AIS Management Review for Ontario

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Purpose

- Compile a list of management options for invasive aquatic plants, fishes, and invertebrates
- Use case studies to look at the efficacy of these options
- Use this to identify areas that need to be improved

Invertebrate Case study: Dreissenid Mussels

Management Tactic	**Results**	**Notes**
Manual Removal	Hand Removal: Easier approval process (fewer regulatory permits required); some success found in Lake George (over 20,000 mussels removed by divers)	Highly unlikely that hand harvesting will remove 100% of adults. Given high reproductive output, any missed adults can establish a new population (California Sea Grant 2013)
Chemical Control	Zequanox: In Lake Minnetonka (Minnesota), zequanox was successful in reducing zebra mussel biomass.	More expensive than chemical options such as potash treatment; limited uses in Canada – not applicable for open water treatments (Luoma & Severson 2016)
	Copper Sulphate: Non-target organisms including algae, invertebrates and fish were killed during treatment; highly toxic to aquatic organisms at all trophic levels	Not registered for use in Canada, and unlikely to be registered in the future due to highly toxic impacts to non-target species. (Fernald & Watson 2014)
	Potash: Concentrations of 100mg/L and higher of potassium will lead to mortality in adult zebra mussels.	Only works in a closed system with limited potential for non-target impacts. (Lewis et al 1997)
	Chlorine: Due to large non-target impacts more research is going into a "BioBullet" approach of delievering KCl. Due to the filter feeding activity by mussels they would take up the particles and accumulate them enough to cause lethality.	Would impact other filter feeding species. (Aldridge, Elliott, & Moggridge 2006)
Barriers	Electrical Fields: There is potential that the use of electric fields may lead to decreased colonization of Dreissenid mussels.	Electric fields may allow managers to contain invasive invertebrates in smaller areas to make manual removal more feasible. (nas.er.usgs.gov 2014; Peters, Kreps, and Lodge 2008)

Fishes Case Study: Sea Lamprey, Asian Carps, Eurasian Ruffe, and Round Goby

Management Tactic	**Results**	**Notes**
Manual Removal/ Trapping	Electrofishing and removal of Grass Carp has been effective in the isolated instances of Grass Carp in the Great Lakes. Commercial trawling did not reduce the numbers of ruffe, can not remove enough to eradicate the populations (only takes a pair to continue