Fisheries Regulations
OIPC	Ontario Invasive Plants Council
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
PAIS	Public Affairs Information Services
PCR	polymerase chain reaction
PSU	Portland State University
RA	risk assessment
RR	rapid response
TPWD	Texas Parks and Wildlife Department
USFWS	U. S. Fish and Wildlife Service
n/a	question not answered

Glossary

Table 2. List of Key Terms

Term	Definition
biological control	Use of another organism to control invasive species populations, often through predation, herbivory or parasitism
chemical control	Use of pesticides (including herbicides) to control invasive species populations
dreissenid mussels	Family of freshwater mussels, including zebra and quagga mussels, that are native to the Ponto-Caspian region of Eurasia, and that have become invasive in North America and in non-native parts of Europe
environmental DNA (eDNA)	Traces of different organisms' DNA that occur in the aquatic environment and that may be collected and measured to detect the presence of particular AIS, (represents a relatively new tool for detecting AIS without having to observe or catch individuals of the species)
introduced species	A species brought to a geographical area beyond its native range for the first time as a result of human activity (either intentional or accidental)
invasive species	An introduced species that is able to spread and cause damage to the environment, economy and/or society
mechanical control	Use of motorized equipment or physical labour to control invasive species populations
monitoring	An on-going process to collect information on presence and absence as well as population density, spread and impacts of an AIS
noxious weed	Directly or indirectly, this class of plants causes harm to humans
pathogen	Virus or bacteria or fungus that can cause harm or disease in an organism
pathway	Route by which invasive species are transported to a new area (e.g., shipping)
polymerase chain reaction (PCR)	Method used in molecular biology to amplify a small amount of DNA to produce millions of copies of it for analysis
risk assessment	A process used to evaluate the likelihood of entry and establishment of an invasive species, as well as its possible adverse effects
stakeholder	A person or group with an interest or concern in AIS
vector	Agent that carries invasive species along a pathway to a new area (e.g., ballast water)

1. Project Background and Objectives

Over the past 30 years, aquatic invasive species (AIS) have become a prominent concern and focus in managing North America's freshwaters. The invasion of dreissenid mussels into the Great Lakes system in the 1980s had significant ecological, economic and management consequences that are still unresolved, and which raised awareness of the need for prevention and management programs. Increased surveillance of freshwater ecosystems since then has identified many new invasive species across the country, as well as range extensions of established invaders (e.g., American bullfrog, *Lithobates catesbeiana*; Asian carp species; rusty crayfish, *Orconectes rusticus*; spiny waterflea, *Bythotrephes longimanus*; European common reed, *Phragmites australis australis*; Eurasian water-milfoil). Rising international trade and travel, combined with climate change will continue to provide many opportunities for AIS to arrive alive, survive and thrive in Canadian freshwater ecosystems. Releasing non-native species from aquariums or ponds will further increase the risk of biological invasions in natural waterways.

There are many pathways and vectors of introduction and spread for AIS in Canada, including shipping, recreational boating, the aquarium and water garden trade, canals and water diversions, live food fish markets and use of live bait. While Alberta's lack of marine access reduces the threat of AIS arriving via international ocean shipping, the province remains vulnerable to aquatic invasions from many other sources, for example the import of pre-owned watercraft that were used in AIS-infested waters. The prevention and management of AIS is a significant challenge because of the many pathways, vectors, and species involved. Predicting what species will be the next invaders, and what their impacts will be, further complicates efforts to tackle the problem. Clearly, an effective response to AIS demands a comprehensive, well-coordinated approach at every stage of the invasion process, from prevention through to eradication, containment and control.

The Alberta Water Council recognizes the risk of invasive species to Alberta's environment, economy and society and is taking steps to help prevent AIS introductions and spread in the province. The Council identified AIS as a priority focus in March 2013, and a project team was established in June 2013 to identify gaps in and opportunities for improving AIS prevention and management in Alberta. The AIS Project Team (AISPT) identified four main tasks to achieve this goal:

1. Document the current prevention and management approaches in Alberta to determine the current state of AIS;

2. Document the current AIS prevention and management approaches of other jurisdictions;

3. Determine the need for a common definition for AIS;

4. Evaluate barriers to, and opportunities for, improving AIS prevention and management within Alberta, and propose recommendations to improve awareness, communication and coordination of activities to respond to AIS threats.

The following report addresses the second task of conducting a jurisdictional review of AIS prevention and management strategies outside Alberta. The main purpose of this study was to collect detailed information on other jurisdictions' AIS programs, to assess strengths and weaknesses of approaches and methodologies employed elsewhere and to learn from lessons and experience collected by AIS managers in implementing their AIS prevention and management systems. It is hoped that this information will be highly valuable in the development of an Alberta AIS Strategy.

We addressed this task through completion of a jurisdictional review and a literature review. We conducted interviews with leading AIS managers in the selected jurisdictions to obtain first-hand knowledge of both the current approaches used in AIS management, along with a candid evaluation of their success. We also performed a literature review to inform the selection of topics for the questionnaire and to put the interview results into a larger context of the scientific literature.

In this report, we first present the methodology applied to the literature and jurisdictional reviews (Section 2). We present the results of the literature review in Section 3 and the results of the interviews in Section 4. We conclude the report with a summary of collected information in Section 5.

2. Methodology

The project was comprised of two main components: a background literature review and interviews with government staff (as well as two academics) from the selected jurisdictions. In consultation with the AISPT, six North American jurisdictions were chosen for the study: Ontario, Idaho, Minnesota, Oregon, Texas and Utah, and for each we documented their approaches to prevention, management and communication relating to AIS. These jurisdictions were selected because they have one or more of the following characteristics:

- Have freshwater lakes, reservoirs or navigable waters;
- Experience periods of water scarcity;
- Have existing prevention, management and/or communication strategies for AIS; and
- Were approved for review by the AISPT.

2.1 Literature Review

We conducted a review of key papers in the natural and social sciences literature relating to AIS prevention, management, and communication, as well as policy documents from the selected jurisdictions, if they were referred to in the interviews and needed to provide additional information. We selected the peer-reviewed literature for review using three online research search engines: Web of Science™, Public Affairs Information Services (PAIS) and Scopus, and the following cross-listed search terms:

Table 3. Search Terms Used in Literature Review

Invasive species terms	Prevention and management terms	Communication terms
invasive species	predict, prediction	stakeholder
introduction	prevention	communication
spread	early detection	public awareness
aquatic	rapid response	education
alien species	management	outreach
exotic species	control	
introduced species	eradication	
non-indigenous species	climate change	
non-native species		
biological invasions		
bioinvasions		

The search generated over 180 records, which we filtered down to 38 relevant papers by scanning the abstracts. We filtered papers for relevance based on their coverage of invasive species issues (i.e., prevention and management topics). We then read each of these final papers and made notes on information relating to any of the following topics: prevention, early detection, rapid response, eradication, containment, control, communication, stakeholder engagement and climate change.

2.2 Interviews

We developed a detailed questionnaire using the example questions provided by the AISPT as a starting point. Information from the literature review further guided our selection of questions. The final questionnaire approved by the AISPT consisted of 15 areas of focus and 149 questions (See Appendix A). We interviewed a total of ten people from the six jurisdictions either by phone or email. They included invasive species biologists, AIS coordinators and a director of a freshwater research centre (See 6.1).

The replies to all questions produced a substantial body of information. Where gaps and unclear responses were identified, we gathered more information through written follow-up communication. We then organized the information by topic, question and jurisdiction into one large table (Appendix A), which formed the basis for this report.

3. Literature Review

3.1 Overview of Problem

Invasive species are a growing threat to the environment, economy and society worldwide. Increasing trade, travel and tourism, combined with ongoing climate change and land use modification, provide a myriad of opportunities for invasive species to be introduced to, and spread in, areas beyond their natural range (Mooney 2001; Perrings et al. 2002; Hellmann et al. 2008). Addressing the threat of invasive species is a complex challenge because of the many pathways, vectors, species, ecosystems and stakeholders involved (Horan and Lupi 2010; Luque et al. 2014). A strategic approach to the problem, in which efforts are prioritized, coordinated, proactive and timely, is needed to successfully combat current and potential invasive species.

Invasive species can have profound effects on the native ecosystems they invade, ranging from suppression or extinction of native species, to changes in ecosystem function and services (Chornesky and Randall 2003). As a result, invasive species also typically have significant impacts on human well-being, through direct damage to industries, food and natural resources, spread of diseases, aesthetic changes to landscapes and through the alteration of ecosystem services we depend on (e.g., water supply, pollination, climate stabilization; Lodge and Shrader-Frechette 2003; Pejchar and Mooney 2009). Biological invasions have had disproportionate ecological, economic and social consequences. For example, approximately 24% of all species at risk in Canada are believed to be at risk, in part, because of the threat posed by invasive species (Stronen 2002). The costs of damage and control of just ten invasive species to Canadian fisheries, agriculture and forestry sectors is calculated as $187 million per year (Colautti et al. 2006). When the impacts of reduced yield are factored in, the cumulative cost of 16 invasive species (out of a total of at least 1500) in Canada has been conservatively estimated to range between $13.3 and $34.5 billion annually (Colautti et al. 2006).

Freshwater ecosystems are particularly vulnerable to the effects of invasive species (Sala et al. 2000). Canada has approximately 60% of the world's lakes and 20% of the world's freshwater supply, and there is a lot of human development and activity along and within our southern waterways, putting them at increased risk of biological invasions (CCFAM 2004). AIS are a leading cause of native freshwater species, like fish and molluscs, becoming threatened or endangered in the country (Dextrase and Mandrak 2006). Historically, ballast water in ships arriving from abroad has represented the single largest source of AIS to Canada, but there are many other ways in which AIS reach new areas, including through live bait, live food fish, canals and water diversions, irrigation systems, and aquarium and water garden pathways (CCFAM 2004). Once AIS are introduced and establish beyond their native range, they may continue to be spread to new areas through a variety of activities. One of the main agents of secondary spread once AIS have established is through transient boaters, who move their boats from waterway to waterway for recreational purposes (Dalrymple et al. 2013; Shaw et al. 2014). This pathway is of particular importance in Alberta.

Prevention is the best option when dealing with AIS, since management efficiency decreases, and management costs increase as the invasion process progresses (Leung et al. 2002; Simberloff et al. 2013). Many invasive species exhibit time lags between when they are introduced and when their

negative impacts are first observed, and eradication may be difficult, if not impossible, once they are well established (Mack et al. 2000; Crooks 2005; Simberloff et al 2013). 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 (Pyšek and Richardson 2010). 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 (Waldner 2008; Eiswerth et al. 2011).

3.2 Prevention

Prevention is the most cost-effective approach to invasive species management, both from an ecological and economic perspective. A proactive strategy should ideally target the early stages of the invasion process, with the aim of preventing invaders being transported to and entering areas beyond their native range (Ricciardi and Rasmussen 1998). A number of tools are available to aid in the prevention of biological invasions, including risk analysis and predictive modelling to determine key threats, pathways, vectors, and areas of entry, well before they become a problem (Gallardo and Aldridge 2013). This information can then be used to identify unwanted species, as well as key routes and vulnerable locations to monitor for their arrival. Surveillance at borders or entry points, as well as along pathways, can help detect AIS and enable their interception before they have a chance to be introduced. Some management practices (like ballast water management) can be carried out well before species cross into new jurisdictions or areas, further minimizing risks.

Effective risk assessment depends on knowledge of a variety of factors, including the biological traits of the species, any past invasion history, and propagule pressure (number of individuals likely to be introduced; Gertzen et al. 2008). Several biological attributes appear to be common among AIS, potentially making them good predictors of future invaders. These attributes include wide environmental tolerance, great abundance and wide distribution in native range, high genetic variability, short generation time, rapid growth, and rapid dispersal capabilities (Ricciardi and Rasmussen 1998).

Predictive models can be extremely useful (and relatively inexpensive) in AIS management, but they are not often incorporated into strategies because detailed information on invasion history of most AIS is not readily available (Ricciardi 2003). Ecological niche modelling uses information from a species' native range (or previously invaded range) to map environmental tolerances and sensitivities of the species. It then predicts the potential invasive distribution of AIS in new areas by matching habitat and climate in the new area to that of the native range (Nantel 2002; Boylen et al. 2006). Management activities can then be prioritized to focus on preventing AIS introductions in areas where invasions are most likely to be successful. Socio-economic factors, such as human population density, trade activity, recreational boat movements and waterway connectivity can also be incorporated into models to help identify likely AIS threats, pathways, vectors and locations of invasion, because these factors can be used as surrogates of propagule pressure (Gallardo and Aldridge 2013). However, datasets on widespread socio-economic indicators (such as fishing intensity, recreational boating activity) that could increase the power of predictive modelling are largely lacking. In the case of aquatic species, temperature is often an important predictor of species distribution, underscoring the need to include climate change in predictive models and risk analysis (Gallardo and Aldridge 2013).

Canada currently lacks consistent legislation across the entire country to prohibit the import, possession, trade, transport and release of live AIS (Smith et al. 2014). Some provinces have prohibitions on some of these activities, for some AIS (e.g., Ontario bans trade in listed live invasive fish species) and the federal *Fisheries Act* prohibits the possession of listed live invasive fish species. This piecemeal approach means that AIS prohibited in one Canadian jurisdiction may be freely available in a neighbouring jurisdiction. Proposed AIS regulations under the federal *Fisheries Act* will begin to address this problem, since they will enable prohibitions on import, possession, and transport of listed species (although only those AIS that cause harm to fish, fish habitat or use of fish). Initially, the federal government proposes listing Asian carp species (i.e., bighead, black, grass[1] and silver) across Canada, as well as zebra and quagga mussels in British Columbia, Alberta, Saskatchewan and Manitoba. New species could be added over time through regulatory amendment.

3.3 Early Detection and Rapid Response

It is inevitable that some invasive species will be introduced to new areas, despite the best prevention efforts. This is where early detection and rapid response (EDRR), come into play. Early detection, comprised of monitoring and surveillance, represents the early warning system, triggering rapid response to deal with invaders soon after they arrive (Anderson 2005). A well-planned EDRR system can be an important tool in AIS management, since many AIS detected early can be successfully eradicated, contained or controlled (Vander Zanden et al. 2010).

There are a number of challenges to designing an effective EDRR system. New invasions are generally characterized by low population numbers, making them difficult to detect. The problem is further complicated when organisms are small, inconspicuous or hard to identify (e.g., the microscopic larval stage of dreissenids; Pyšek and Richardson 2010; Hosler 2011). These issues may be addressed by identifying areas at high risk to invasions, targeting sampling of these hotspots (especially during times of year when likelihood of arrival and establishment rises, such as summer months for spiny waterflea; Vander Zanden et al. 2010), using detection techniques that do not require high abundance (e.g., environmental DNA [eDNA][2]), and improving taxonomic expertise for AIS (Pyšek and Richardson 2010; Simberloff et al. 2013).

An ongoing monitoring program is essential to determine whether subsequent rapid response protocols have successfully eradicated the invasion (Simberloff 2009). Whereas passive discovery of an invader (i.e., outside of organized surveillance programs) often occurs once the species is already well established (with high population numbers and large geographic extent), early detection monitoring increases the chance that the invader will be found much earlier, when populations are localized and relatively small (Horan and Lupi 2010).

Once an invasion has been detected, a successful response depends on readiness to act and immediate access to the resources and funding needed for action (Anderson 2005). Steps in a rapid response may include identification of the threat and extent of the infestation, determination of AIS impacts and feasibility of management, evaluation of treatment options, implementation of treatment, and monitoring

[1] Except for triploid grass carp used for weed control in southern Alberta.

[2] Environmental DNA is DNA in the aquatic environment left behind by organisms (e.g., through skin, urine, feces). It is used to monitor for the presence of AIS without the need to actually observe or catch individuals of the species.

and evaluation of response (Modley 2008). Ideally, response planning should include emergency preparedness exercises to ensure all necessary experts, agencies, resources and funding are in place and ready well before an invasion occurs. Such drills can also help raise public awareness about the risks of AIS and the value of prevention (Anderson 2005). Rapid response is most likely to succeed if there is a person or agency to oversee the process, ensuring cooperation and coordination among stakeholders (Simberloff 2009).

3.4 Long-term Management

If rapid response efforts to eradicate fail, or if an invader is only detected once it is already well established, the strategy shifts toward long-term management, focused on limiting the size and further spread of the invasive population, and possibly mitigating its effects and/or restoring damaged habitats (Horan and Lupi 2010). Challenges arise when determining which populations to target and what management tools to use (e.g., mechanical, chemical, biological). Restrictions may exist on what tools can be implemented (e.g., pesticide bans, public aversion to chemicals or biological controls), which further complicates management planning, and sometimes requires that the "second-best" option is selected (Horan and Lupi 2010).

3.5 Stakeholder Engagement and Public Awareness

Invasive species can affect a wide variety of stakeholders, and perceptions of the problem and how it should be managed can vary significantly among these different groups (Stokes et al. 2006). Communication and engagement of stakeholders and the general public is key to creating broad scale support for prevention and management programs (e.g., surveillance and control efforts), while at the same time helping to promote desired behaviours (Waldner 2008). In addition, open dialogue between managers and the public allows potential concerns and opposition to management to be anticipated and addressed in advance (e.g., use of pesticides or biological control; Warner and Kinslow 2011). Outreach can also lead to cooperation (e.g., landowners granting access to land for control efforts) and participation in stewardship activities (Waldner 2008; Dresner and Fischer 2013).

Public outreach and education raises awareness about invasive species, and can motivate people to take action (Waldner 2008; Dresner and Fischer 2013; Reis Schreck et al. 2013). Education on invasive species can take many forms, including workshops and seminars, control and eradication events, brochures, websites and ads on television and in cinemas (Waldner 2008; Reis Schreck et al. 2013; Shaw et al. 2014). 'Opinion leaders' can also serve as strategic communicators on AIS to particular target audiences. For example, bait vendors interact with large numbers of boaters and anglers, and could act as key messengers on the risks of AIS spread through the boating and live bait pathways (Dalrymple et al. 2013). Vendors could be provided with educational materials (e.g., stickers for bait buckets and trailers, floating key chains with AIS preventative steps), as well as key talking points to engage their customers on AIS issues (Dalrymple et al. 2013).

Ultimately, identifying the objective of the educational campaign will help determine who the target audience will be, and thus how the campaign should best be designed. If the goal is to slow the spread of AIS through inter-lake boat transport, for instance, then boaters will be the most appropriate audience. If

public support for government action and spending on AIS is the goal, then broader scale outreach will need to occur (Eiswerth et al. 2011).

Citizen science programs can contribute to raising public awareness of invasive species, while also providing valuable data that can be used by resource managers, scientists and policymakers to combat the problem. For example, the Invaders of Texas program, which trains volunteers to detect the arrival and spread of invasive plants and report findings to an online mapping system, has expanded the known distribution of giant reed (*Arundo donax*), an invasive plant of wetland and riparian habitats, in the state (Gallo and Waitt 2011). Citizen science programs have not been widely used, however, to aid with IAS prevention and management efforts. Typically, such programs have been short-term and geared toward eradication, although this is gradually changing as the educational, environmental and economic benefits of citizen science monitoring become apparent (Delaney et al. 2008; Gallo and Waitt 2011). AIS monitoring initiatives based on citizen science that have been recently developed include Ontario's Lake Association AIS Monitoring Program[3] and New York's Adirondack Park Invasive Plant Program's Volunteer Monitoring[4].

3.6 Legislation and Policy

Legislation and policy can play an important role in guiding, prioritizing and mandating efforts to prevent the introduction and spread of AIS. In Canada, a national strategy on invasive species was introduced in 2004, and it has acted as a framework for the development of provincial and territorial plans for action (e.g., British Columbia and Ontario have developed strategies; Gov. of Canada 2004; ISCBC 2012; MNR 2012). The national strategy has also led to the release of several national action plans on invasive species, including one on AIS, which focuses on pathway management via legislation, risk management, public engagement and science (CCFAM 2004). Currently, no legislation in Canada is dedicated to invasive species, although many acts and regulations at both the federal and provincial/territorial levels address them in some capacity (Smith et al. 2014). In general, however, legislation on invasive species is not well integrated across jurisdictions, and it is fragmented in its coverage of threats, pathways and vectors (CCFAM 2004; Smith et al. 2014).

Other countries (e.g., Australia, Norway, South Africa) are more advanced in their legislative and policy frameworks on invasive species. New Zealand's approach, in particular, is considered a model for addressing biological invasions (Kelly and Sullivan 2010). The country has two pieces of invasive species legislation: the *Biosecurity Act* (focused on the prevention of introductions and the eradication and management of established populations) and the *Hazardous Substances and New Organisms Act* (focused on the prevention and management of adverse effects of invasive species). Under this legislative structure, New Zealand has designed and implemented a comprehensive strategy to enable widespread and systematic pre- and post-border control, early detection monitoring, rapid response procedures and long-term management, within a well-coordinated network of agencies (Simberloff 2009; Kelly and Sullivan 2010). Since its inception, New Zealand's biosecurity program to address invasive species has successfully eradicated a number of AIS fish (e.g., mosquitofish, *Gambusia* spp.; koi carp,

[3] *foca.on.ca/foca-aquatic-invasive-species-monitoring-program/*
[4] *Adkinvasives.com/get-involved/volunteer/*

Cyprinus carpio) and terrestrial invasive species (e.g., kudzu, *Pueraria lobata*; gypsy moth, *Lymantria dispar*) (Green 2006; Kelly and Sullivan 2010).

4. Results of Consultation

The following sections present summaries of information collected through the interviews. Each section reflects a different component of the AIS prevention and management process. In each section, we present highlights of the results, then tabulate the specific points we gleaned from the interviews in each jurisdiction.

4.1 Overview of the Prevention and Management System

All reviewed jurisdictions have a strategy or plan in place to deal with AIS. In the Great Lakes jurisdictions, these were initiated in the mid-1980s and early 1990s in response to the zebra mussel invasion, while the programs in inland jurisdictions date from approximately the past 10 years. State or provincial agencies responsible for natural resources, agriculture or fish and wildlife consistently lead AIS programs. The definition of invasive species generally refers to non-native species that are harmful to the native environment, economy or society, but AIS programs are often directed towards both non-native (from outside the jurisdiction) and native species (from inside the jurisdiction) that are spread beyond their natural range by human activities. For example, Ontario considers native species that have expanded their range due to climate change as AIS if they are causing harm in their new environment. The most common goals of AIS programs are the prevention of invasions, spread and AIS impacts.

All programs cover the entire jurisdiction, including public and private lands, and deal with both new and established species. Boat traffic is the number one pathway that is targeted with the prevention and management system, but all possible pathways are considered by many jurisdictions, most explicitly including angler bait, bait hatcheries, fish markets, international trade, and pet and aquarium stores. Incoming and outgoing pathways are considered in all jurisdictions, although incoming pathways generally receive much greater attention.

Key species considered in the programs depend on geographical patterns of existing invasions and severity of impacts, with dreissenid mussels leading the priority list in most jurisdictions, Asian carp species in Great Lakes jurisdictions, and a number of plants (e.g., Eurasian water-milfoil; hydrilla, *Hydrilla verticillata*; water lettuce, *Pistia stratiotes*), invertebrates (e.g., spiny waterflea; rusty crayfish; New Zealand mud snail, *Potamopyrgus antipodarum*), and fish (e.g., round goby, *Neogobius melanostomus*; Eurasian ruffe, *Gymnocephalus cernuus*; northern snakehead, *Channa argus*). Pathogens are often considered, but receive much less attention in general.

All jurisdictions have defined lists of invasive species, also called “prohibited” or “exotic”; and in the case of plants, “noxious”. Most jurisdictions have comprehensive species lists that are considered in AIS programs, except Ontario, which has no list for aquatic plants. Some states distinguish classes with differing associated levels of regulation, 1) completely prohibited species that cannot be imported for any reason, 2) controlled species that require a permit and must meet certain conditions, 3) exempt species,

such as regular pets (dogs, horses, in legislation that includes terrestrial species), and 4) non-regulated species.

Principles of adaptive management are part of all AIS programs, recognizing the rapidly evolving nature of AIS status and ongoing research. In Idaho, for example, data from statewide watercraft inspections and invasive species surveys are uploaded daily, allowing for almost real-time observation of what is occurring. This information is then used to address any problems or issues that may arise in the AIS program. In Texas, incremental stocking of triploid grass carp has been used to control hydrilla, with the number of fish stocked every few months adjusted based on vegetation surveys of the extent of hydrilla infestation. Minnesota uses an integrated pest management approach, and incorporates feedback from stakeholders into its AIS program.

Research on, and implementation of, emerging techniques and management tools, is also an integral part of all AIS programs. Ontario does not carry out its own research, but relies on findings from other jurisdictions for guidance. Minnesota's Sea Grant program has provided funding for research into novel approaches to AIS prevention and control since the early 1990s, including work on developing pheromones for sea lamprey (*Petromyzon marinus*) control. The University of Minnesota's AIS Research Centre was recently established to focus on finding solutions for threats from Asian carp species (i.e., bighead and silver carps), zebra mussels and Eurasian water-milfoil. Texas, meanwhile, is raising weevils for use as biological control against giant salvinia (*Salvinia molesta*). Several jurisdictions use eDNA to monitor for emerging AIS. Research into chemical control is conducted in Minnesota and Utah, while in Ontario, pesticide companies are encouraged to develop and register products for use on AIS. In Utah, research is also underway to determine legal and effective options for tracking boats once they move from infected waterbodies.

Barriers to AIS prevention and management were insufficient funding and personnel to help with all aspects of the program, above all community engagement, monitoring and surveillance. Ontario lacks legislative tools for prevention and management implementation while lack of political will and behavioural motivation were cited as challenges in some U.S. jurisdictions. Recommendations to improve programs included increased involvement of law enforcement, local capacity-building for early detection and management, improved internal structures for rapid response and extended windows for boat inspections (both temporally and spatially).

Table 4. Summary of Interviewee Responses on Program Overview

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Overview	• Ontario Invasive Species (IS) Strategic Plan, including 'Leadership and Coordination', 'Legislation, Regulation and Policy, 'Risk analysis', 'Monitoring and Science', 'Management Measures', 'Communication and Education'	• IS Program, IS Strategic Plan and state legislation • focus on coordination of efforts to prevent, control and minimize IS and their impacts in the state through inspection and public education	• IS Program and state legislation • focus on coordination of efforts, designation and identification of infested waters, regulatory classification of non-native species based on risk, boat inspections, identification of potential IS, prediction of their spread and development and implementation of solutions, management of existing AIS and reporting	• AIS Prevention Program and state legislation • focus on watercraft inspection and decontamination, public education and training	• Texas State Comprehensive Management Plan for Aquatic Nuisance Species and state legislation • address prevention, control and impacts of AIS through management, research and public education; training of large detector network	• AIS Program, Management Plan and state legislation • mainly to deal with dreissenid mussels • large public outreach component • watercraft pre-launch interdiction and decontamination
Age of program	• since 1992	• 2005	• 1987; legislated in 1991	• 2003, legislated 2009	• 2005	• 2007

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Definition of invasive species	• "harmful alien species whose introduction or spread threatens the environment, the economy, or society, including human health"	• species not native to Idaho… that cause economic or environmental harm and are capable of spreading in the state	• non-native species that: (1) causes or may cause economic or environmental harm or harm to human health; or (2) threatens or may threaten natural resources or the use of natural resources in the state	• "AIS" means any aquatic life or marine life determined by the State Fish and Wildlife Commission by rule to be invasive or any aquatic noxious weed determined by the Oregon Department of Agriculture (ODA) to be invasive	• "non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (U. S. Federal Executive Order 13112)	• "aquatic nuisance species" are non-native species "that threaten native species' abundance or diversity, stability of aquatic systems and commercial or water recreational use"

Current Prevention and Management Approaches for Aquatic Invasive Species in Jurisdictions outside Alberta

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Goals	• prevent new invaders from arriving and surviving in Ontario; slow, and where possible reverse, the spread of existing IS, and reduce the harmful impacts of existing IS	• prevent the introduction of new IS; limit the spread of existing IS populations; abate ecological and economic impacts that result from IS populations	• prevent new introductions into the state, prevent further spread within the state of organisms that are here; reduce the negative effects of IS on the economy, society and the environment	• protect Oregon's lakes, rivers and streams from the introduction and spread of AIS	• protect state waters against the introduction of exotic species; coordinate management activities; detect, monitor, contain, reduce or eradicate AIS; educate public and stakeholders; identify problems, develop and conduct research, and disseminate results; ensure federal and state rules and regulations promote prevention and control	• prevent and control the spread of aquatic invasive species within the state • main focus is dreissenid mussels, with secondary focus on New Zealand mud snail and Eurasian water-milfoil and tertiary focus on all other AIS
Native and non-native species?	• yes	• no, just non-native	• yes	• no, just non-native	• yes	• no, just non-native
Geographic scope? **Public & private lands?**	• province wide • yes	• statewide • yes	• statewide • yes	• statewide • yes	• statewide • yes	• statewide • yes
Established and new AIS?	• yes	• yes	• yes	• yes	• yes	• yes
Pathogens?	• yes	• plant pathogens only	• a few	• yes	• no	• yes

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Pathways and vectors	• consider all; evaluate what attention needed	• "conveyance" – any means of transportation	• main focus: boats and anglers; approximately 25 different pathways	• main focus: boats international trade, mail order, ballast	• main focus: boats • ceremonial & aquarium releases	• main focus: boats; • anglers
Incoming and outgoing AIS?	• both, but primarily incoming	• both, but primarily incoming	• both	• both, but primarily incoming	• both	• both, but primarily incoming
Which AIS considered and which are the focus?	• consider all, priority on manageable (see Appendix B for regulated list)	• zebra and quagga mussels; noxious weeds + a large number of other listed species (see Appendix B for regulated list)	• zebra mussels and Asian carp species + a large number of others listed (see Appendix B for regulated list)	• zebra and quagga mussels • live bait, bait fish, crayfish; New Zealand mud snail; milfoil, hydrilla (see Appendix B for regulated list)	• long list of fish, shellfish and aquatic plants (see Appendix B for regulated list)	• zebra and quagga mussels (see Appendix B for regulated list)
Terms used for regulated species	• 'invasive fish' (under Ontario Fisheries Regulations [OFR]) • 'fish that do not exist in Ontario waters[5]' (under provincial *Fish and Wildlife Conservation Act* [FWCA])	• Idaho Invasive Species List and Idaho Noxious Weed List	• 4 classes: prohibited, regulated, unlisted and unregulated (stop light approach)	• 4 categories: animals exempt from rules (pets); prohibited (not allowed to possess, transport, import), non-controlled (because unlikely to survive in Oregon); controlled (permit required)	• invasive, prohibited and exotic Species	• dreissenid mussels • other AIS classified as prohibited or controlled

[5] There is no explanation in the Act`s regulations of whether this term means `fish that do not *currently* exist`or `fish that do not *naturally* exist`, although the latter was probably the intent of the legislation (J. Brinsmead, MNRF, pers. comm.)

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Is adaptive management part of approach?	• yes, through flexible plan (strength & weakness)	• yes • data collected statewide through Watercraft Inspection Program and IS Survey Program, any anomalies or trends used immediately to inform efforts	• yes • use integrated pest management approach • use adaptive management for research and outreach also • incorporate suggestions from stakeholders	• yes	• yes • incremental triploid grass carp stocking to control hydrilla	• yes • regular changes to approach (e.g., criteria for watercraft decontamination, waterbody classification and declassification • any time waterbody infected written into legislative rules
Are emerging technologies and management tools considered?	• yes, look at research in other jurisdictions • actively encouraging pesticide companies to register products for use on IS	• yes	• yes • long history of funding novel approaches (e.g., pheromones for sea lamprey control) • University of Minnesota AIS Research Centre recently established to research prevention and control (e.g., for bighead and silver carp, Eurasian water-milfoil and zebra mussels) • new herbicides • eDNA,	• yes • eDNA used to indicate which waterbodies need closer inspection	• yes • raising weevils as biological control for giant salvinia	• yes • genetic research • research into chemical control • research on effective methods for tracking boat movement (to ensure boats from infected waterbodies decontaminate)

Current Prevention and Management Approaches for Aquatic Invasive Species in Jurisdictions outside Alberta

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Lead agency to coordinate program implementation	• Ontario Ministry of Natural Resources and Forestry (MNRF) for biodiversity impacts, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) for impacts to agriculture	• Idaho State Department of Agriculture (ISDA)	• Minnesota Department of Natural Resources (DNR)	• Oregon Department of Fish and Wildlife (ODFW); • ODA for plants; Portland State University (PSU) coordinates	• Texas Parks and Wildlife Department (TPWD)	• Utah Division of Wildlife Resources (DWR)
Barriers to program	• funding, personnel, legislative tools	• n/a	• funding, resources, cultural and behavioural resistance (e.g., belief that people should be free to move from lake to lake without restrictions), perception of ineffectiveness	• funding and personnel	• n/a	• funding, political climate; structure for response time
Areas of improvement	• funding to engage community	• n/a	• re-instate paid sticker program; redesign and retrofit water craft to allow cleaning; law enforcement; local capacity; more research into efficacy of approaches and impacts	• increase funding and staff levels; improve ability to do early detection; open boat inspections sooner (e.g., in March instead of April or May)	• competitive grant assistance to landowners for control and restoration	• more focus on borders; existing infested locations; better internal structure; improve funding

Note: n/a = not answered

4.2 Stakeholder Engagement

Only two of the jurisdictions reviewed have formal communication plans (Idaho and Minnesota), while the rest rely on more informal arrangements (e.g., regular calls and emails as needed). Most states have organizations in place to facilitate stakeholder engagement and communication: Idaho Invasive Species Council, Minnesota's Invasive Species Advisory Council, Oregon's Invasive Species Council, and Utah's AIS Taskforce. These groups are made up of a wide cross-section of stakeholders, representing federal and state government, industry, academia, non-governmental organizations (NGOs) and the general public. The purpose of communication networks ranges from internal communication, to public education and stakeholder training. Idaho relies on its network to notify key stakeholders of critical information in the event of an emergency AIS detection.

Communication with stakeholders occurs through news releases, email lists, newsletters, public outreach and regular meetings. Idaho and Oregon also benefit from membership in external multi-agency and multi-jurisdictional organizations (the 100th Meridian Columbia Basin Team [CRB] and the Pacific State Marine Fisheries Commission respectively), which enables broader-scale communication about AIS threats, and access to EDRR support.

A diversity of stakeholders are involved in AIS prevention and management programs. At the government level, several different agencies are typically responsible for addressing different aspects of the invasive species problem. For example, in Ontario the Ministry of Natural Resources and Forestry (MNRF) deals with invasive species that affect biodiversity and has an overall coordinating role, while the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) deals with invasive species that affect agriculture, Ministry of the Environment and Climate Change (MOECC) deals with chemical control, and Ministry of Transportation covers invasive species that occur along highways (including AIS, such as purple loosestrife [*Lythrum salicaria*]). States with formalized councils or taskforces are able to engage a wide range of stakeholders through their participation in these groups. For example, Minnesota has 40 different entities on its Invasive Species Advisory Council. The purpose of the councils and taskforce are to provide advice to government on their invasive species programs, and, in the case of the Minnesota Council, to also facilitate communication, coordination, and integration in the implementation of the state's Plan. NGOs, such as watershed councils and water management companies, provide funding for programming in Utah, and lobby for legislative change in Oregon. In Ontario, the Ontario Federation of Anglers and Hunters (OFAH) has a long-term partnership with MNRF to lead public outreach efforts.

Jurisdictions tend to rely on both informal and formal partnerships, often formed from the bottom-up (e.g., groups approach government), instead of by regulation. Examples of formal partnerships include Idaho's membership in the CRB, and Oregon's work with the Marine Board. Partnerships that occur in the form of councils are formed by regulation.

Only two jurisdictions have staff dedicated to managing their communication networks (Oregon and Utah). Estimates of the cost of running networks vary considerably, from very little in Utah (e.g., the cost of phone calls and local travel) to substantial in Minnesota (e.g., around $200, 000 per year). Most jurisdictions indicated that the success of their communication networks had been tested, either through actual EDRR incidents, or practice exercises. Utah reported that they receive weekly notifications of boats infested with quagga mussels entering the state, as the early detection program requires weekly

reporting (see Section 4.6, Surveillance/Inspections), and are able to quickly activate rapid response and successfully intercept these boats at the border to inspect and decontaminate them.

A number of barriers were identified that hinder effective stakeholder engagement. Most jurisdictions find that there is not enough time or resources to reach out to all stakeholders, and often a lack of staff further complicates efforts. Another major barrier is that stakeholders may not fully understand the magnitude of the AIS problem (especially legislators) and may resist changing their behaviours. Stakeholders often have many other priorities, which make them slow to respond to AIS initiatives. Texas pointed out that agencies tend to work independently of each other, unless a clear communication process is established.

Table 5. Summary of Interviewee Responses on Stakeholder Engagement

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Do you have a communication plan?	• strategic Plan had one • no official one, although MNRF works with the Ontario Federation of Anglers and Hunters (OFAH) every year to establish list of deliverables, including communication	• yes	• yes	• no official one • communication occurs through regular meetings of the Oregon Invasive Species Council (made up of representatives from the public and all natural resource agencies in the state) and through phone calls and emails	• yes, informally	• AIS taskforce brings together key stakeholders, federal and state agencies, and other interested parties to discuss program, funding, legislative needs and plans
What are the purposes of the communication network?	• no network *per se* • MNRF's EDDMaps is a communication tool for reporting on the distribution and occurrence of IS	• dissemination of critical information to key stakeholders in the case of an emergency AIS detection	• public education, internal communication, stakeholder training	• mainly for communication on legislation, also for outreach and education, and internal communication	• public education, internal communication, stakeholder training	• outreach division coordinates all public education
How is the communication network structured?	• not applicable	• ISDA coordinates with the CRB Multiagency Coordination Group to provide emergency AIS information, and to outline and implement response procedures	• put out news releases for general information sharing	• via list server for general information sharing • part of Pacific State Marine Fisheries Commission, which operates a network with alerts issued if AIS found in any of the member states	• primarily through list server for general information sharing	• AIS taskforce and groups meet at least quarterly • coordinate public outreach and education through outreach division

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
What stakeholders are involved in the strategy, and what are their roles and responsibilities?	• MNRF: overall coordination and deals with IS that affect biodiversity • OMAFRA: deals with IS that affect agriculture • Ministry of the Environment and Climate Change (MOECC): deals with chemical control • Ministry of Transportation: deals with IS management along highways • OFAH: deals with public outreach • Ontario Invasive Plants Council (OIPC): plants (mainly terrestrial), public outreach, coordination	• critical state agencies, federal agencies, regional partners	• in 1992 established Minnesota Interagency Task Force on Aquatic Nuisance Species • replaced by Minnesota Invasive Species Advisory Council in 2002 and comprised of 40 different entities from across state representing industry, academia, government and non-governmental organizations (NGOs) • IS Advisory Council role is to provide advice to government and to facilitate communication, coordination and integration among members in implementing state IS Plan	• state and federal agencies, local government and NGOs were engaged in development of Oregon AIS Plan • state and federal agencies and local governments do on the ground management • NGOs help with lobbying the legislature	• state and federal agencies, local government, conservation NGOs, green industry, academia, anglers, property owners,	• DWR: protection to state from AIS • Utah Division of State Parks and Recreation: DWR trains them to participate • Bureau of Land Reclamation, National Parks Service, U. S. Fish and Wildlife Service (USFWS) (all federal agencies): contribute funding • watershed councils and water management companies: contribute funding • all of the above agencies have a representative on the AIS taskforce, providing direction on program management
Are there informal and/or formal partnerships in place? How are	• both informal and formal • tend to be formed from the bottom up, none by	• formal partnership for emergency regional communication is structured through	• both informal and formal • bottom up, not by regulation	• formal, by regulation for Marine Board and for Council • many other	• both informal and formal, depends on the situation and available funding	• formal

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
they developed?	regulation • usually groups approach MNRF, but sometimes MNRF initiates link	the CRB		partnerships		
How is information shared among stakeholders and/or partners?	• depends on the situation and what groups are involved • OFAH issues bimonthly newsletter • MNRF has no formal communication schedule or requirements	• as needed	• via list server, website, ad hoc committees, advisory council (meets quarterly), news releases and annual report	• as needed • Invasive Species Council meets 3 times/year	• as needed	• at least once a year visit stakeholders (more often if needed) • emails sent regularly • task force meets quarterly and at least annually with each stakeholder group
Who is responsible for managing the network?	• not really applicable, no one person or agency as several different networks operate	• Pacific States Marine Fisheries Commission and USFWS in charge of Columbia River Basin Multi-Agency Coordination Team	• DNR, Minnesota Department of Agriculture (MDA), USFWS, National Parks Service, University of Minnesota, Lake Improvement Districts, NGOs	• IS Council	• many cooperating agencies and stakeholder groups	• DWR
Under what authority do they operate?	• not applicable	• State of Idaho manages the response	• state or federal authority	• state authority (statute established Council), regulated by ODA	• some operate informally, others through Memoranda of Understanding	• n/a
How many, if any, staff are needed to manage the	• not applicable	• n/a	• 40 different groups are part of the Council	• 1 full-time, 1 part-time, but need more	• n/a	• 5 regional staff on the ground communicate when threats

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
work of the network?						detected
What is the cost of this communication?	• not applicable	• n/a	• hard to calculate, but significant • total communication budget for DNR ~ $200, 000 US/year, within Minnesota Sea Grant likely less than $10, 000 US/year	• unsure	• costs vary depending on scope of project	• within the network costs typically very cheap: the cost of a call or email, sometimes costs for mail and local travel
Has the network been tested in the real world (i.e., has it communicated any AIS threats that led to prevention or successful control)?	• not applicable	• rapid response (RR) exercises held annually throughout region to test and refine network	• yes	• twice, both false alarms, but activated early detection and rapid response (EDRR)system	• n/a	• yes • receive weekly notifications of boats infested with quagga mussels entering state • notify staff who then intercept boats at border, inspect and decontaminate
What are the strengths of the communication network? How could it be improved?	• having a formal council would strengthen communication capacity, but would have large maintenance costs • could improve government efforts to communicate, mostly through external partners	• network seems to work well	• it's comprehensive, reaches all sectors, provides consistent messaging (e.g., via Stop the Aquatic Hitchhikers campaign), uses multiple approaches, has been going for a while	• works pretty well • need more staff dedicated just to IS	• creating a single point of contact, which is a non-regulatory and NGO hosting the network helps avoid confusion for the general public	• it is very effective and simple, quick and inexpensive

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
			• if more money available might want to address more equitable division of funding among counties			
What are the barriers to engaging your stakeholders?	• money, resources, time, many different priorities • reaching all stakeholders across the province • getting message out quickly	• stakeholder understanding of and support for EDRR	• time needed for engaging stakeholders • receptivity of citizens • changing behaviour • money	• time • stakeholders not fully informed of consequences of AIS (especially legislators)	• agencies operating in isolated silos	• time needed for engaging stakeholders • not enough staff to communicate with stakeholders • changing behaviour
How could communication be improved?	• create a formal IS Council to improve communication	• n/a	• establish dedicated funding for coordination of communication activities both within and among jurisdictions (federal, state, and local levels) • provide more support to communication staff (e.g., talking points, key messages)	• unsure	• a formal agreement with all stakeholders would ensure a clear communication process	• more staff to manage it

Note: n/a = not answered

4.3 Stakeholder Coordination

Prevention and management efforts are typically spearheaded by one main government agency (or a university in Oregon's case), with up to three other agencies participating in some way. Coordination of roles and responsibilities may be determined based on invasive species impacts (e.g., in Ontario, MNRF deals with invasive species that affect biodiversity, while OMAFRA deals with invasive species that affect agriculture), taxa (e.g., in Oregon, the Department of Fish and Wildlife [ODFW] covers AIS animals, and the Oregon Department of Agriculture [ODA] covers AIS weeds), or simply because one organization decides to take the lead because no one else has (i.e., Oregon). Government agencies involved in prevention and management efforts deal with natural resources, fish and wildlife, and agriculture.

A variety of resources and support are provided to stakeholders, including advice to the general public, best management practices (BMPs) to landowners, identification and reporting tools, technical support and expertise to assist with management and educational campaigns, and funding for prevention and control projects. Utah pointed out that support works both ways, with the state government providing information and technical support, and stakeholders providing funding to government, and direction on how to spend funding.

All jurisdictions have some process in place to coordinate activities and/or promote consistency in approach among stakeholders, although an overall formal structure for the entire prevention and management program is rare. Instead, coordination tends to come from individual funding programs, which will outline expectations, deliverables, guidelines and requirements. In Utah, the DWR oversees supervision of the program and coordinates with stakeholders. In Ontario, widespread application of BMPs among stakeholders (coordinated by MNRF and OFAH) ensures consistency in approach, while in Minnesota, permits issued for AIS plant control are based on consistent standards.

The lead agency (or agencies) tends to be accountable for various elements of the program. Minnesota has a supervisor for its program, and coordinators who oversee individual components, such as AIS management, watercraft inspection, and prevention. In Oregon, coordinators are also responsible for different parts of the program. In general, jurisdictions do not have overall reporting requirements for stakeholder coordination, although individual funding programs may require some form of accountability as a condition of receiving financial support.

Table 6. Summary of Interviewee Responses on Stakeholder Coordination

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
What agency or agencies is in charge of AIS prevention and management, and why?	• MNRF for IS affecting biodiversity, OMAFRA for IS affecting agricultural crops	• ISDA by legislative authority	• DNR for AIS and terrestrial vertebrate IS, MDA for invasive terrestrial pests	• PSU for coordination, ODFW for AIS animals, ODA for AIS weeds	• TPWD	• Utah DWR by legislative authority
What kind of resources and support is provided to stakeholders?	• advice to general public (e.g., via Invading Species Awareness Program [ISAP]) • BMPs for landowners • IS reporting tool (IS hotline) • some funding opportunities	• coordination via Idaho Invasive Species Council (IISC) • resources via grants and agreements with regional partners	• funding for prevention (e.g., watercraft inspection) and control projects • expertise and technical advice from 8 IS specialists (mainly to manage AIS plants) • help with implementing educational campaigns (e.g., to stop aquatic hitchhikers and to stop release of aquarium pets into waterways) • communication outreach (e.g., pamphlets, YouTube videos)	• not a lot • ODFW communicates with Marine Board on interception of AIS	• identification and reporting tools • prevention measures • BMPs	• information and technicians • stakeholders provide support for government (e.g., funding and direction on how money should be spent)
Are there formal processes in place to coordinate activities, provide support to	• not overall (may be with individual funding programs) • BMPs meant to ensure consistency and efficiency in approach and are	• under written agreements outlining expectations and deliverables in exchange for funding	• grants have guidelines and requirements • permits issued for AIS plant control are based on consistent standards	• agreement with Oregon Marine Board determines how money is divided up and what each organization	• sometimes	• DWR is the only agency with authority to administer program • DWR provides training and supervising of

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
stakeholders, promote efficient use of resources, and ensure consistency in approach among stakeholders?	widely used by many groups			does • Oregon Marine Board act as accountants and do public outreach, ODFW implements inspections		program, and data collection • coordinate with stakeholders
Who is accountable for the various elements of the AIS program?	• MNRF is lead agency, OMAFRA: agricultural threats, OFAH: some outreach and public awareness, OIPC: plants • no IS Council exists to oversee various elements	• ISDA	• one program supervisor and several coordinators to cover management of AIS (mainly plants), watercraft inspection, and prevention • no firm reporting requirements overall, depends on where the funding comes from and what kind of accountability and evaluation practices are built in	• agency coordinators	• accountability is shared among stakeholders	• DWR

Note: n/a = not answered

4.4 Public Awareness and Education

Most of the jurisdictions interviewed have some form of public awareness and education plan, often formalized in their Invasive Species Strategic Plan. Activities can be both organized (e.g., through educational programming such as Ontario's Invading Species Awareness Program [ISAP]) and more ad hoc in nature (e.g., through face-to-face informal conversations with boaters). Many jurisdictions target specific audiences with their messages, especially anglers and boaters, gardeners, and aquarium owners. Several states also focus on broader messaging for the general public. For example, Oregon communicates on the importance of keeping quagga mussels out, while Utah emphasizes that the public can be part of the problem or part of the solution. A wide variety of educational activities and materials are produced, including websites, a reporting hotline, factsheets, radio and TV ads, billboards, workshops, calendars, social media messages, curriculum and teaching resources, signage at boat launches and media releases.

AIS curriculum modules have been developed in Ontario for grades 4 and 6. In other jurisdictions, staff give school presentations and provide training for the general public on watercraft inspection protocols, preventative steps, AIS identification and AIS threats. The University of Minnesota offers an interdisciplinary graduate training program on invasive species risk analysis, which gives students the opportunity to work with external partners in research and decision-making on biological invasions around the world. The general purpose of education is to raise awareness and understanding of the AIS problem and to provide people with the tools to make positive changes to prevent introductions and spread. In Ontario, part of the logic behind developing elementary curricula is to reach students when they are young, so they grow up recognizing the issue and knowing how to help solve the problem. Additionally, youth may take the message back to their parents, leading to behavioural change in older generations as well.

Public awareness and educational initiatives are coordinated by government agencies, partners and educational specialists, who may work within government or academia.

Jurisdictions identified a number of barriers to outreach on AIS issues. One major problem is ensuring that people move beyond hearing the message to actually becoming motivated to take action and change their behaviour. It is particularly challenging to reach people who simply do not care, and convince them that AIS is an important issue. For example, the lack of legislative authority in Ontario makes it hard to motivate this group of people to take preventative steps. Texas found the lack of targeted messaging problematic and Ontario identified gaps in which stakeholders have been reached (e.g., First Nations have not received much attention in the past). Limited staff and limited funding were further barriers. Minnesota found that getting educational content into school curriculum was challenging because there is currently no requirement to address AIS in the schools. It was recognized that to really do public awareness and education well takes a significant amount of time and effort. Partnerships with other organizations may help, as well as more dedicated funding, and regulation to back up messaging with teeth.

Table 7. Summary of Interviewee Responses on Public Awareness and Education.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Is there a strategic plan for awareness and education?	• in provincial strategy	• in IS Strategic Plan	• yes	• no	• informal plan	• no
Are awareness and education activities ad hoc or part of a larger program?	• several activities, largest is ISAP	• part of ISDA program	• both	• Oregon Sea Grant does a lot • on the ground contact with boaters	• mainly Invaders of Texas Citizen Scientist Program	• on the ground contact with boaters etc.
Are public awareness and education activities part of the communication plan?	• not applicable	• partly	• n/a	• no	• yes	• outreach division coordinates all public education
What are the key messages or issues addressed by the campaign?	• mainly aimed at recreational audiences (e.g., anglers and boaters) to stop the spread • focus on gardeners to encourage planting of native and noninvasive plants • campaign with aquarium industry to encourage pet owners not to dump aquatic plants and animals	• Clean, Drain, Dry (boats) • Don't Let It Loose (pet owners)	• AIS prevention, control and mitigation of impacts • cleaning equipment • minimizing spread • Aquatic Hitchhikers campaign • Habitattitude campaign for aquarium and water gardens	• Clean, Drain, Dry • Don't Let it Loose • keep quagga mussels out of state	• Clean, Drain, Dry • EDRR	• Clean, Drain, Dry • public can be part of the problem or part of the solution

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Who are the target audiences?	• anglers, boaters, gardeners, aquarium hobbyists	• anglers, boaters, pet owners, general public	• anglers, boaters, bait harvesters and dealers • curriculum: grades 4-7	• teachers and elementary students • general public	• boaters, educated citizen scientist, general public	• anglers, boaters, water users, stakeholders
What activities have been developed to educate the broader public?	• ISAP website, IS Hotline, factsheets, EDDMaps, guides, BMPs, elementary curriculum modules • most outreach targeted toward specific audiences: tried to prioritize resources on pathways	• roadside inspection stations very effective at educating boating public • radio ads, billboards, workshops	• annual calendar, trade shows, social media, news releases, watercraft inspection, print materials, videos, radio ads • 4 main campaigns: Aquatic Hitchhikers, Habitattitude, Nab the Aquatic Invader and AIS Hazard Analysis and Critical Control Point Program (HACCP)	• curriculum and teaching resources • radio and TV ads, billboards, brochures, posters, signage at boat ramps	• billboards, internet ads, social media, boat launch signage, workshops	• flyers, boat/trade shows, news stories, media releases
Have AIS curriculum modules been developed and tested for your primary and secondary schools?	• yes, OFAH has them for grades 4 and 6 • provincial curriculum has units in grades 7,9 and 10	• training for general public	• difficulty making teachers aware of modules and convincing them to use them • no requirement to teach about AIS in schools	• yes	• no	• regional staff give school presentations

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Are there post-secondary AIS curricula in your jurisdiction? Are they interdisciplinary?	• mandatory training for bait harvesters and fish bait retailers as part of licensing process (HACCP)	• n/a	• depends on postsecondary institution-University of Minnesota has interdisciplinary program	• yes	• n/a	• n/a
What are the curricula designed for?	• elementary curricula: general understanding and awareness, getting message out while they're young, encouraging behavioural change, taking message to their parents	• education on watercraft inspection protocols, AIS prevention methods, AIS identification, AIS impacts	• PhD-level graduate program at the University of Minnesota offers interdisciplinary training	• primarily understanding, also training, changing behaviour	• n/a	• n/a
Who coordinates the development and delivery of public awareness and education activities?	• OFAH, with content developed in partnership with MNRF annually	• ISDA	• educational specialists (within government and at universities)	• Sea Grant, ODFW, Marine Board, IS Council • ODFW and Marine Board have education sections	• shared process	• DWR
What are the barriers to public awareness and education?	• reaching all relevant groups (e.g., First Nations, cottagers) • no legislative authority to mandate prevention (which would make people more motivated)	• limited staff	• getting people's attention • ensuring people don't just listen but actually change behaviour • integrating curriculum into schools	• reaching those who don't care • making issue a "household conversation" • funding	• outreach not currently target to specific groups	• lack of funding and training • inconsistent messaging

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
How would public awareness and education be improved?	• regulation makes people more interested in the message • public awareness and education takes a lot of investment and time to do well	• more focused effort	• reaching out and coordinating with other organizations	• more funding	• widening scope of targeted groups	• funding • ensuring consistent and understandable message • training

Note: n/a = not answered

4.5 Risk Assessment

Risk assessment of existing and potential AIS represents a key component of AIS management in almost all reviewed jurisdictions. Most risk assessments consider probabilities of arrival, establishment, and secondary spread, as well as economic, social and environmental impacts. Climate change has only been addressed to a limited extent in risk assessments and then only by academia, in the Far North or in long-term scenarios, complementing the regular short-term scenarios. The results of risk assessments conducted within and outside jurisdictions are essential for prioritizing species and funding for management. In addition, they are used to develop regulations, prioritize pathway management and help identify locations for monitoring, inspections and public awareness campaigns (e.g., signage).

The process to identify the need for risk assessments for a specific species is generally not formalized and varies among jurisdictions. Information from other locations, federal agencies or interregional jurisdictions, such as the CRB or the International Joint Commission, is used to identify emerging threats and is complemented by ad hoc local observations or animal import applications. Lastly, who makes the decision for risk assessments and who conducts them depends somewhat on the governance structure in place, and can be either the responsible government agency or a collaborative group, often supported by academia or contractors.

The main barrier to the satisfactory implementation of risk assessments is the availability of resources (i.e., funding, time and qualified personnel). The lack of a consistent, robust methodology that is applicable to the species in question was also cited as a limitation. Overall it was agreed that risk assessments need to receive a higher priority in resource allocation and training programs to develop the expertise required to conduct such assessments.

Table 8. Summary of Interviewee Responses on Risk Assessments.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Are risk assessment (RA) tools used?	• work with federal tools • draft RA is being revised on ongoing basis	• yes, adopted RAs from other areas	• yes	• yes, to develop roles	• yes	• partly • data collection, process in development
Risk assessment components (e.g., probabilities of arrival, establishment, secondary spread, economic, social and environmental impacts, including impacts on valued aquatic resources)?	• all, but data qualitative, based on literature review • working on semi-quantitative method using scorings and probability distributions	• n/a	• species and pathways, establishment, adverse impacts on ecosystem and natural resource use, ability to control or eradicate	• all	• all	• arrival, economic impacts
How is the risk assessment information used to prioritize action on specific species and/or pathways/vectors?	• prioritize species • funding (for further assessment and for management) • assess if regulations are sufficient or need to develop new ones	• watercraft inspections • AIS prohibited for sale	• prioritize resources towards species and pathways	• location of signage • location of boat inspections • listing noxious weeds • develop wildlife integrity rules	• listing as harmful or potentially harmful, which makes possession illegal	• geographic resource allocation • species priorities set by law
Are potential and existing AIS addressed?	• yes	• yes	• yes	• yes	• yes	• n/a

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
What prompts a risk assessment?	• managers' judgment • ad hoc: field and enforcement officers (markets) • list established by Great Lakes Governors	• use existing RAs for problematic species in other places	• if has caused problems elsewhere in U.S. and globally • identify threats to natural resources (forest, water, urban) and agricultural production: • identify key recreational and commercial pathways	• "crystal ball" : anticipate emerging threats • triggered by request for new animal import (classification required)	• collaborative decision	• n/a
Have risk assessments been used to identify areas requiring monitoring/surveillance for RR procedures?	• no, except for Asian carp species	• yes	• yes	• no	• yes	• yes • aim to have RR plans for all areas
Are impacts of climate change included in risk assessments?	• recommended • propose 2 RAs: one over short-term without climate change consideration; another for longer term including climate change • Far North invasion risk by native and AIS studied	• no	• no	• yes, but not consistently	• somewhat	• no

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Who does the risk assessments?	• MNRF, Department of Fisheries and Oceans	• third party	• DNR, U. S. Dept. of Agriculture, USFWS, U. S. Geological Survey	• ODFW. • PSU	• TPWD • Texasinvasives.org	• n/a
Barriers to risk assessments?	• lacking consistent, robust methodology • time, money, people	• resources • knowledge of which species to assess	• lacking expertise and capacity • resources, research	• funding • use formats from other, irrelevant organisms (e.g., plant approach for animals)	• limited Resources	• people, time funding
How to improve risk assessments?	• working on new methodology	• utilize existing information	• more training	• more funding	• make RAs a priority	• more people that are dedicated to RA

Note: n/a = not answered

4.6 Surveillance/Inspections

Surveillance and inspections are conducted by all jurisdictions. State or provincial natural resources or wildlife agencies are responsible for inspections and employ conservation officers, biologists or full- and part-time (summer) technicians to conduct the inspections in a variety of locations within jurisdictions (e.g., along highways, at boat launches, in bait retailers and live food fish markets). The most common cited goals of inspections are to verify and enforce compliance with AIS regulations and prevention of invasions. Education and data collection for risk assessment are secondary purposes.

The main focus of the inspections is boats travelling on major highways across borders. Live fish markets, fish bait hatcheries and internet trade are also targeted. The approach to reporting varies vastly among jurisdictions, ranging from only noting law infractions to a full suite of information about the boat's origin and destination, time since last lake visit, presence and type of AIS, water plug observations (in or out), zip code to target education and boat registration numbers to identify repeat offenders. These data are generally stored centrally, but only selected jurisdictions make them publicly accessible on the internet (sometimes only in processed format). Data analysis and reporting is conducted on a regular basis (e.g., annually or weekly) in most jurisdictions, although in Ontario it is not done systematically.

All but one of the five U.S. states we covered in the review have made inspections mandatory. The exception, Texas, wishes to improve their system by making inspections mandatory. Mandatory inspections are either enforced by law enforcement staff (including the Sheriff Department or the police), or conservation officers. Summer interns also conduct watercraft inspections in Minnesota, Oregon and Utah for educational purposes, but do not have the legal authority to enforce compliance. Inspections are not mandatory in Ontario, but they are carried out by conservation officers to enforce general fish and wildlife regulations (including prohibitions on possession and trade in listed species), as well as by summer interns for educational purposes.

The main barriers to effective surveillance and inspections are resources (funding and staff time, including enforcement staff) and legal issues, for example the inability to track boats due to privacy restrictions on boat registration numbers. In Minnesota, there is a constant balancing act between legal authority for inspections and the public's right to privacy. Conservation officers have the authority to inspect both the interior and exterior of boats, but may avoid the interior in order not to appear too intrusive. DNR is sensitive to the possibility that its inspection powers might be curtailed significantly if the public perceives that it is overstepping its boundaries. Internet surveillance was thought to be challenging in Ontario, but effective in identifying trade in illegal species. The presence of law enforcement at Oregon's boat inspection stations increased the number of inspections "drastically" (Rick Boatner, ODFW, personal communication).

Table 9. Summary of Interviewee Responses on Inspections.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Are there inspections?	• yes	• yes	• yes	• yes	• yes	• yes
Mandatory or voluntary?	• voluntary	• mandatory	• mandatory, based on criteria	• boats: mandatory	• at discretion of game wardens	• mandatory
Which pathways and vectors inspected?	• boats at launches and roadsides, bait buckets, live food fish markets, ballast tanks (federal), borders (federal)	• highways, borders, some boat launches	• water access points, Manitoba border, highways (if probable cause)	• highways border crossings	• boats, boat motors, trailers, typically at boat ramps	• highways, borders, boat launches, roadways increasingly
Priority pathways	• live food fish, bait: determined by regulatory power	• changes depending on level of risk	• boats, bait, hatcheries	• trailered boats, ships, mail order, pet stores; specific high-volume highways	• boats, boat motors, trailers	• major highways at borders, changes based on additional funding
Purpose of inspections	• compliance with regulations, education	• prevention and education to protect infrastructure and environment	• assess risk, compliance with regulations, education	• prevention because cost effective • education • proof of inspection for inter-state travel	• check for possession and transport of illegal AIS	• prevention, education, compliance with law
Record-keeping process?	• yes	• yes	• yes	• yes	• yes	• yes
Responsibility for record-keeping?	• MNRF conservation officers (COs)	• ISDA	• DNR	• ODFW: trailered boats, Oregon Department of Environmental Quality: ships	• TPWD game wardens	• DWR
Information recorded	• charges laid • purpose of	• waterbodies visited in last 30	• awareness of laws, actions	• # of boats, origin, volume, source	• records of tickets	• last waterbody visited and when,

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
	inspections is to ensure compliance with fish and wildlife regulations in general, not to inspect for AIS specifically	days, destination, zip code, boat registration number, presence of ballast tanks, presence of weeds, if hot washed, if commercially transported • additional details recorded if boat from mussel-infested waters: how many days in and out of water, from what marina/boat ramp	taken at water access, presence, frequency and status (prohibited or not) of aquatic plant species, presence of water, plug in or out, level of "citation", origin and destination waterbodies	and treatment of ballast water		other waterbodies visited in the last 30 days, boater zip code to target education and outreach, and bow number (to track repeat offenders in the future)
What fraction of pathways and vectors are inspected?	• unknown	• unknown	• n/a	• 70% of highways and roadways along eastern border	• unknown	• highways and roadways <10%, borders: 20%, major developed boat ramps: 60-80%
Is there a central data repository?	• yes	• yes, at ISDA	• yes	• yes	• n/a	• yes, cloud-based data storage
Is the data publicly available?	• some to public (through press releases and EDDMaps), some not even available to other MNRF staff	• compiled data on web	• no	• public website	• some on website	• through government records acquisition management
Are invaded waterbodies	• EDDMaps • no classification	• yes • if vessel has been	• yes, declared "infested" with	• yes, signs at boat ramps, press	• zebra mussel infested waters	• yes, weekly report

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
identified to public? How?	as “invaded”	in mussel-infested water, it receives a detailed high-risk inspection and boater informed of why AIS a problem	legal consequences • website, access point signs, fishing regulations book for public	releases		
Is data available to other jurisdictions?	• data on inspections not specifically collected for AIS purposes so little systematic information available	• yes	• yes	• yes	• yes	• upon request
Who analyses data? How often?	• COs do some	• ISDA annually	• watercraft inspection supervisor, annually	• ODFW, annual report	• biologists	• weekly, monthly, annual reports
Enforcement of inspections	• not applicable	• sheriff	• legal authority, specific criteria	• police	• not applicable	• any sworn officer, mainly COs
Who inspects?	• COs, Canadian Border Services Agency	• ISDA and contracted regional partners	• 148 watercraft inspectors • volunteer program trained inspectors for education	• seasonal staff at ODFW	• game wardens and biologists	• 35 technicians; summer part-time and full-time; full times often oversee par- times • contract 150 people who are monitored by regional staff as well, but they are overseen by their park management and parks that they are hired to

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
						work in
Barriers?	• can't be everywhere • keeping track of internet-based trade in AIS	• enforcement to ensure compliance	• resources	• funding	• unknown	• legal barriers: unable to track boats or record personal information (e.g., bow number)
How to improve?	• legislated mandate for inspections	• enhanced enforcement support	• more funding	• longer hours at inspection stations (high risk commercial haulers) • more law enforcement – significantly increases # of inspections	• mandatory inspection	• more staff and funding to improve roadway surveillance

Note: n/a = not answered

4.7 Early Detection/Monitoring

All jurisdictions monitor for the purpose of early detection of new invaders. State departments lead and coordinate these monitoring efforts in the U.S., and they are often supported by citizen scientists. In Ontario, AIS monitoring is integrated with existing government aquatic monitoring and citizen science programs which have objectives other than AIS detection.

Dreissenid mussels are a major focus of monitoring across the temperate jurisdictions and Asian carp species in the Great Lakes area. Aquatic plants (such as alligator weed, *Alternanthera philoxeroides*; Eurasian water-milfoil; floating heart, *Nymphoides peltata*; flowering rush, *Butomus umbellatus*, and water hyacinth, *Eichhornia crassipes*), are monitored in all U.S. jurisdictions. Additional local focus is on the spiny waterflea, gobies and bloody red mysid shrimp (*Hemimysis anomala*) in Ontario, and the New Zealand mud snail in Utah and Oregon. Likely invaders are identified through literature reviews, and communication with neighboring jurisdictions and, monitoring plans are developed as regulated species lists are populated. The monitoring needs are generally reviewed and updated on an ongoing basis, typically by the lead agency responsible for the AIS program.

The monitoring frequency and locations in programs directed specifically at AIS are often determined by the probability of introductions and establishment as well as the number of lakes in the jurisdiction. For example, invasion risk sets priority and thus determines sampling frequency in Idaho and Utah. Low vs. high priority lakes have sampling frequencies of annual to biweekly in Utah. High calcium and high use lakes are the focus for monitoring in Oregon, and waterbodies where AIS have been detected are monitored most frequently in Texas. Jurisdictions with large numbers of lakes solve the work load challenge by either only responding to reported sightings (Minnesota) or by using randomized lake surveys (Ontario, Wisconsin), which have been successful in detecting new AIS in Wisconsin. Sampling is conducted in summer, with Idaho aligning sampling with the optimal timing for dreissenid veliger larvae detection. It monitors for other invasive species at the same time.

Although little reference was made to formal protocols in the interviews, most jurisdictions have adopted similar monitoring programs for dreissenids, i.e. tow net and substrate surveys for veliger larvae. Idaho and Utah screen water samples visually for veligers by microscopy. If any veligers are found, their identity is confirmed through DNA testing, and, in Utah, if dreissenids are confirmed, scuba surveys are executed to determine exact locations of populations. Utah also conducts in-stream, walking surveys and dock inspections. Zooplankton species are detected through plankton hauls in Ontario. Asian carp species are detected through netting and DNA analysis on captured individuals, as well as through eDNA analysis of water samples. Aquatic invasive plants are monitored using vegetation surveys, often using the point-intercept method.

Presence and absence of AIS is recorded in all active monitoring programs and number of individual AIS in half of the jurisdictions. Additional details on the invasion, such as geographic extent, pattern of spread and frequency of introduction events are recorded in Utah.

If a new AIS is reported, it consistently triggers a rapid response action across the states (see section 4.8 on Rapid Response), as well as for Asian carp species in Ontario. Other AIS sightings in Ontario prompt consideration of a rapid response.

Lack of funding and personnel were the most common barriers to early detection, but lack of public awareness, and the inability of the public to identify AIS were also recognized as problems in Minnesota. Texas is trying to address these issues by increasing public involvement in citizen science and master naturalist programs. Lack of political will and communication with other monitoring groups to coordinate initiatives were also mentioned as barriers. In fact, representatives of several jurisdictions thought that more collaboration with partners, such as lake associations and conservation groups, would benefit early detection efforts.

Table 10. Summary of Interviewee Responses on Early Detection.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Monitoring?	• yes	• yes	• yes	• yes	• yes	• yes
What species?	• dreissenids, spiny waterflea, gobies, bloody red mysid shrimp • look out for others • DFO: Asian carp species	• all listed taxa	• Asian carp species • Eurasian water-milfoil, flowering rush by citizens and DNR lake staff • rusty crayfish (watershed groups)	• freshwater and marine plants, mussels, snails and crayfish	• fisheries habitat and vegetation surveys	• quagga and zebra mussels, New Zealand mud snail, Eurasian water-milfoil and more
Have you identified key invaders that are priorities for monitoring?	• take a blanket approach, monitoring for any AIS	• yes • target list and any others observed	• dreissenids, Asian carp species, Eurasian water-milfoil, flowering rush	• dreissenids	• yes • zebra mussels, giant salvinia, water hyacinth, hydrilla, alligator weed, floating heart, water lettuce	• “prohibited list”
How is priority list determined?	• general monitoring	• dictated by Statute (Noxious Weed Rule and IS Rule)	• incidental public and staff sightings of new occurrences	• literature review • communications with neighboring jurisdictions	• n/a	• wildlife staff proposes, board decides
How often is priority list updated?	• n/a	• periodically	• incidentally	• constantly (at least 1x a year)	• as needed	• as needed, up to monthly
Protocol for monitoring new AIS?	• DFO: netting and eDNA • integrated with existing programs	• ISDA protocol similar to CRB	• informal: reports are investigated by 8 IS specialists	• minimum 2x in summer, plankton tows and substrate surveys • aerial plant surveys	• habitat surveys	• lake surveys, walking surveys in streams; dock, boat and hatchery inspections, boats,; • if DNA found, do

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
						scuba surveys
Temporal and spatial coverage of monitoring	• fisheries surveys: 5-year cycle, aim to cover 5-10% of inland lakes over 20 ha in area; AIS plankton haul at same time	• optimal times for zebra and quagga mussel veliger early detection; all else concurrent • several per year, depending on waterbody priority • 70 sites	• special projects • ad hoc in response to sightings	• annually • high calcium and high use lakes for mussels; • minimum 10 samples per lake; near high risk areas (e.g., marinas, boat launches, dams) • 30-40 / year	• public waterbodies every 4 years • annually if AIS detected	• every boatable waterbody • annually to bi-weekly, depending on risk • in summer • 90 sites
Site selection	• random inland lake survey	• follow guidance of a report which is based on likelihood of invasion (IDA et al. 2012)	• ad hoc, in response to sightings	• lakes with boat ramps (if funded)	• random for fish • entire reservoir for plants	• high traffic sites due to high likelihood of introduction
Monitoring methods	• plankton haul, netting for fish	• plankton tows, rake sampling, shoreline sampling • point intercept sampling for high frequency invasive plants.	• nets for veliger larvae • point intercept method for plants • effort depends on type of AIS (e.g., hydrilla & Asian carp species = very high)	• plankton tows for veliger larvae • artificial and natural substrates	• n/a	• scuba, plankton net, substrate samplers hanging off of boat docks and ramps, microscopy, genetics
What is measured?	• presence and absence	• presence and absence	• presence and absence	• # of individuals • presence and absence • if expanding	• geographic extent for plants • # of individuals for fish	• frequency of introduction events • # of individuals • geographic extent • pattern of spread
How does early detection	• leads to discussion of RR	• CRB RR plan	• opportunity for control, monitoring	• protocol for Columbia Basin	• AIS program staff notified of new	• triggers RR plan

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
inform RR plans?	needed and feasibility of RR • RR plan may also determine what ED monitoring required		and potential eradication	team	infestations immediately	
Who leads or coordinates?	• individual monitoring programs (since no AIS monitoring program *per* se)	• ISDA	• DNR	• lead: ODFW (director – AIS Coordinators); conducts: PSU	• management biologists	• DWR leads, regional staff coordinate
Who participates?	• volunteer lake monitoring, Ontario Federation of Cottagers Associations, EDDMaps, NGOs, (e.g., Ducks Unlimited)	• ISDA, other agencies, regional partners, and the public assist with monitoring efforts	• citizen science program for zebra mussels	• PSU • citizen scientists	• management staff • citizen scientists	• DWR staff • water conservation districts
Resources needed?	• protocols for early detection • personnel to design optimal monitoring for integrating with existing programs	• limited cost for early detection laboratory cost for plankton is greatest expenditure	• state constituency • protocols • equipment • training • resources for producing identification watch cards for 16 species	• funding and personnel • $50k/year – not enough	• 15 fisheries management offices: each has 2 biologists and a varying number of technicians • AIS Program: 2 IS biologists, a program director, a permit coordinator, a Habitat Enhancement office (with a biologist and technicians)	• sampling equipment, boat, global positioning system, microscope, polymerase chain reaction (PCR) equipment, scuba equipment, substrate samplers

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Reporting	• recommended reporting to MNRF, not mandatory	• report to ISDA	• report infestation to DNR (legislated)	• PSU reports to ODFW and in Columbia Basin to river basin management team	• annual reports	• report to DWR
If regulated species encountered – any management steps?	• no, except for Asian carp species • discussion on whether RR feasible	• yes if it is a priority EDRR species (i.e., dreissenids)	• yes – in state management plan	• yes for mussels • check establishment and size of infestation, consider containment	• yes	• yes
Barriers?	• MNRF not set up to monitor AIS plants and algae • impossible to "be in all places at all times" • opposition to inclusion of AIS protocols in existing protocols	• need more willing partners to assist in monitoring efforts	• personnel and funding • awareness	• personnel and funding	• personnel and funding	• staff, time, political will, communication with other groups that are doing monitoring
Ways to improve	• n/a	• more active monitoring from partners around the state	• partnering with local lake associations, conservation and environmental groups	• more funding • more data on where boaters are going	• increased funding would increase frequency of surveys • using citizen scientist and master naturalist programs to encourage public participation	• more funding to hire more people, more sampling

Note: n/a = not answered

4.8 Rapid Response

Rapid Response plans are in place for all jurisdictions in some form. They are species-specific in Idaho, Minnesota, and Oregon, waterbody specific in Texas and Utah, and there is a generic draft plan for AIS in Ontario. In Ontario, only one species-specific rapid response plan is in place, for Asian carp species,

Rapid response efforts in the U.S. jurisdictions are mainly lead by the government agencies which are in charge of the entire AIS management system, but who may also work with external stakeholders. Parties that participate in rapid response efforts include local stakeholders or landowners in the majority of jurisdictions and can include federal departments, regional states (if partners in a watershed initiative, such as the Columbia River Basin), counties and law enforcement. In Ontario, landowners are responsible for rapid response, but MNRF and Ducks Unlimited Canada provide support in some cases. The actual control and eradication activities are conducted by agency staff, often supported by contractors, volunteers and, in some cases school children and convict labour. Few jurisdictions have dedicated response teams in place, but all jurisdictions have partners or resources that they know they can use if required.

The main steps to verify, notify, educate and respond are generally enshrined in the rapid response plans. Taxonomic experts verify the validity of an AIS report. Once the identification is confirmed, other involved agencies are notified or information is transmitted to regional and national databases. At this point decisions are made in terms of control options. When an AIS invasion is confirmed in the CRB, for example, state coordinators convene promptly and decide on next steps. The response to mussel confirmation for Oregon consists of quarantining the waterbody, conducting focused inspection efforts on boats that arrive and leave and closing some boat launches to assure all boats go through the inspected access points. The extent of infestation and the feasibility of its successful elimination, determine whether eradication or containment is conducted. In Ontario, the response follows the general protocol set up by the province to deal with all types of emergency situations.

The public is notified in all jurisdictions via news releases by the lead agency, once the invasion has been confirmed. Other means of public notification include list servers, signs at boat ramps, as well as radio and newspapers.

A process to enable quick approvals, permits and/or exemptions to pesticide use is an integral part of the rapid response system in most U.S. jurisdictions, but not in Ontario, i.e. no exemptions exist in the province to allow pesticide use for rapid response. This lack of permitting was cited as one of the weaknesses of Ontario's program because it slows down the response process significantly.

All jurisdictions have had the opportunity to test their rapid response systems, either through planning exercises or through response to false or real AIS reports. Regardless of the outcome or seriousness of threats, all jurisdictions agreed that these exercises were invaluable to test their systems, in particular the communication and coordination of efforts. Furthermore, Idaho finds that regular drills remind stakeholders and decision-makers of their roles and responsibilities, and the extent of action required (e.g., that boat ramps may need to be closed and decontamination stations may need to be set up). Implementation of rapid response leading to successful eradication was recorded by a number of jurisdictions, but only for aquatic plant invasions. For example, Texas has eradicated local giant salvinia infestations on several occasions, while Oregon has eradicated *Spartina* species.

Success was defined in various ways, ranging from “public satisfaction” and “effective communication” to “successful eradication and no re-occurrence within three years”. The measure of “how early in the invasion” a species is detected provides a more subtle way of assessing the effectiveness of the system. Ontario and Minnesota highlighted that realistic expectations based on a good understanding of AIS biology and behaviour in ecosystems are important to measure success, and may only involve a certain percentage reduction of the population each year. The transition to long-term management is usually determined on a case-by-case basis, and in Oregon is based on reaching consensus that eradication is not possible.

Particular effective rapid response systems had a single lead agency, with funding in place for rapid response, plus effective communication and partnerships. The key barriers to successful rapid response systems were inadequate funding and personnel, limited authority to close waterbodies, no designated lead agency, and the lack of permitting of control agents.

Table 11. Summary of Interviewee Responses on Rapid Response.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
RR protocol for new and existing AIS	• draft Plan for all • specific Plan for Asian carp species	• yes for dreissenids	• "reasonably detailed framework"	• yes for mussels and *Spartina* species • mussels: quarantine waterbody, focused inspections of boats (in & out), closing boat ramps to force boats to inspected ones, eradicate if small enough; otherwise containment	• yes, a tiered response system for plants	• yes = communication and protocol is defined for each individual waterbody by stakeholders and user groups
Approval/permits process defined?	• no	• yes	• yes; "permit to themselves"	• yes	• yes	• none needed
Coordination	• International Joint Commission is coordinating; MNRF incorporates some into RR framework	• coordinated delineation sampling, quarantine, treatment, and public notification	• case-by-case	• CRB: Command type system • state: Agency lead	• local and state, drinking water users if treatment and U.S. Environmental Protection Agency (EPA) protocols followed	• RR = coordination for control
Protocol for verifying, notifying, educating and responding?	• experts for verification • notify other agencies • education through OFAH & public notification • response: Provincial "All	• mussels: 2 labs verify veligers by microscopy, followed by PCR	• Great Lakes: verify: taxonomic expert database • notify: regional and national databases • other: DNR does it all	• ODFW internally and PSU • if Columbia Basin, notify state coordinators and instant command meeting to determine next steps	• verify: staff biologists or other experts	• verify: lab • notify: consultation with directors and supervisors about data release • educate: communication tree outlined in RR plan

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
	Hazards Response System"					
Response Teams	• no, except for Asian carp species • identified resources and technical expertise	• regional partners are lined up	• yes	• depending on size • if CRB, other states help	• contractors	• yes, waterbody specific
Emergency Planning Exercises	• no, except, for Asian carp species	• yes – participates in CRB exercises	• no	• yes, one	• no, lots of experience with real infestations	• no
Are there species-specific RR plans?	• for Asian carp species	• yes	• yes	• yes for mussels and *Spartina* species • less for aquatic plants because response is similar	• no, waterbody specific	• no, waterbody specific
When does RR switch to long-term management?	• case-by-case, guidance provided	• case-by-case	• case-by-case	• when there is consensus that eradication is not possible	• n/a	• n/a
Who leads RR and who participates?	• landowner • sometimes MNRF substitutes • supporting working groups, such as Ducks Unlimited	• ISDA • state, federal, regional states, impacted stakeholders	• DNR • stakeholders	• ODA for plants • ODFW animals • CRB if there • counties, law enforcement, marina or landowners, partnering states within CRB	• TPWD	• DWR with local stakeholders
Labour options	• volunteers	• contractors	• school children • sentence to serve labour • volunteers	• agency staff	• TPWD • contractors • volunteers	• contractors • volunteers

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
			• contractors			
Public notification	• whoever leads response	• ISDA's Public Information Officer and Governor`s office	• local residents as soon as possible using radio and newspapers • after verification and internal communication	• news release, list server, and posting at boat ramps • one person responsible	• news release	• news release within 2 weeks of notifying stakeholders
Budget	• small emergency fund • other sources require advance planning	• up to $5M	• 22% of annual budget (Sea Grant) • DNR: program overall well-funded	• $300 k emergency response fund	• yes	• no
Examples of implementation of RR plans	• yes, unsuccessful, but good practice; • some false alarms	• no, but false alarm initiated the process	• yes, successfully for an aquatic plant	• yes, successfully for *Spartina* species	• yes, giant salvinia successfully in early stages	• yes, unconfirmed threat, but communication worked well
Measure success	• realistic expectations: % reduction per year	• successful prevention, monitored reduction of targeted organisms	• how early was detection of infestation? • level of understanding to guide realistic expectations	• eradication and no reoccurrence in 3 years • "success = if we don't get it"	• public satisfaction	• if everybody gets the message
Strengths	• good at assessing problem	• maintain stakeholder support through regular RR exercises and education	• not overly prescribed	• funding for small scale response	• only one agency responsible	• good communication and partnerships
Barriers	• leadership • permitting, mobilizing	• stakeholder understanding of, and support for,	• funding, personnel • authority, collaboration,	• not clear who has authority to close boat ramps and	• funding	• some places do not have a RR plan yet

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
	response and eradication • landowner permission	RR in the event of a mussel infestation	reasonable levels of expectations communicated to all	waterbodies • detection of populations when small enough to eradicate		
How to Improve	• n/a	• overdue for RR exercise	• make sure those involved have the authority	• legislation to allow closing a waterbody during an emergency	• increased and stable funding	• complete more RR Plans, working on it

Note: n/a = not answered

4.9 Long-term Management

All jurisdictions have long-term AIS management plans for purposes of containment, control and ultimately eradication (if feasible). The main determinants for developing long-term management plans for AIS include the scale of infestation, the likelihood and feasibility of success, economic and ecological benefits of eradication, and cost. In Utah, the law governing long-term management dictates which species are managed. In Minnesota, the DNR assists in management of new infestations, however, management of established AIS is left to the discretion of local interested parties.

Ontario attempts to incrementally reduce the spatial scale of AIS infestations, including partitioning off portions of waterbodies. For example, water soldier (*Stratiotes aloides*) has been contained successfully to a part of one river. Most American jurisdictions attempt management at the scale of entire lakes, reach of rivers, or downstream watersheds. Texas conceded that on certain occasions, the desired containment was impossible and the attempted scale of management was thus the entire state.

All jurisdictions included mechanical, chemical and biological control methods among their management tools. Biological control has been used for over two decades to successfully suppress purple loosestrife in Ontario, and is being investigated for Eurasian water-milfoil. Triploid grass carp are used to control aquatic noxious weeds in Idaho and Texas. There are quite limited chemical control options in Ontario, because pesticides require both federal and provincial approval and specific registration for AIS control before they can be used. Such registration is rare. All states require federal approval prior to using chemical control agents. Oregon also must receive DOA approval.

Various jurisdictions have monitoring programs to track the spread and impacts of established AIS, as well as to evaluate management and public outreach programs. Ontario also has a monitoring program to discover new invasions. Neither Minnesota nor Oregon have monitoring programs as part of their long-term management plans.

Funding is a major barrier to AIS management in all jurisdictions. Ontario suffers due to the minimal number of chemical options legally available for use, and due to internal resistance (within government) to their use. Idaho's DOA also indicates that greater chemical management tools would improve the program. Minnesota and Oregon struggle with a lack of 'technically competent personnel'. Maintaining the public's interest in established AIS and stakeholder buy-in are also noted as major barriers. Communicating stories of successful eradications was noted as a method of improving public opinion towards AIS management.

Table 12. Summary of Interviewee Responses on Long-term Management.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Management options used	• species-specific • control using mechanical, chemical, and biological tools in combination with outreach and enforcement to prevent spread	• control and containment using mechanical, chemical and biological tools	• eradication, control and containment using biological tools in combination with increased outreach and enforcement	• species–specific • eradication, control and containment using mechanical, chemical and biological tools with assistance from other agencies	• control and containment using mechanical, chemical and biological tools	• primarily containment with some control
Spatial scale	• depends on species, how long it's been there and where it's spread • smallest scale possible (including a portion of a waterbody)	• typically a lake or river reach	• lake	• lake and downstream watershed	• typically lake and watershed, but in some cases state-wide	• waterbody
Criteria for managing established AIS? What methods used?	• scale of establishment, prevalence, likelihood and feasibility of eradication, risk of spread, impacts, priority to public or economy or biodiversity	• cost, likelihood of success and benefit of eradication to the ecosystem and public	• depends on species • established species: parties outside DNR must deem it worthy of monitoring • new species establishment: warrants DNR involvement • considerations include cost and ecosystem harm	• AIS impact, likelihood of success, non-target impacts of methods, and cost	• economic and ecological impacts	• cost and law dictating management
Control options	• mechanical, chemical and	• mechanical, (e.g., removal by	• mechanical, chemical and	• mechanical, chemical and	• mechanical (including drawing	• mechanical, chemical and

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
	biological, but chemical options are limited • chemicals used: reward for water soldier, rotenone for fish • resistance to chemical use in the government due to a lack of education	divers), chemical	biological; • mechanical control for common carp includes harvesting and fences	biological; • acceptable chemicals have both EPA and ODA approval (e.g., rotenone used for fish, working on getting state approval for use of equinox)	down of water), chemical and biological;	biological; • acceptable chemicals have been approved by the U. S. Food and Drug Administration
Purpose of monitoring established AIS and parameters measured	• track the spread of AIS and monitor for new species, and to assess the effectiveness of education and outreach program • few species are monitored	• track impacts to public access, as well as AIS spread, density and distribution	• established AIS are not monitored	• established AIS are not really monitored	• determine the efficacy of management programs and to ensure unchecked population expansion doesn't occur	• monitor extent and expansion of the population
Barriers	• lack of pesticide tools, permitting for control and management, time and money, and keeping people engaged with established species	• need more partner assistance with monitoring	• lack of resources and technically competent people, long term and emergency funding	• funding, personnel and deciding what the management objective is	• funding	• funding, stakeholder buy- in and political climate
n/a	• need individual plans that identify key pathways and engage MNRF and other agencies to	• need more approved effective treatment tools (herbicides)	• demonstrate successful eradication	• long-term management is not a sustainable option • priorities should include	•	• n/a

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
	prevent and manage • need to determine priorities for funding and resource allocation • need more information on the status of established AIS			prevention, early detection and eradication		

Note: n/a = not answered

4.10 Legislation and Policy

Four of the six jurisdictions have a stand-alone law focused on invasive species or AIS prevention and management. The other jurisdictions have multiple pieces of legislation which cover invasive species in some capacity (although invasive species may not be the main focus). Individual acts vary in age, from less than five years to more than 20. All acts have undergone recent updates (i.e., at least within the last nine years), and some legislation is updated on a regular schedule (e.g., every legislative session). Updates occur when legislation is out of date, to address new threats, to better respond to stakeholder needs, and to increase compliance. In Ontario, updates may also occur for reasons unrelated to AIS, since the existing legislation is more broadly focused on fish and wildlife issues.

All jurisdictions have prohibitions in place to control the introduction and movement of listed invasive species. The scope of these provisions varies, as do the number of species listed. In Ontario, prohibitions apply to the possession and trade of several invasive fish species (if live). In the states, prohibitions tend to be much more extensive, covering a wider range of activities, including import, export, trade, transport, possession, propagation, and introduction (e.g., in Idaho and Texas). The number of prohibited species is also higher in the U.S. jurisdictions reviewed compared with Ontario. Minnesota has a hierarchical classification system for invasive species, allowing regulations to be customized according to threat level of the listed species. For example, prohibited species may not be possessed, imported, purchased, transported or introduced. Regulated species, however, may be possessed, traded and transported, but not released into the environment. Minnesota also prohibits the transport of all aquatic plants and the transport of state waters, requiring that all boats and associated equipment (e.g., bait containers, live wells, and bilges) be drained before moving from one waterbody to another. Minnesota has legislative authority to designate infested waters, to restrict activities that might lead to spread of AIS. Similarly, in Texas, the draining of boats and removal of harmful plants and animals from boats and trailers, is required by law when moving between waterbodies. Idaho prohibits the transport of equipment or conveyances containing dreissenid mussels on public roads (unless they have been decontaminated) and prohibits their placement in any waterbody or water supply system. Its legislation also guides specific sectors to minimize the introduction and spread of dreissenids (i.e., fire-fighting activities should take precautions not to introduce and spread dreissenids, while construction, road-building and maintenance activities must be free of dreissenids).

Jurisdictions face challenges when trying to control some of their listed species, such as zebra mussels and marine tunicates. Preventative practices, such as prohibiting possession, and encouraging boats to be cleaned, drained and dried, help limit the spread of listed species. In many cases, however, additional control options are limited. Even when controls exist, they may not be implemented because of lack of funding and/or personnel (e.g., in Oregon). All jurisdictions except Utah have exceptions to their prohibitions for activities such as education and/or research. Idaho also has an exemption on transport permits for three established AIS (New Zealand mud snail, Asian clam, *Corbicula fluminea*; and American bullfrog), unless they are moved outside of their current area of known infestation.

None of the jurisdictions reviewed have actual agencies or departments specifically dedicated to AIS prevention and management, but all jurisdictions do have staff focused on AIS.

Half of the jurisdictions reviewed (Minnesota, Oregon, and Utah) expressed satisfaction with how existing AIS policy, legislation and regulations are working. Ontario indicated that, although policy is up to date

(through the Ontario Invasive Species Strategic Plan), legislation and regulations are lagging behind, especially with respect to addressing AIS plants. Ontario introduced proposed invasive species legislation in February 2014, which subsequently died on the order paper when a spring election was called. If passed, this legislation would have been the first of its kind in Canada, providing a broad range of prohibitions on listed invasive species, as well as provisions to address EDRR, control and eradication. In September 2014, the Ontario premier directed MNRF to prepare the proposed act for reintroduction. Oregon found that funding was a limitation, while Idaho emphasized the importance of public support and cooperation to ensuring an effective policy or legislative framework actually works. Texas can only list fish, shellfish and aquatic plants as prohibited AIS, but not other taxa (e.g., amphibians, reptiles). Recommendations for improvements to existing policy and legislation included the need to: regulate more AIS (Ontario), prohibit overland transport of aquatic vegetation (Idaho), better coordinate activities between adjacent jurisdictions (Minnesota), and increase authority to: inspect commercial vessels (Idaho), close infested waterbodies (Oregon) and track individual boats (Utah). Key barriers to strengthening policy and legislation are mainly related to lack of political will and understanding about the AIS issue. Minnesota pointed out that communicating success stories to policymakers is critical for garnering support because it can demonstrate that a comprehensive program and investment in prevention really can work.

Table 13. Summary of Interviewee Responses on Legislation and Policy.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Is there a stand-alone act on IS?	• no stand-alone act, but one was proposed earlier in 2014 (died when provincial election called but slated to be reintroduced in near future) • currently AIS covered under the OFR (under federal *Fisheries Act*) and the provincial FWCA • agricultural weeds are covered under the provincial *Weed Control Act*	• stand-alone act: 1 statute + administrative rules	• stand-alone act: 1 statute + administrative rules	• multiple state laws including revised statutes, administrative rules and house bills	• AIS are regulated under 1 statute, terrestrial IS are regulated under other laws	• 1 act + administrative codes almost entirely focused on invasive mussels
How long has the legislation and regulation been in place?	• OFR: 1985; FWCA: 1997	• AIS: 2008; noxious weeds with aquatics: 2007	• provisions since late 80's • consolidation in mid to late 90's • present statute and rule: 1991 • Minnesota was first state to have a comprehensive IS program	• noxious weed and wildlife integrity rules have existed for decades • ballast water regulations have existed for less than 10 years • legislation for quagga and zebra mussel: 2010	• prohibited list since 1990	• 2007
When were they last updated?	• OFR: 2007; FWCA: list of prohibited species last updated in 2005	• both updated in 2013	• 2012 or 2013 • ongoing process	• updated every session (every other year)	• 2014	• 2014

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
What prompts an update?	• out of date legislation • not necessarily for AIS issues because acts and regulations address other things too	• addition of new species, biofuel issues	• potential threats	• agency and stakeholder needs • to increase compliance	• agency action • legislative direction	• trying to adopt model law provisions
Does the legislation enable management?	• preventative	• yes	• yes	• yes	• primarily preventative	• yes, gives authority to run IS program
What government policy addresses AIS?	• primarily Ontario IS Strategic Plan	• Idaho Statute Title 22 Chapter 19 The Idaho IS Act of 2008 and Idaho Administrative Rules 02.06.09 Governing IS	• Minnesota Statutes Chapter 84d IS and Minnesota Administrative Rules Chapter 6216 IS	• Oregon Revised Statutes (e.g., Chapter 570 Plant pest and disease control; IS) , Oregon Administrative Rules Chapter 340, Division 143 Ballast water management; Chapter 635, Division 56, Non-native wildlife + House Bills 2625 and 2714	• Texas Administrative Code Title 31 Part 2 Chapter 57 Subchapter A	• Utah Code Title 23 Chapter 27 AIS Interdiction Act, Utah Administrative Code R58-17-13 Importation of aquatic animals or aquaculture products, Administrative Code R657-60 AIS Interdiction, Utah Administrative Code R657-3-22, 23, and 24 Classification and specific rules for crustaceans, mollusks, fish and mammals

Current Prevention and Management Approaches for Aquatic Invasive Species in Jurisdictions outside Alberta

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Are there government staff/agencies or departments dedicated to AIS?	• staff	• ISDA staff	• staff within IS program at DNR and staff for research, outreach, education	• each agency has 12 people assigned to AIS	• yes	• staff
Are multiple agencies involved?	• primarily MNRF (OMAFRA for agricultural pests, but these not typically aquatic)	• ISDA is lead, + partners	• mainly DNR, + partners	• yes	• yes	• WDR is lead, + partners
How are activities among them coordinated?	• n/a	• by ISDA and IISC	• at multiple levels through different stakeholder groups	• by IS Council	• through discussion between partners and cooperators	• through partnerships and staff
What are the limitations of policy, legislation and/or regulation?	• out of date list of prohibited species • no legislation to deal with AIS plants	• no prohibitions on transport of aquatic vegetation	• Minnesota has more authority now than it has ever had, so no obvious problems	• funding • otherwise, major policies are in place and seem effective	• TPWD only has authority to list fish, shellfish and aquatic plants (not prohibited amphibians, reptiles etc.)	• no obvious limitations at the moment

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
How effective are they?	• policy is up to date • legislation and regulations lag behind	• have an effective framework but ultimately depends on public support and cooperation	• policy generally effective • addressing major pathways through prohibitions on transport of aquatic plants, transport of water from any waterway, and overland transport • use education, roadside inspections, licensing	• better than before	• fairly effective	• effective
Are there any regulated species that have no control options? How are these addressed?	• only fish are regulated • relatively limited control options • regulations prohibit possession and use as bait which limits introduction and spread	• many of them • monitoring and containment by encouraging "Clean, Drain, Dry" is focus of these	• depends on species and setting • zebra mussels in natural waterbody have very few control options • a few pesticides can be used in localized area • new biocontrol agent, but still experimental	• biggest problem is marine tunicates: very few control options • lack of funding and/or personnel may mean controls are not implemented	• by preventing spread to new areas	• no control options for invasive mussels • being controlled by monitoring and decontamination

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Are there any exceptions to the regulations?	• for research	• New Zealand mud snails, Asian clams and bullfrogs are exempt from statewide transport permits (unless they are moved outside of their known established distribution area)	• for education and research	• for education and research	• yes	• no
What could be improved for policy or legislation?	• need regulation of AIS plants and additional species not currently listed	• need to prohibit transport on a vessel of any aquatic vegetation • need inspections on all commercially transported vessels	• need to reinstate sticker program (which required all watercraft over 8 ft. launched in the state to purchase a sticker indicating they had been inspected and decontaminated) to generate long-term revenue for IS program and ensure reciprocity between states using sticker or tag system (i.e., stickers issued in one state valid in another)	• need clear authority for closing waterbodies • need more funding (through allocation of an emergency control budget for RR)	• broaden taxonomic coverage of prohibitions	• need more authority to track individual boats

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
What are the barriers to improving policy and legislation?	• political will (in the past, but this is improving)	• n/a	• need to ensure that policymakers are aware of the success stories and of the fact that it takes a comprehensive program and investment in prevention to make it work	• political will	• n/a	• not being able to track individual boats

Note: n/a = not answered

4.11 Enforcement

State or provincial agencies, including the AIS lead agency and sometimes law enforcement, enforce the applicable regulations. Fines and warnings are the most common types of penalty, but impoundment, quarantine, and civil citations are also used and intentional violation can even result in a jail sentence in Minnesota.

Jurisdictions with mandatory inspections conduct or require decontamination of any fouled boat or trailer, while conservation officers in Ontario, where inspections are voluntary, can only ask for a boat cleaning. Seizing and quarantine are common procedures for fouled boats and fines are charged in a number of jurisdictions. Civil charges are considered on a case-by-case basis, for example, in the case of resistance to decontamination in Oregon.

The number of tickets and types of violations are recorded and reported on in all reviewed U.S. jurisdictions, mostly annually. The data are used to calculate violation rates, guide management decisions and demonstrate program effectiveness (Minnesota) and to determine the need for law enforcement at specific places or times (Oregon).

Funding and personnel were cited as the most common barriers to enforcement. In the states, where law enforcement personnel are involved, the understanding of the importance of the issue by enforcement staff and their level of involvement were deemed unsatisfactory. Interestingly, Minnesota also mentioned that there were local jurisdictions who were interested in being involved in enforcement but lacked the training to do so.

Table 14. Summary of Interviewee Responses on Enforcement.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
What acts, regulations, policies require enforcement?	• FWCA, OFR	• AIS Rule	• State Statutes (84D)	• all of them (Oregon Revised Statutes, Oregon Administrative Rules)	• listed species possession, transport and sale	• AIS Interdiction Act and AIS Rule
Agencies involved and type of enforcement used	• MNRF • fines and warnings	• county law enforcement: Idaho Fish and Game • confiscate, impound and quarantine	• DNR (armed peace officers),DA, USFWS, Minnesota Department of Agriculture Plant Health Inspection Service • fines, warnings, quarantines (rare), decontamination, seizure, education	• state police, sheriffs: AIS registration fees, which include AIS prevention fees, ODA: levy fines for plants, fines and warnings most common, citations	• TPWD game warden	• any sworn officer, main responsibility lies with COs. fines, warnings, quarantines, decontamination, seizure, education, check points
Protocol for fouled boat or trailer	• ask to clean • technically could charge, but difficult to implement	• if mussels are suspected to be alive, impound, decontaminate and quarantine	• depending on who finds it, can be cease and desist, quarantine, decontaminate; • fines $100-$1000; if intentional: jail time	• advised that it is illegal to transport mussels, • boat is cleaned for free (140°F water & pressure) • failure to comply can result in civil penalty • if dirty, ask for 6 months history	• boat may be seized, cleaned, and quarantined	• technicians contact COs and collect evidence • COs determine culpability, worthiness of citation and need for boat seizure and quarantine; • always decontaminate boats • judge decides further penalties
Data collection,	• record charges laid and if new	• ISDA collects and presents data	• record number of citations, written	• OFDW collects data and reports	• record number of tickets, violations	• record boat, model, size,

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
analysis, and follow-up	species found • leads to RAs		and verbal warnings • calculate violation rates annually and use to guide management decisions	annually • record number of citations, tickets, stops, bypasses of check stations, possession of prohibited species • determines need for law enforcement presence		mussel location, and origin of boat.
Barriers and opportunities to improve	• number of officers • Internet-based trade in AIS • Aquatic plants not listed	• participation by enforcement personnel	• funding, training for motivated local jurisdictions	• funding, personnel • finding contaminated boats • having law enforcement understand the importance	• funding, personnel	• funding, personnel

Note: n/a = not answered

4.12 Governance

The governance model used by all jurisdictions is either one or two lead agencies, working with internal and external partners. Several states also have advisory bodies helping to provide leadership and direction. Full-time staff dedicated to aquatic and terrestrial invasive species, or AIS exclusively, help implement the program in each jurisdiction. Minnesota and Utah employ the most staff (25-36 full-time and over 150 seasonal). In addition to full-time dedicated staff, some jurisdictions may also have staff that work on invasive species periodically or occasionally (e.g., Ontario).

The single agency approach was identified as a governance strength because it improves coordination and communication within government, provides leadership and facilitates action. The existence of a statewide program was considered beneficial, as it ensures a consistent approach and increases public awareness about government initiatives and invasive species issues in general. The complete prohibition on possession of listed species, combined with effective enforcement, was seen as a major strength of the system in Texas. Numerous weaknesses and limitations to the current governance approach exist, however, including the lack of a centralized advisory committee (Ontario), not enough staff (Oregon, Utah) and lack of partner buy-in or involvement (Idaho, Utah). Ontario has found that the loose and ad hoc approach has restricted progress, since there is no legislative authority for dealing with invasive species, nor for establishing advisory committees. Minnesota emphasized the importance of clearly delineating how advice from advisory committees will be used, so that recommendations are not simply lost in the process and never implemented. Oregon highlighted the problem of not having enough staff for inspections and the fact that some people take advantage of times when no staff are available to access waterways and avoid inspections.

Annual or biennial reporting is mandatory in Idaho, Minnesota and Oregon.

Table 15. Summary of Interviewee Responses on Governance.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
What are the components and interactions of the governance structure?	• MNRF is the lead agency among multiple agencies • committees provide advice	• ISDA is the lead agency	• DNR is the lead agency among multiple agencies • work with a lot of external partners • statewide advisory committee	• 2 agencies: Marine Board and OFW • Oregon IS Council	• TPW is the lead agency	• DWR is lead agency • work with partners
How many staff?	• 5 full-time MNRF staff deal with aquatic and terrestrial IS • other MNRF staff may address IS as part of their jobs	• 5 full-time staff dedicate ≥ 50% of time to AIS	• >25 full-time staff at DNR + ~150 seasonal staff • ~10 full-time staff at Minnesota Sea Grant + 7 regions each have AIS coordinators + 1 AIS outreach specialist	• 2 full-time staff + 12 seasonal	• 2 IS biologists, a program director, a permit coordinator, and a Habitat Enhancement office (with a biologist and technicians)	• 1 full-time AIS Coordinator • 5 full-time biologists • 25 seasonal Technicians • 60 seasonal Lead Ranger Aids • 1 full-time technical writer • 1 part-time Criminal Information Technician • 5 part-time Region COs
What are the strengths and weaknesses of the governance model?	• strength: -one agency as lead = improved coordination and communication • weaknesses: -need larger MNRF program -no centralized advisory committee	• strength: -single lead agency provides leadership	• strength: -statewide program = consistent approach and increased public awareness	• strength: -lead agency streamlines process • weakness: -not enough staff	• strength: -illegal to possess a prohibited species and tickets can be issued quickly by game wardens for violations	• strength: -freedom to act, moving people and resources around the state • weaknesses: -lack of partner buy-in -not enough staff

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
What are the limitations?	• loose and ad hoc governance (although improving) • no legislative authority for IS and for advisory committees	• need better partner involvement and support	• need to educate counties • need clear structure outlining how advice from committees to be used	• not enough staff mean we can't work around the clock • vessels may sneak in when we're not working	• n/a	• n/a
Is reporting part of your program, and is it required?	• no legislated requirement, but it occurs through OFAH initiatives	• annual report required	• annual report required • Sea Grant program has to report • report at regional level to the Great Lakes Panel	• biennial report required	• not to public	• part of program, but not required

Note: n/a = not answered

4.13 Funding

All jurisdictions interviewed have dedicated funding though sources vary with each jurisdiction. In Ontario, funding comes from the sale of fishing and hunting licenses, the collection of fines related to violations from hunting and fishing, as well as general funding from centralized tax dollars. The primary source of funding in Idaho is from the sale of Invasive Species stickers, which are required for all vessels launched in the state. The annual revenue from the sticker program is approximately $1.2 million, which goes toward prevention, EDRR and education initiatives. All other states have dedicated general state funds while Oregon and Texas also receive federal funding and Oregon collects additional funding from the lottery and ship fees (for ballast water). Oregon is moving away from general funds and moving more towards funding from fees. Utah was the only jurisdiction interviewed which had contract funding. Minnesota receives funding from several sources including boat registration fees, non-resident fishing licenses, state funding from the Heritage Enhancement fund, monies from the U.S. Fish and Wildlife Service, and from the Environment and Natural Resources Trust fund. All jurisdictions with the exception of Texas receive funding consistently.

Funding allocation is determined by the lead agency in Idaho, Minnesota, Texas and Ontario. In Ontario, however, there are several sources of funding. The bulk of funding for the AIS program comes from MNRF centralized tax dollars and revenue from fish and wildlife activities (e.g., hunting and fishing licenses and fines). The Canada-Ontario Agreement (COA) is also a major funder of AIS work, providing funds to MNRF's annual budget for Great Lakes related work (which must then be approved by MOECC). MNRF funds the Invasive Species Centre, as well, which provides financial support to invasive species projects across the province. In Texas, the legislature allocates invasive species funds every two years. In Oregon, funding is received equally by the two main agencies involved: 50% to the Marine Board and 50% to Fish and Wildlife.

Various elements of the AIS program are funded to different degrees and from different sources within each jurisdiction. In Ontario, most elements are funded through MNRF's internal budget, while COA funds some risk assessment and partnerships with other agencies are used to leverage funds for long-term management. In Idaho, all aspects of the AIS program are funded through the sticker program—with the exception of noxious weeds, which are funded through the general fund. In Minnesota, most funding is dedicated to enforcement and management. In Oregon most elements of the AIS strategy have independent sources for funding.

Idaho, Oregon and Utah's focus their priorities on individual AIS threats, (i.e., dreissenid mussels). These three jurisdictions, in addition to Texas and Minnesota, concentrate their efforts on watercraft inspections. Minnesota also prioritizes other vectors, including bait dealers, harvesters, and lake services providers. Many of Ontario's priorities are dictated by the COA, at least for the Great Lakes. Money derived from fish and wildlife activities is not exclusively reserved for the province's AIS program, but also goes to other biodiversity work within MNRF.

Reporting is required for all funding sources in all jurisdictions interviewed and varies depending on the source of the funding and may change temporally. An annual report is required in Texas and Minnesota. In Oregon, the Marine Board requires monthly statements indicating the money used and work completed; reimbursement is not guaranteed.

Minnesota, identifying itself as the state with likely the greatest funding resources, says it could improve funding by identifying the most effective ways of leveraging these resources. Oregon's funding is described as limited and unreliable (because it largely relies on boat registration fees, which depend on people continuously buying boats), but with potential additions of general government funds or from partnerships with groups such as the Bonneville Power Administration — an electrical marketing company—funding could be increased and stabilized. Use of funds in Texas is hampered by the bureaucratically heavy federal pre-approval requirements. In Utah, money obtained from contracts and grants is restricted to pre-identified waterbodies or access points, which may not be locations with AIS concerns. This situation could be resolved by putting all monies in one fund to be distributed by the Division of Wildlife Resources (DWR). Funding scenarios in Ontario could be ameliorated by the MNRF having its own invasive species fund when working with partners, which would give the agency a financial stake in the program. Secondly, there is also a need to clearly identify the role of the Invasive Species Centre, which is intended to assist the MNRF in identifying key invasive species initiatives to be supported financially.

Table 16. Summary of Interviewee Responses on Funding.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Dedicated funding	• yes	• yes	• yes	• yes	• yes	• yes
Funding priorities	• COA for Great Lakes related work • government and partners identifies priorities	• dreissenid mussels prevention • watercraft inspection	• prevent spread • recreational boaters • bait dealers and harvesters • lake service providers	• dreissenid mussels • watercraft • A-listed aquatic weeds[6]	• public access	• dreissenid mussels • contract funding must be used at dedicated places
Funding sources	• sale of licenses • fines • general funding • COA	• sale of stickers for vessels	• boat registration fees • non-resident fishing licenses • Minnesota general fund • state trust funds • federal IS funds	• boat registration fees • ship fees (for ballast water) • general fund • lottery • federal IS funds	• state general funds • federal boating access funds • federal IS funds	• general state funds • contract funds
Allocation	• COA allocated by MNRF and verified by MOECC • general funding through MNRF's annual budgeting	• funds allocated by ISDA	• allocated by DNR • 43% enforcement • 22% management and control • 7% administration • 18% state and regional coordination • 10% public awareness	• 50% to Marine Board and 50% to ODFW • moving away from general funds to fees	• state funds allocated by legislature every 2 years	• state funds allocated by DWR • constant surveillance budget
Consistency	• yes	• yes	• yes	• yes	• no	• yes
Research and	• yes	• yes	• yes	• sometimes	• sometimes	• yes

[6] ODA classifies noxious aquatic and terrestrial non-native plants based on economic importance, extent of infestation, and likelihood of control or eradication. A-listed weeds are of known economic importance and either occur in state in small enough infestations as to make eradication or containment possible, or are not known to occur in Oregon, but are present in neighbouring states, making future invasion possible.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
innovation funding?				• grant and contract money		
Reporting requirements	• depends on funding source	• ISDA stipulates requirements	• depends on funding source	• depends on funding source • Marine Board requires monthly statements	• annual reports for federal funds	• changes year to year
How are different components of the AIS program funded?	• mostly through MNRF • RA through COA • long-term management through partnerships	• AIS projects through IS sticker fund • aquatic noxious weeds through general fund	• DNR determines	• RR through emergency fund • communication and awareness through federal grants • early detection through lottery and federal contracts • boat inspection through boat registration fee	• federal funds used to increase access to boaters • state funds used for all other activities	• state fund is used as DWR sees fit • contract and grant money tied to specific locations
Barriers to funding model?	• n/a	• enforcement of IS sticker program responsibility of local law enforcement	• leadership	• unreliable and not enough funding, and not strategic	• pre-approval needed to use federal money on waterbody	• contract and grant money tied to specific waterbodies that may not require coverage
Ways to improve	• MNRF should establish its own IS fund • clearly define role of Invasive Species Centre	• n/a	• leveraging resources in the most effective way	• receive outside funding (e.g., general government funds or from user groups, like hydropower companies)	• working on new model	• have a contributive account where money is allocated by the DWR

Note: n/a = not answered

4.14 Measuring Success

Measuring success of an AIS program can be difficult. One objective is measurement of the direct impact of AIS programs on the introduction and spread of AIS, and the other is indirect, as increased awareness and enforcement, which, over time, may achieve the first objective. Success in the first objective is difficult to evaluate when the main goal is—as one interviewee put it—to 'have nothing happen' to the environmental status quo. Minnesota, Idaho and Texas formally evaluate success. Minnesota evaluates success based on the number of new occurrences of AIS discovered annually, while Idaho monitors treatment success (e.g., number of watercraft intercepted with mussels). Texas keeps track of acres and waterbodies treated. Ontario evaluates certain programs, but admits there is no dedicated program to looking at success. Oregon gives itself an unofficial report card and receives a low score if a new species is introduced or an established population expands its range.

While most jurisdictions (aside from Minnesota and Idaho) do not formally evaluate success, all produce reports to evaluate their programs to some degree or another. In the U.S., each state produces an annual report (Idaho uses this as an opportunity to enact new initiatives to improve program efficacy and efficiency), while Ontario produces reports on a project by project basis. An Ontario example is an MNRF project which evaluates the success of the province's ISAP public awareness program by surveying anglers and boaters every five years to determine if public knowledge has increased and what additional steps the public is currently taking to address invasive species.

Even though success is difficult to measure, each jurisdiction has made notable accomplishments. In Ontario, biological controls are used to suppress purple loosestrife populations. Coordination within the government has been established and priority actions have been identified. In addition, ISAP has succeeded in increasing public knowledge and awareness of invasive species, and MNRF has worked with partners to identify and prevent the invasion of Asian carp species. Meanwhile, OIPC has established communication and outreach programs about invasive plants. Both Idaho and Oregon note fouled boat interceptions as a key success as well as a lack of dreissenid mussel detections; Oregon considers its *Spartina* response plan as a great success. The goal of this program is to prevent the establishment and spread in Oregon of any of the four invasive *Spartina* cordgrass species (*S. alterniflora, S. anglica, S. densiflora,* and *S. patens*) present in estuaries and wetlands along the west coast of North America. Through the plan, the state has managed to almost completely eradicate *Spartina* from targeted sites. Utah considers the lack of invasive mussels in the state as a key success story, along with removal of various lakes, ponds and rivers from its lists of infected or contaminated waterbodies. Minnesota's DNR looks to its neighbours as a means of comparison and feels achievement in having a smaller proportion of infested lakes than they do. The Minnesota Sea Grant program evaluates success in terms of raising awareness, changing public attitude and protecting resources. Texas has successfully reduced hydrilla populations in two lakes without harming native vegetation or recreational fisheries.

Each jurisdiction also concedes there are areas which require improvement. In Ontario, regulatory and public consultation hurdles prevent rapid response; there is the need to address gaps in the regulatory framework to cover all fish and aquatic plants; and long-term management coordination is necessary instead of an ad hoc approach. Idaho believes there is a need for metrics for measuring success of prevention programs. Minnesota requires coordination of an early detection campaign, where large groups of agency personnel search for AIS. Oregon states several areas requiring improvement: the first

is addressing warm water and marine fishes, with attention as well on freshwater macroinvertebrates; the second is increasing boat inspection hours. Utah recognizes the need to increase awareness of species other than invasive mussels. Texas needs resources to keep AIS populations at very low levels once they are initially suppressed.

Each jurisdiction can claim several years of experience with AIS and many lessons have been gained along the way. Those interviewed stressed the importance of being adaptable and flexible; recognizing that you do not always have the tools to deal with the situation; and the importance of being as prepared as possible. They advised that any AIS program should learn from existing programs, that evaluation must be built into the system from the very beginning and that discrete endpoints must be identified. Others cautioned that some management tools can do more harm than good, and it is better to move deliberately rather than quickly. For example, in Minnesota, large-scale control of Eurasian water-milfoil in a eutrophic lake led to reduced water clarity and reduced growth of non-target vegetation. A more selective approach to the infestation might have avoided these unintended consequences. Blindly trusting in the inspections of other jurisdictions was not advised. Working with partners was emphasized to ensure effective programs. Convincing the public to take personal responsibility to prevent the spread of AIS was also identified as critically important. Lastly interviewees stressed the absolute requirement of having a champion in the legislature for true success!

Minnesota expressed the importance of merging the principles of natural resource management and social science; to utilize personnel who are trained in education to improve public awareness and attitude by creating an educated populous that has an understanding of the greater concept of AIS and why action is required.

Table 17. Summary of Interviewee Responses on Measuring Success.

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
Do you measure success of AIS program?	• not officially	• yes: treatment success is monitored	• yes	• no	• yes: acres and waterbodies treated	• not officially
How often?	• project by project	• annually	• annually	• no formal evaluation • legislature evaluates annually	• n/a	• annually
Key successes	• purple loosestrife: suppressed • establishment of strategy: coordinating and prioritizing action • ISAP: raising public awareness • Asian carp species: keeping out • OIPC: communication, coordination and outreach for IS plants	• interception of 118 fouled vessels • over 100,000 vessels inspected • boater education • no detection of dreissenid mussels in state • reduction of aquatic noxious weeds	• raising awareness • behavior change • protecting resources	• no mussels to date • intercepting fouled boats • *Spartina* program	• Hydrilla significantly reduced in Lakes Austin and Conroe without harming other vegetation and trophy fisheries	• keeping dreissenid mussels out of the state • removal of waterbodies from infected and contaminated lists • implementation of more public awareness and research
Need for improvement	• RR: regulatory and consultation obstacles • regulatory framework • coordination of long-term management	• measuring prevention success	• have state agency crew search for new infestations	• adequately address warm water and marine fish and freshwater invertebrates • increase inspection hours and inspection	• increased and stable funding • resources to keep AIS populations at very low levels once initially reduced; to use less chemicals; to increase public	• awareness of IS other than mussels

State/Province	Ontario	Idaho	Minnesota	Oregon	Texas	Utah
				sites	access	
Lessons learned	• be adaptable • be prepared	• learn from existing programs • prevention is never finished and you never win • holding the line is the goal, success difficult to quantify	• build evaluation into the project • careful management needed	• a champion in the legislature is critical to success • don't trust other jurisdictions inspections	• n/a	• need public buy-in • move deliberately not quickly • working with partners makes you more effective
Barriers to measuring success	• need metrics in place to measure success	• quantifying success of prevention	• time • money • educated experience staff	• personnel	• n/a	• unable to measure success without monitoring
Ways to improve	• n/a	• conduct a poll on public awareness of IS issues	• merge principles of social sciences into the program	• more hours for inspection	• n/a	• monitoring

Note: n/a = not answered

5. Summary

5.1 Summary of Jurisdictional Review

All reviewed jurisdictions have comprehensive AIS prevention and management systems in place, which consist of the same main components:

- Education and Outreach,
- Risk Assessments,
- Surveillance/Inspections,
- Early Detection, and
- Rapid Response.

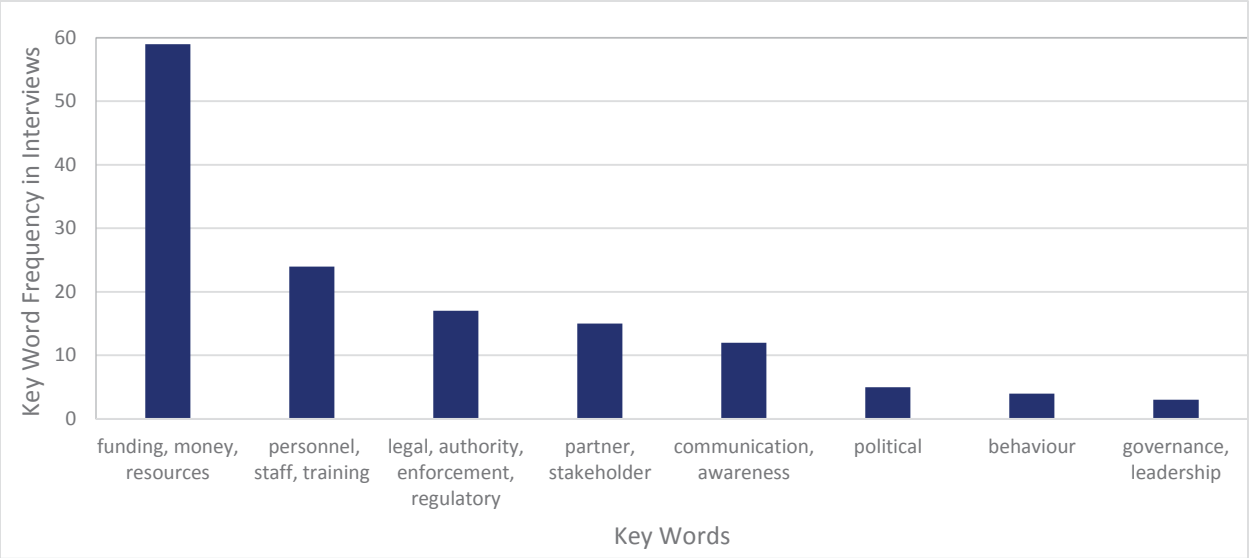
Proper planning, coordination and implementation of these major components are assured by structures and tools that work effectively together, including:

- Governance structures,
- Laws and regulations and their enforcement,
- Funding, and
- Stakeholder engagement and coordination.

Weaknesses in any one of these components or supporting structures lead to reduced effectiveness of the program. The most important barriers to a successful AIS program were repeatedly cited as insufficient funding and personnel, legislation and legal authority, and limited coordination with partners, while resistance to behavioural changes and lack of political will were also mentioned. These results clearly demonstrate that the technical components of AIS management are well known and developed, but that the resources, strategies and structures to implement them are limiting program success.

The frequency by which some key words were recorded in answers to the questions on barriers and improvement showed that funding and personnel, as well as legislation and authority are the most common barriers to effective AIS management (Figure 1).

Figure 1. Most Commonly Cited Barriers to AIS Management



In our view, these findings indicate that governments have not fully recognized the severity of the threat of aquatic invasions. There appears to be a disconnect between those directly working on the problem (e.g., biologists, resource managers) and government decision-makers responsible for allocating resources for that work, highlighting the need for better communication with, and education of, senior levels of government. Scientifically defensible risk assessments, that incorporate environmental, social and economic impacts of potential aquatic invasions, are one way to inform decision-makers of the significance of the AIS problem, and its wide-ranging implications on society. Maintaining support for AIS initiatives in government remains an ongoing challenge, however, as AIS work must compete with many other issues for attention and limited resources. Increasingly, partnerships with other stakeholders at local, regional and federal levels seem crucial to the long-term success of AIS programs, as these collaborations can open up increased opportunities for funding, resources, and personnel, while maximizing public outreach. Ultimately, effective stakeholder involvement may lead to increased public awareness of the AIS issue, which in turn may result in increased public pressure for government to allocate more resources to address the problem. Alberta organizations that involve stakeholders in water management and invasive species, such as Watershed Planning and Advisory Councils, watershed and lake stewardship groups, the Alberta Lake Management Society, and the Alberta Invasive Species Council are well positioned to fill this role, as are private entities willing to cost-share prevention activities with government.

When one part of the system is working very well, it can help the entire program. For example, Texas benefits from a very comprehensive outreach and coordination program, which increases public acceptance significantly. Minnesota is probably the most well-funded and well-legislated program and consequently has the advantage of a rich risk assessment database, powerful inspection and enforcement, research resources and funds for management and control.

The results of our jurisdictional review are presented in Table 18 as a condensed summary (see below).

Table 18. Summary of Approaches to AIS Prevention and Management Strategies by Jurisdiction

Component	Jurisdiction					
	Ontario	**Idaho**	**Minnesota**	**Oregon**	**Texas**	**Utah**
Stakeholder engagement	• no formal communication network, but informal and formal partnerships coordinated by MNRF	• focus on emergency AIS response	• focus on public education, stakeholder training, and internal communication; Minnesota Invasive Species Advisory Council	• focus on legislation, outreach, internal communication; Oregon Invasive Species Council	• focus on public education, stakeholder training, and internal communication	• focus on public education; Texas AIS Task Force
Stakeholder coordination	• MNRF coordinates other government agencies and external partners;	• ISDA coordinates via IISC	• DNR and MDA coordinate	• PSU coordinates	• PWD coordinates	• DWR coordinates
Public awareness and education	• outreach mainly targeted to specific groups (e.g., recreational audiences, elementary students)	• outreach targeted to general public and specific groups (e.g., boaters, pet owners)	• outreach mainly targeted to specific groups (e.g., recreational audiences, elementary students)	• outreach targeted to general public, teachers and students	• outreach targeted to general public and specific groups (e.g., boaters, citizen scientists)	• outreach targeted to specific groups (e.g., recreational audiences)
Risk assessment	• draft RAs updated continuously; used to prioritize species and assess regulations	• use RAs from elsewhere; used to prioritize species, monitoring, inspections	• complete RAs on species that have caused problems elsewhere and pose threat; used to prioritize species and pathways	• complete RAs on potential emerging threats to inform species lists, inspections, signage	• complete RAs on species determined in collaborative decision; used to add species to “illegal” list	• early phases of RAs: data collection; used to prioritize locations and species

Component	Jurisdiction					
	Ontario	**Idaho**	**Minnesota**	**Oregon**	**Texas**	**Utah**
Surveillance/ Inspections	• voluntary inspections of boats, bait buckets, fish markets to assess compliance with regulations	• mandatory boat inspections on border highways and some boat launches for prevention and education, supported by law enforcement	• mandatory boat inspections, bait and hatchery inspections to assess risk, educate and assess compliance with regulations	• mandatory boat inspections at border highways • for Prevention and education, enforced by police	• boat inspections at "discretion" of game wardens; to check for possession and transport of illegal AIS	• mandatory boat inspections at border highways, boat launches and roads for prevention, education and assess compliance with law
Early detection	• various groups monitor AIS in lakes as part of existing broader monitoring programs	• ISDA, regional partners and public monitor AIS (dictated by statute) at ideal times to detect dreissenids	• DNR monitors priority species in response to reported sightings	• PSU supported by citizens monitor boat-accessible lakes annually for priority species; high-risk lakes most frequently	• dedicated biologists and citizens monitor fish and plants in reservoirs every 4 years or more	• DWR and water conservation districts conduct comprehensive monitoring and reporting on every boatable waterbody and in streams
Rapid response	• well established for Asian carp species; draft response plan in place for other species; often led by MNRF in partnership with other groups	• ISDA leads RR for dreissenids in collaboration with other states, federal and regional agencies, stakeholders and uses contractors	• DNR and stakeholders conduct RR under a detailed framework and with help from contractors and other creative labour options	• ODFW leads RR for mussels and ODA leads RR for *Spartina* species in collaboration with other states, federal and regional agencies and stakeholders	• TDPW leads water-body specific RR; assisted by contractors and volunteers	• waterbody specific RR consists of communication of State Agency and all else is done by local stakeholders

Component	Jurisdiction					
	Ontario	**Idaho**	**Minnesota**	**Oregon**	**Texas**	**Utah**
Long-term management	• use mechanical, chemical and biological management tools to contain and control AIS to smallest possible scale followed by monitoring	• use mechanical, chemical and biological management tools to control and contain AIS to waterbody followed by monitoring	• use mechanical, chemical and biological management tools to eradicate, control and contain AIS to waterbody	• use mechanical, chemical and biological management tools to eradicate, control and contain AIS to waterbody	• use mechanical, chemical and biological management tools to control and contain AIS to waterbody followed by monitoring	• use mechanical, chemical and biological management tools to control and contain AIS to waterbody followed by monitoring
Legislation and policy	• multiple pieces of legislation with limited prohibitions; policy up to date but legislation lags behind	• single act and rule with wide range of prohibitions	• single act and rule with wide range of prohibitions, as well as ability to designate infested waters	• multiple pieces of legislation with limited prohibitions, as well as ability to stop boats for inspection	• single act with wide range of prohibitions	• single act focused on prohibiting invasive mussels
Enforcement	• MNRF officers can give fines and warnings, but cannot oblige to decontaminate	• law enforcement and Game and Wildlife impound, decontaminate and quarantine	• armed DNR peace officers or other state officials issue fines, warnings, educate and decontaminate, occasionally seize and quarantine; jail time an option	• law enforcement issues fines, warnings, citations, educates, decontaminate for free	• game wardens seize, clean, quarantine, issue tickets	• technicians detect and decontaminate, COs decide on citations, seize, quarantine; judge issues fines

Component	Jurisdiction					
	Ontario	**Idaho**	**Minnesota**	**Oregon**	**Texas**	**Utah**
Governance	• one lead agency, full-time staff, no required reporting	• one lead agency, full-time staff, advisory council, annual reporting required	• one lead agency, full-time and seasonal staff, advisory council, annual reporting required	• two lead agencies, advisory council, full-time and seasonal staff, biennial reporting required	• one lead agency, dedicated full-time staff	• one lead agency, task force, staff
Funding	• dedicated, consistent funding from licenses, fines, general funds and COA. Allocation determined by MNRF	• dedicated, consistent funding from sticker sales. Allocation determined by ISDA	• dedicated, consistent funding from fees, licenses, state and federal funds. Allocation determined by DNR	• dedicated, consistent funding from fees, lottery, general funds and federal funds; 50% to Marine Board and 50% to ODFW	• dedicated, not consistent funding from state and federal funds. Allocation determined by legislature	• dedicated, consistent funding from state funds and contract funds. Allocation determined by DWR
Measuring success	• success not officially measured; each project evaluated independently	• measure success; annual program evaluation	• measure success; annual program evaluation	• success not measured; annual program evaluation	• measure success through acres and waterbodies treated	• success not officially measured; annual program evaluation
Main Barriers and Opportunities for Improvement	• funding, personnel, legislative tools	• better partner involvement, stakeholder understanding and support of RR	• funding, resources, cultural and behavioral resistance	• funding, personnel, improve enforcement and authority	• funding, personnel, isolated agencies	• funding, political climate; structure for response time, legal authority

Amongst the large number of individual approaches, methods, structures and strategies, a few stand out that have been tested and proven effective for AIS prevention or management in a number of jurisdictions, as indicated by their adoption by the large majority of jurisdictions and by their citation as a barrier when missing. These include:

- Focus on prevention,
- One lead agency, collaborating with a large range of other groups and stakeholder,
- Mandatory inspections that are enforced,
- Outreach targeted to specific groups,
- Risk assessments to inform program priorities and allocate efforts to the right species, pathways, and locations,
- Readiness to act for rapid response,
- A single piece of legislation with a wide range of prohibitions, and
- Reliable sources of funding, including operational government and user-fee derived funds.

Some jurisdictions, such as Oregon and Idaho, have so far prevented invasion of dreissenid mussels within their borders and have reduced the impact of existing aquatic invasive plants. This provides reassurance that, despite the general perception that invasions cannot be halted, success is possible to a certain degree with an effective AIS program.

5.2 Lessons from Similar Jurisdictions to Alberta – Idaho and Utah

Information from states without marine and Great Lakes influence, Idaho and Utah, may be particularly relevant to Alberta AIS programs, since these jurisdictions share similar geographic conditions, and potentially the same major pathways, vectors and invasion histories as Alberta.

Both Idaho and Utah have well-developed AIS programs, complemented by legislation dedicated to AIS prevention and management. AIS initiatives are coordinated by a single state agency in both jurisdictions, with clear legislative authority and accountability. Advisory groups are an integral part of AIS efforts, ensuring consistent communication and engagement with a diverse range of stakeholders from across each state.

Both Idaho and Utah focus on preventing the invasion of dreissenids, through widespread mandatory and well-enforced inspection and decontamination of watercraft, as well as through extensive public outreach. EDRR systems are in place, with ongoing monitoring in key locations and at key times for early warning of biological invasions that trigger established RR protocols. Idaho further promotes RR preparedness by holding annual drills to test RR plans. Utah has a frequent and regular ED reporting system and an effective communication network, which means that notification is simple, quick and relatively inexpensive. Both states maintain detailed records of AIS interceptions (e.g., Utah tracks boat movements, repeat offenders etc.).

Long-term management of established populations is achieved through containment and control, mainly focused on individual waterbodies, using mechanical, chemical and biological treatment options. Monitoring of established populations is also part of management. In the case of Idaho, presence and

absence data are collected, while in Utah information on the frequency of introduction events, abundance, geographic extent and pattern of spread are also recorded.

Legislation provides an effective framework to support AIS initiatives in both states, and is enforced through strong powers to confiscate, decontaminate and quarantine. In Idaho, dedicated funding for the AIS program is mainly secured through the invasive species sticker program, required for all boats launching in state waters. Utah receives dedicated state funding, as well as funding for individual projects.

To date, both Idaho and Utah have been successful at preventing dreissenid invasions. However, they each acknowledge barriers and areas needing improvement. In particular, Utah believes there should be a greater focus on border monitoring and dealing with existing infestations, as well as increased authority to track individual boats. It also recognizes that public awareness of AIS other than dreissenids, needs to increase. Idaho needs more chemical treatment options, and a prohibition on the overland transport of aquatic plants. Both jurisdictions identify numerous barriers to the success of their AIS programs, including insufficient time, staff and money, and lack of public support and political will,

6. Conclusion

A large number of the reviewed and proven approaches could be useful in an Alberta Strategy to prevent and manage AIS. While the Canadian regulatory context is different from that in the U.S., possibly limiting the adoption of some of the regulatory and enforcement tools in Alberta, our review identified a large number of universally applicable approaches, methods and tools that build an effective AIS program. Learning from experience collected in other places was an essential part of all reviewed jurisdictions' programs; showing that this study is one step in the right direction for Alberta's AIS program.

7. References

7.1 Interviewed Resources

Name	Organization	Jurisdiction
Jeff Brinsmead	Ministry of Natural Resources and Forestry	Ontario
Francine Macdonald	Ministry of Natural Resources and Forestry	Ontario
Thomas Woolf	Dept. of Agriculture	Idaho
Doug Jensen	Sea Grant	Minnesota
Chip Welling	Dept. of Natural Resources	Minnesota
Mark Sytsma	Portland State University	Oregon
Rick Boatner	Fish and Wildlife	Oregon
Justin Bush	Lady Bird Johnson Wildflower Center	Texas
Dr. Earl Chilton	Parks and Wildlife Dept.	Texas
Jordan Nielson	Division of Wildlife Resources	Utah

7.2 Bibliography

Anderson, L. W. J. 2005. California's reaction to *Caulerpa taxifolia*: a model for invasive species rapid response. Biological Invasions 7: 1003-1016.

Boylen, C. W., L. W. Eichler, J. S. Bartkowski and S. M. Shaver. 2006. Use of geographic information systems to monitor and predict non-native aquatic plant dispersal through north-eastern North America. Hydrobiologia 570: 243-248.

Canadian Council of Fisheries and Aquaculture Ministers (CCFAM) Aquatic Invasive Species Task Group. 2004. A Canadian Action Plan to Address the Threat of Aquatic Invasive Species. 26 pp.

Chornesky, E. A. and R. M. Randall. 2003. The threat of invasive alien species to biological diversity: setting a future course. Ann. Missouri Bot. Gard. 90: 67-76.

Colautti, R. I., S. A. Bailey, C. D. A. van Overdijk, K. Amundsen, and H. J. MacIsaac. 2006. Characterised and projected costs of nonindigenous species in Canada. Biological Invasions 8, 45-59.

Crooks, J.A. 2005. Lag times and exotic species: the ecology and management of biological invasions in slow-motion. Écoscience 12:316-329.

Dalrymple, K. E., B. R. Shaw and D. Brossard. 2013. Following the leader: using opinion leaders in environmental strategic communication. Society and Natural Resources 26: 1438-1453.

Delaney, D. G., C. D. Sperling, C. S. Adams and B. Leung. 2008. Marine invasive species: validation of citizen science and implications for national monitoring networks. Biological Invasions 10: 117-128.

Dextrase, A. J. and N. E. Mandrak. 2006. Impacts of alien invasive species on freshwater fauna at risk in Canada. Biological Invasions 8: 13-24.

Dresner, M. and K. A. Fischer. 2013. Environmental stewardship outcomes from year-long invasive species restoration projects in middle school. Invasive Plant Science and Management 6(3): 444-448.

Eiswerth, M. E., S. T. Yen and G. Cornelis van Kooten. 2011. Factors determining awareness and knowledge of aquatic invasive species. Ecological Economics 70: 1672-1679.

Gallardo, B. and D. C. Aldridge. 2013. The 'dirty dozen': socio-economic factors amplify the invasion potential of 12 high-risk aquatic invasive species in Great Britain and Ireland. Journal of Applied Ecology 50(3): 757-766.

Gallo, T. and D. Waitt. 2011. Creating a successful citizen science model to detect and report invasive species. BioScience 61(6): 459-465.

Gertzen, E., O. Familiar and B. Leung. 2008. Quantifying invasion pathways: fish introductions from the aquarium trade. Canadian Journal of Fisheries Aquatic Sciences 65: 1265-1273.

Government of Canada. 2004. An Invasive Alien Species Strategy for Canada. Ottawa, 36 pp.

Green, W. 2006. Sustaining New Zealand's Biodiversity – A Progress Report. 30 pp.

Hellmann, J. J., J. E. Byers, B. G. Bierwagen and J. S. Dukes. 2008. Five potential consequences of climate change for invasive species. Conservation Biology 22 (3): 534-543.

Horan, R. D. and F. Lupi. 2010. The economics of invasive species control and management: the complex road ahead. Resource and Energy Economics 32: 477-482.

Hosler, D. M. 2011. Early detection of dreissenid species: zebra/quagga mussels in water systems. Aquatic Invasions 6(2): 217-222.

Idaho Department of Agriculture, Aquatic Ecosystem Restoration Foundation and Pacific States Marine Fisheries Commission 2012. A Review of the State of Idaho Dreissenid Mussel Prevention and Contingency Plans February 2012.

Invasive Species Council of B. C. 2012. Invasive Species Strategy for British Columbia. 26 pp.

Kelly, D. and J. J. Sullivan. 2010. Life histories, dispersal, invasions, and global change: progress and prospects in New Zealand ecology, 1989-2029. New Zealand Journal of Ecology 34(1): 207-217.

Leung, B., D. M. Lodge, D. Finoff, J. F. Shogren, M. A. Lewis and G. Lamberti. 2002. An ounce of prevention or a pound of cure: bioeconomic risk analysis of invasive species. Proceedings of the Royal Society of London B 269: 2407-2413.

Lodge, D. M., and K. Shrader-Frechette. 2003. Nonindigenous species: ecological explanation, environmental ethics, and public policy. Conservation Biology 17(1): 31-37.

Luque, G. M., C. Bellard, C. Bertelsmeier, E. Bonnaud, P. Genovesi, D. Simberloff and F. Courchamp. 2014. The 100th of the world's worst invasive alien species. Biological Invasions 16: 981-985.

Mack, R. N., D. Simberloff, W. M. Lonsdale, H. Evans, M. Clout and F. A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences and control. Ecological Applications 10: 689-710.

Ministry of Natural Resources (OMNR). 2012. Ontario Invasive Species Strategic Plan. Queen's Printer for Ontario, Toronto, 58 pp.

Modley, M. D. 2008. Aquatic invasive species rapid response planning partnerships in the Lake Champlain basin: bridging international, political, social, and economic gaps. Water SA 34(4): 476-480.

Mooney, H. A. 2001. A global strategy for dealing with alien invasive species. *In* O. T. Sandlund, P. J. Schei and Å. Viken (eds.). Invasive Species and Biodiversity Management. Pp. 407-418. Kluwer Academic Publishers, Netherlands.

Nantel, P. 2002. Predictive ecology for a proactive approach to alien invaders. *In* R. Claudi, P. Nantel and E. Muckle-Jeffs (eds.). Alien Invaders in Canada's waters, wetlands, and forests. Pp. 303-306. Natural Resources Canada, Canadian Forest Service, Science Branch, Ottawa, Ontario, Canada.

Pejchar, L. and H. A. Mooney. 2009. Invasive species, ecosystem services and human well-being. Trends in Ecology and Evolution 24(9): 497-504.

Perrings, C., M. Williamson, E. B. Barbier, D. Delfino, S. Dalmazzone, J. Shogren, P. Simmons, and A. Watkinson. 2002. Biological invasion risks and the public good: an economic perspective. Conservation Ecology 6(1): 1. [online] URL: http://www.consecol.org/vol6/iss1/art1.

Pyšek, P. and D. M. Richardson. 2010. Invasive species, environmental change and management, and health. Annual Review of Environment and Resources 35: 25-55.

Reis Schreck, C., H. Marchange, H. Freitas and E. Marchante. 2013. Public perception of invasive plant species: assessing the impact of workshop activities to promote young students' awareness. International Journal of Science Education 35(4): 690-712.

Ricciardi, A.. 2003. Predicting the impacts of an introduced species from its invasion history: an empirical approach applied to zebra mussel invasions. Freshwater Biology 48: 972-981.

Ricciardi, A. and J. B. Rasmussen. 1998. Predicting the identity and impact of future biological invaders: a priority for aquatic resource management. Canadian Journal of. Fisheries and Aquatic Sciences 55: 1759-1765.

Sala, O. E., F. S. Chapin III, J. J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L. F. Huenneke, R. B. Jackson, A. Kinzig, R. Leemans, D. M. Lodge, H. A. Mooney, M. Oesterheld, N. L. Poff, M. T. Sykes, B. H. Walker, M. Walker and D. H. Wall. 2000. Global biodiversity scenarios for the year 2100. Science 287: 1770-1774.

Shaw, B. R., A. Howell and K. Genskow. 2014. Evaluation of a movie theater advertisement campaign to promote behaviors that prevent spread of aquatic invasive species. Society and Natural Resources 27: 768-776.

Simberloff, D. 2009. We can eliminate invasions or live with them. Successful management projects. Biological Invasions 11 (1): 149-157.

Simberloff, D. J-L. Martin, P. Genovesi, V. Maris, D. A. Wardle, J. Aronson, F. Courchamp, B. Galil, E. García-Berthou, M. Pascal, P. Pyšek, R. Sousa, E. Tabacchi and M. Vilà. 2013. Impacts of

biological invasions: what's what and the way forward. Trends in Ecology and Evolution 28(1): 58-66.

Smith, A. L., D. R. Bazely and N. Yan. 2014. Are legislative frameworks in Canada and Ontario up to the task of addressing invasive alien species? Biological Invasions 16(7): 1325-1344. DOI 10.1007/s10530-013-0585-x.

Stokes, K. E., K. P. O'Neill, W. I. Montgomery, J. T. A. Dick, D. A. Maggs, and R. A. McDonald. 2006. The importance of stakeholder engagement in invasive species management: a cross-jurisdictional perspective in Ireland. Biodiversity and Conservation 15: 2829-2852.

Stronen, A. V. 2002. Impacts on Canadian species at risk from invasive alien species. Canadian Wildlife Service, Environment Canada.

Vander Zanden, M. J., G. J. A. Hansen, S. N. Higgins and M. S. Kornis. 2010. A pound of prevention, plus a pound of cure: early detection and eradication of invasive species in the Laurentian Great Lakes. Journal of Great Lakes Research 36: 199-205.

Waldner, L. S. 2008. The kudzu connection: exploring the link between land use and invasive species. Land Use Policy 25: 399-409.

Warner, K. D. and F. Kinslow. 2011. Manipulating risk communication: value predispositions shape public understandings of invasive species science in Hawaii. Public Understanding of Science 22(2); 203-218.

Appendix B. Regulated Species Lists of Reviewed Jurisdictions

Ontario

B. 1. Species of Fish Regulated under the Ontario Fishery Regulations (possession of these species live is prohibited without a license and use as bait is prohibited)

Common Name	Scientific Name
Ruffe	*Gymnocephalus cernuus*
Grass carp	*Ctenopharyngodon idella*
Bighead carp	*Hypophthalmichthys nobilis*
Silver carp	*Hypophthalmichthys molitrix*
Black carp	*Mylopharyngodon piceus*
Snakehead family	Channidae spp.
Rudd	*Scardinius erythropthalmus*
Round goby	*Neogobius melanostomus*
Tubenose goby	*Proterorhinus marmoratus*

B. 2. Species of Fish Regulated under Ontario's *Fish and Wildlife Conservation Act* (buying or selling of these species live is prohibited without a license).

Common name	Scientific name
Grass carp	*Ctenopharyngodon idella*
Bighead carp	*Hypophthalmichthys nobilis*
Silver carp	*H. molitrix*
Black carp	*Mylopharyngodon piceus*
Snakehead family	Channidae spp.
Round goby	*Neogobius melanostomus*
Tubenose goby	*Proterorhinus marmoratus*

Idaho

B. 3. Aquatic Invasive Species Regulated under Idaho Statute Title 22 Chapter 19 *Idaho Invasive Species Act* and Idaho Administrative Code 02.06.09 Rules Governing Invasive Species (importing, exporting, possessing, purchasing, selling, bartering, distributing, propagating, transporting or introducing these species into or within Idaho prohibited except under permit or under exemptions from permit requirements).

Common name	Scientific name
Aquatic invertebrates	
Zebra mussel	*Dreissena polymorpha*
Quagga mussel	*D. bugensis*
New Zealand mud snail*	*Potamopyrgus antipodarum*
Red claw crayfish	*Cherax quadricarinatus*
Yabby crayfish	*C. albidus/C. destructor*
Marone crayfish	*C. tenuimanus*
Marbled crayfish	*Procambarus marmorkrebs*
Rusty crayfish	*Orconectes rusticus*
Asian clam*	*Corbicula fluminea*
Spiny waterflea	*Bythotrephes cederstroemi*
Fishhook waterflea	*Cercopagis pengoi*
Marmorkrebs	*Procambarus* spp.
Fish	
Green sturgeon	*Acipenser medirostris*
Walking catfish	Claridae spp.
Bowfin	*Amia calva*
Gar	Lepiostidae spp.
Piranhas	*Serrasalmus* spp., *Rosseveltiella* spp., *Pygocentrus* spp.
Rudd	*Scardinus erythropthalmus*
Ide	*Leuciscus idus*
Diploid grass carp	*Ctenopharyngodon idella*
Bighead carp	*Hypopthalmichthys nobilis*
Silver carp	*H. molitrix*
Black carp	*Mylopharyngodeon piceus*
Snakeheads	*Channa* spp., *Parachanna* spp.
Round goby	*Neogobius melanostomas*
Ruffe	*Gymnocephalus cernuus*
Amphibians	
Rough-skinned newt	*Taricha granulose*
Bullfrog*	*Lithobates catesbeianus*

*Species that are exempt from permitting requirements because they were present in parts of the State prior to the adoption of the Rules. Transport of exempt species outside of known established distribution area, however, requires a transport permit.

B. 4. EDRR AIS under Idaho Administrative Rules 02.06.09 Governing Invasive Species (immediately reportable to State; transport of equipment or conveyance containing these species is prohibited without prior decontamination; no equipment or conveyance contaminated with these species can be place into any waterbody or water supply system; precautions should be taken to prevent the introduction and spread of these species via fire-fighting equipment; construction and road-building and maintenance equipment must be free of these species).

Common name	Scientific name
Quagga mussel	*Dreissena bugensis*
Zebra mussel	*D. polymorpha*

Minnesota

B. 5. Aquatic Invasive Species Regulated under Minnesota Statute Chapter 84d Invasive Species and Minnesota Administrative Rules Chapter 6216 Invasive Species (prohibited invasive species may not be possessed, imported, purchased, sold, propagated, transported or introduced without a permit; regulated invasive species may not be introduced without a permit; unlisted nonnative species may not be introduced unless the Commissioner of DNR is notified and has made a classification determination and listed the species as appropriate, and the introduction is allowed under the Statute).

Common name	**Scientific name**
Prohibited invasive species	
Aquatic plants (including wetland species)	
African oxygen weed	*Lagarosiphon major*
Arrowhead	*Sagittaria sagittifolia*
Asian ambulia	*Limnophila sessiliflora*
Brittle naiad	*Najas minor*
Curly-leaf pondweed	*Potamogeton crispus*
Duck-lettuce	*Ottelia alismoides*
Eared watermoss	*Salvinia auriculata*
Eurasian water-milfoil	*Myriophyllum spicatum*
European frog-bit	*Hydrocharis morsus-ranae*
Exotic bur-reed	*Sparganium erectum*
Flowering rush	*Butomus umbellatus*
Hydrilla	*Hydrilla verticillata*
Indian swampweed	*Hygrophila polysperma*
Killer algae	*Caulerpa taxifolia*, Mediterranean strain
Leaf pondweed	*Monochoria hastata*
Melaleuca tree or paperbark tea tree	*Melaleuca quinquenervia*
Miramar weed	*Hygrophila polysperma*
Mosquito fern, water velvet	*Azolla pinnata*
Oval-leafed pondweed	*M. vaginalis*
Purple loosestrife	*Lythrum salicaria, L. virgatum,* or any variety, hybrid or cultivar thereof)
Salvinia (includes giant salivina, eared watermoss)	*Salvinia auriculata, S. biloba, S. herzogii, S. molesta*
Water aloe or water soldiers	*Stratiotes aloides*
Water chestnut	*Trapa natans*
Water hyacinth	*Eichhornia crassipes, E. azurea*
Wetland nightshade	*Solanum tampicense*
Fish	
Amur sleeper	*Perccottus glenii*
Bighead carp	*Hypophthalmichthys nobilis*

Common name	Scientific name
Black carp	*Mylopharyngodon piceus*
Crucian carp	*Carassius carassius*
Eurasian minnow	*Phoxinus phoxinus*
European perch	*Perca fluviatilis*
Grass carp	*Ctenopharyngodon idella*
Largescale silver carp	*H. harmandi*
Northern snakehead fish	*Channa argus*
Oriental weatherfish	*Misgurnus anguillicaudatus*
Prussian carp	*C. gibelio*
Roach	*Rutilus rutius*
Round goby	*Neogobius melanostomus*
Rudd	*Scardinius erythrophthalmus*
Ruffe	*Gymnocephalus cernuus*
Sea lamprey	*Petromyzon marinus*
Silver carp	*H. molitrix*
Stone moroko	*Pseudorasbora parva*
Tubenose goby	*Proterorhinus marmoratus*
Wels catfish	*Siluris glanis*
Western mosquitofish	*Gambusia affinis*
White perch	*Morone americana*
Yabby	*Cherax destructor*
Zander	*Stizostedion lucioperca*
Aquatic invertebrates	
Faucet snail	*Bithynia tentaculata*
New Zealand mud snail	*Potamopyrgus antipodarum*
Quagga mussel	*Dreissena bugensis*
Red swamp crayfish	*Procambarus clarkii*
Zebra mussel	*D.* spp.
Regulated invasive species	
Aquatic plants	
Brazilian waterweed	*Egeria densa*
Carolina fanwort or fanwort	*Cabomba caroliniana*
Chines water spinach	*Ipomoea aquatic*
Parrot's feather	*Myriophyllum aquaticum*
Nonnative waterlilies	*Nymphaea* spp., or any variety , hybrid or cultivar thereof
Yellow iris or yellow flag	*Iris pseudacorus*
Fish	
Alewife	*Alosa pseudoharengus*
Common carp, koi	*Cyprinus carpio*

Common name	**Scientific name**
Goldfish	*C. auratus*
Rainbow smelt	*Osmerus mordax*
Tilapia	*Tilapia, Oneochromis, Sartheradon* spp.
Aquatic invertebrates	
Banded mystery snail	*Viviparus georgianus*
Chinese mystery snail	*Cipangopaludina* spp.
Rusty crayfish	*Orconectes rusticus*
Spiny waterflea	*Bythotrephes longimanus*
Birds	
Mute swan	*Cygnus olor*
Unregulated nonnative species	
Fish	
Atlantic salmon	*Salmo salar*
Brown trout	*S. trutta*
Coho salmon	*Oncorhynchus kisutch*
Chinook salmon	*O. tshawytscha*
Pink salmon	*O. gorbuscha*
Rainbow trout	*O. mykiss*
Subtropical, tropical and saltwater fish, except anadromous species	
Aquatic invertebrates	
Subtropical, tropical and saltwater invertebrates	

Oregon

B. 6. Aquatic Invasive Species Regulated as Prohibited Species under Oregon Administrative Rules Division 56 (may not be imported, possessed, sold, purchased, exchanged or transported in the state without a permit).

Common name	Scientific name
Amphibians	
Tiger salamander	*Ambystoma tigrinum*, all nonnative sub-species
Amphiumas	All species and hybrids
Giant salamanders and hellbenders	Cryptobranchidae, all species and hybrids
American giant salamanders	Dicamptodontidae, all nonnative species and hybrids
Asian salamanders	*Ranodon* spp., all species and hybrids
Shovel-nosed salamander	*Leurognathus marmoratus*
Waterdogs	*Necturus* spp., all species and hybrids
Firebelly newts	*Cynops* spp., all species and hybrids
European mountain or brook salamanders	*Euproctus* spp., all species and hybrids
Caucasus or spine-tailed salamanders	*Mertensiella* spp., all species and hybrids
Red-spotted or eastern newt	*Notophthalmus* spp., *viridescens*
Chinese newts	*Pachytriton* spp., all species and hybrids
Warty newts	*Paramesotriton* spp., all species and hybrids
Ribbed newts	*Pleurodeles* spp., all species and hybrids
Fire salamanders	*Salamandra* spp., all species and hybrids
Roughskin newts	*Taricha rivularis, T. torosa*
Alpine newts	*Triturus* spp., all species and hybrids
Crocodile newts	*Tylotriton* spp., all species and hybrids
Siren salamanders	Sirenidae, all species and hybrids
Fire-bellied toads	*Bombina* spp., all species and hybrids
True toads	*Bufo* spp., all nonnative species and hybrids except *Bufo marinus*
Midwife toads	*Alytes* spp., all species and hybrids
Painted frogs	*Discoglossus* spp., all species and hybrids
Cricket frog	*Acris* spp., all species and hybrids
European tree frog	*Hyla arborea*
Cope's gray tree frog	*H. chrysoscelis*
Green tree frog	*H. cinerea*
Mediterranean tree frog	*H. meridionalis*
Chorus frog	*Pseudacris* spp., all nonnative species and hybrids

Common name	Scientific name
Australian froglets	*Crinia* spp., all species and hybrids
Australian swamp frogs	*Limnodynastes* spp., all species and hybrids
Barred frogs	*Mixophyes* spp., all species and hybrids
Spadefoot toads	Pelobatidae, all nonnative species and hybrids
African clawed frog	*Xenopus* spp., all species and hybrids
African bull frog	*Pyxicephalus* spp., all species and hybrids
Siberian frog	*Rana altaica*
Khabarovsk frog	*R. amurensis*
Crawfish frog	*R. areolata*
Swedish swamp frog	*R. arvalis*
Asian frog	*R. asiatica*
Rio Grande leopard frog	*R. berlandieri*
Plains leopard frog	*R. blairi*
Caucasus frog	*R. camerani*
Inkiapo frog	*R. chensinensis*
Toudaohe frog	*R. chevronta*
Green frog	*R. clamitans*
Spring frog	*R. dalmatina*
Dybowski's frog	*R. dybowskii*
Stream frog	*R. graeca*
Pig frog	*R. grylio*
River frog	*R. heckscheri*
Turkish frog	*R. holtzi*
Iberian frog	*R. iberica*
Agile frog	*R. japonica*
Italian agile frog	*R. latastei*
Kokarit or taipa frog	*R. longicrus*
Brusa frog	*R. macrocnemis*
Nikko frog	*R. ornativentris*
Pickeral frog	*R. palustris*
Mink frog	*R. septentrionalis*
Wood frog	*R. sylvatica*
Tago frog	*R. tagoe*
European common frog	*R. temporaria*
Tsushima frog	*R. tsushimensis*
Carpenter frog	*R. virgatipes*
Reptiles	
Snapping turtle	Chelydridae, all species and hybrids
Chinese pond turtle	*Chinemys* spp., all species and hybrids
Pond turtle	*Clemmys* spp., all nonnative species

Common name	Scientific name
Painted turtle	*Chrysemys* spp., all nonnative sub-species
European pond turtle	*Emys orbicularis*
Blanding's turtle	*Emydoidea blandingii*
Map turtle	*Graptemys* spp., all species and hybrids
Asian pond turtle	*Mauremys* spp., all species and hybrids
Pond slider	*Pseudemys* spp. and *Trachemy* spp., all species and hybrids
Common musk turtle	*Kinosternon odoratum*
Common mud turtle	*K. subrubrum*
North American soft shell	*Apalone* spp., all species and hybrids
African soft shell	*Trionyx triunguis*
Fish	
Bowfin	*Amia calva*
Piranha or caribe	Characidae subfamily Serrasalminae, all species and hybrids except carnivorous species of *Pygocentrus, Serrasalmus* or *Pristobrycon*
Walking catfish	Claridae, all species and hybrids
Oriental weatherfish	*Misgurnus anguillicaudatus*
Ide	*Leuciscus idus*
Rudd	*Scardinius erythropthalmus*
Asian carp	*Hypophthalmichthys* spp., all species and hybrids
Black carp	*Mylopharyngodon piceus*
Gar	Lepisosteidae, all species and hybrids
Snakehead	*Channa* spp., all species and hybrids
Round goby	*Neogobius melanostomus*
Ruffe	*Gymnocephalus cernuus*
Zander or pike-perch	*Sander lucioperca*
Pikes, pickerel, muskellunge	Escocidae, all species and hybrids except tiger muskellunge (*Esox Lucius X E. masquinongy*) in Phillips Reservoir
Aquatic invertebrates	
Asian clam	Corbiculidae, all species
Zebra mussel, quagga mussel	Dreissenidae, all species (whether live or dead)
Japanese oyster drill	*Ceratostoma inornatum*
Chinese mystery snail	*Cipangopaludina chinensis*
Japanese mystery snail	*C. japonica*
Chinese mitten crab	*Eriocheir* spp., all species
Blue crab	*Callinectes sapdius*

B. 7. Aquatic Invasive Species Regulated as Controlled Species under Oregon Administrative Rules Division 56 (specific controls established for each species, subspecies or hybrid when classified).

Common name	Scientific name	Controls
Birds		
Mute swan	*Cygnus olor*	No import; possession, transport, sale, purchase, exchange allowed subject to certain restrictions
Amphibians		
Bullfrog	*Rana catesbeiana*	No import, purchase, sale, barter or exchange of live bullfrogs; no release without a permit
Reptiles		
Crocodiles, alligators, gavials	Crocodylia	Possession, breeding, sale, release and transport regulated
Fish		
Grass carp	*Ctenopharyngodo idella*	May only be released with a permit; may be purchased and imported from approved suppliers if sterile triploids; no propagation or holding for distribution in Oregon
Mozambique tilapia, Nile tilapia, Wami tilapia, blackchin tilapia and hybrids thereof	*Oreochromis mossambicus, O. niloticus, O. urolepsis, Sarotherodon melanotheron*	Possession, propagation, transportation, sale, purchase, exchange and disposition subject to certain restrictions
Barramundi	*Lates calcarifer*	Possession, propagation, transportation, sale, purchase, exchange and disposition subject to certain restrictions
Aquatic invertebrates		
Suminoe oysters	*Crassostrea ariakensis*	May be purchased and imported from outside Oregon (or from other estuaries within the state) for release into estuaries in Oregon with a permit
Pacific oysters	*C. gigas*	
Kumamoto oysters	*C. sikamea*	
Eastern oysters	*C. virginica*	
European flat oysters	*Ostrea edulis*	
Softshell clam	*Mya arenaria*	May be harvested, possessed and sold commercially or harvested and possessed recreationally subject to certain restrictions
Japanese varnish clam	*Nuttalia obscuratai*	
Japanese littleneck clam	*Venerupis philipinnarum*	
Green crabs	*Carcinus maenas*	May be harvested recreationally subject to certain conditions; may not be returned to state waters or taken for commercial purposes
Whiteleg shrimp	*Litopenaeus vannamei*	Possession, propagation, transportation, sale, purchase, exchange and disposition subject to certain restrictions
Crayfish	Cambaridae and Parastacidae, all species	Importation, possession, propagation, transportation, sale, purchase, exchange and disposition subject to certain restrictions

Texas

B. 8. Aquatic Invasive Species Regulated under Texas' Administrative Code Title 31 Part 2 Chapter 57 Subchapter A (possessing, selling, importing, exporting, transporting or propagating prohibited without a permit, and then only for zoological, research, aquaculture [e.g., tilapia] or aquatic weed control [e.g., grass carp] purposes).

Common name	Scientific name
Fish	
Lampreys	Petromyzontidae, all species except *Ichthyomyzon castaneus* and *I. gagei*
Freshwater stingrays	Potamotrygonidae, all species
Arapaima	*Arapaima gigas*
South American pike characoids	*Acestrorhyncus* spp., all species
African tiger fishes	*Hydrocynus* spp., all species
Piranhas	*Catoprion* spp., *Pristobrycon* spp., *Pygocentrus* spp., *Pygopristis* spp. and *Serrasalmus* spp., all species
Payara and vampire tetras	*Hydrolycus* spp., *Rhaphiodon* spp. and *Cynodon* spp/
Dourados	*Salminus* spp., all species
South American tiger fishes	Erythrinidae, all species
South American pike characids	*Ctenolucius* spp., *Boulengerella* spp., all species
African pike and lute fishes	Hepsetidae and Citharinidae, all species
Electric eels	*Electophorus electricus*
Asps	*Aspius* spp., *Pseudoaspius* spp., *Aspillucius* spp., all species and hybrids
Old world breams	*Abramis* spp., *Blicca* spp., *Megalobrama* spp., *Parabramis* spp., all species and hybrids
Bighead and silver carp	*Hypopthalmichthys* spp., all species and hybrids
Black carp	*Mylopharyngodon* spp., all species and hybrids
Grass carp	*Ctenopharyngodon* spp., all species and hybrids
Mud and white carp	*Cirrhinus* spp., all species and hybrids
Sandkhol carp	*Thynnichthys* spp., all species and hybrids
Catla	*Gibelion* spp., all species and hybrids
European daces	*Leuciscus* spp., all species and hybrids
Barbs and mahseers	*Tor* spp. and *Neolissochilus hexiglonolepsis*, all species and hybrids
Roaches	*Rutilis* spp., all species and hybrids
Rudds	*Scardinius* spp., all species and hybrids
Yellowcheek	*Elopichthys* spp., all species and hybrids
Giant barb	*Catlocarpio* spp., all species and hybrids
Labeos	*Labeo* spp., all species and hybrids except *. L. chrysophekadion*
Walking catfishes	Claridae, all species
Electric catfishes	Malapteruridae, all species

Common name	Scientific name
South American parasitic candiru catfishes	Trichomycteridae, all species
Pike killifish	*Belonesox belizanus*
Marine stonefishes	Synanceiidae, all species
Tilapia	*Tilapia* spp., *Oreochromis* spp., and *Sarotherodon* spp., all species
Asian pikeheads	*Luciocephalus* spp., all species
Snakeheads	Channidae, all species
Old world pike-perches	*Sander* spp., all species except *S. canadensis* and *S. vitreus* and hybrids between these two species
Nile perch	*Lates* spp., all species
Seatrouts and corvinas	*Cynoscion* spp., all species except *C. nebulosus, C. nothus,* and *C. arenarius*
Whale catfishes	Cetopsidae, all species
Air sac catfishes	Heteropneustidae, all species
Swamp eels, rice eels, or one-gilled eels	Synbranchidae, all species
Round gobies	*Neogobius* spp., all species
Temperate basses	Moronidae, all species except *Morone saxatilis, M. chrysops, M. mississippiensis*, and hybrids of these three species
Temperate perches	Percichthyidae, all species
Aquatic invertebrates	
Crayfishes	Parastacidae, all species
Mitten crabs	*Eriocheir* spp., all species
Applesnails and giant ram's-horn snails	*Marisa* spp. and *Pomacea* spp., all species except *Pomacea bridgesii*
Zebra mussels	*Dreissena* spp., all species
Penaeid shrimp	*Penaeus* spp., *Litopenaeus* spp., *Farfantepenaeus* spp., *Marsupenaeus* spp., and *Melicertus* spp., all species except *L. setiferus, F. aztecus and F. duorarum*
Oysters	Ostreidae, all species except *Crassostrea virginica* and *Ostrea equestris*
Aquatic plants	
Dotted duckweed	*Landoltia punctata*
Salvinia	*Salvinia* spp., all species
Water hyacinths (floating waterhyacinth and rooted waterhyacinth)	*Eichhornia crassipes* and *E. azurea*
Waterlettuce	*Pistia stratiotes*
Hydrilla	*Hydrilla verticillata*
African elodea	*Lagarosiphon major*
Eurasian water-milfoil	*Myriophyllum spicatum*

Common name	Scientific name
Alligatorweed	*Alternanthera philoxeroides*
Paperbark	*Melaleuca quinquenervia*
Torpedograss	*Panicum repens*
Water spinach (ong choy, rau mong, kangkong)	*Ipomoea aquatic*
Asian marshweed (ambulia)	*Limnophila sessiflora*
Narrowleaf false pickerelweed	*Monochoria hastate*
Heartshaped false pickerelweed	*M. vaginalis*
Duck-lettuce	*Ottelia alismoides*
Wetland nightshade (aquatic soda apple)	*Solanum tampicense*
Exotic bur-reed	*Sparganium erectum*
Brazilian peppertree	*Schinus terebinthifolius*
Purple loosestrife	*Lythrum salicaria*

Utah

B. 9. Aquatic Invasive Species Regulated under Utah Code Title 23 Chapter 27 AIS Interdiction Act and Utah Administrative Code R58-17-13 (no possessing, importing, exporting, shipping, transporting, releasing, placing, or planting of these species; conveyance or equipment that have been in infested waters in the past 30 days may not be transported without decontamination).

Common name	Scientific name
Dreissena mussels	*Dreissena* spp.

B. 10. Aquatic Invasive Species Regulated under Utah Administrative Code R657-3 Classification and Specific Rules for Crustaceans and Mollusks, Classification and Specific Rules for Fish and Classification and Specific Rules for Mammals (prohibited and controlled as detailed in table).

Common name	Scientific name	Prohibitions and controls
Aquatic invertebrates		
Asiatic (mitten) crab	*Eriocheir* spp., all species	Collection, importation, possession prohibited
Brine shrimp	Mysidae, all species	Collection controlled
Crayfish	Astacidae, Cambaridae, and Parastacidae, all species except *Cherax quadricarinatus*	Collection, importation and possession prohibited
Daphnia	*Daphnia lumholtzi*	
Fishhook waterflea	*Cercopagis pengoi*	
Spiny waterflea	*Bythotrephes cederstroemii*	
Dark falsemussel	*Mytilopsis leucophaeta*	
New Zealand mud snail	*Potamopyrgus antipodarum*	
Quagga mussel	*Dreissena bugenses*	
Red-rimmed melania	*Melanoides tuberculatus*	
Zebra mussel	*D. polymorpha*	
All nonnative species and subspecies of crustaceans and mollusks not listed above, excluding ornamental aquatic animal species		
Fish		
Koi	*Cyprinus carpio*	Collection prohibited
All species and subspecies of ornamental aquatic animal species not listed below		Collection prohibited

All nonnative species and subspecies of fish that are not ornamental aquatic animal species and are not listed below		Collection prohibited; importation and possession controlled
Carp	Cyprinidae, all species except koi	Collection, importation and possession prohibited
Catfish (blue, flathead, giant walking catfish, labyrinth, parasitic)	*Ictalurus furcatus*, *Pylodictus olivaris*, Heteropneustidae (all species), Clariidae (all species), Trichomycteridae (all species)	
Herring (alewife and gizzard shad)	*Alosa pseudoharengus*, *Dorosoma cepedianum*	
Killifish	Fundulidae, all species	
Pike killifish	*Belonesox belizanus*	
Minnows (creek chub, emerald shiner, sand shiner)	*Semotilus atromaculatus*, *Notropis athernoides*, *N. stramineus*	
Burbot	*Lota lota*	
White sucker	*Catostomus commersoni*	
White perch	*Morone americana*	
Bowfin	Amiidae, all species	
Bull shark	*Carcharhinus leucas*	
Drum	Sciaenidae, all freshwater species	
Gar	Lepisosteidae, all species	
Jaguar guapote	*Cichlasoma managuense*	
Lamprey	Petromyzontidae, all species	
Mexican tetra	Astyanax mexicanus, except blind form	
Nile perch	*Lates* spp., *Luciolates* spp., all species	
Northern pike	*Esox lucius*	
Piranha	*Serrasalmus* spp., all species	
Round goby	*Neogobius melanostomus*	
Ruffe	*Gymnocephalus cernuus*	
Snakehead	Channidae, all species	
Stickleback	Gasterosteidae, all species	
Stingray	Dasyatidae, all freshwater species	
Swamp eel	Synbranchidae, all species	
Tiger fish or guavinus	*Hoplias malabaricus*	
Tilapia	*Tilapia* spp., *Sarotherodon* spp., all species	
Mammals		
Nutria or coypu	*Myocastor coypus*	Importation prohibited, possession controlled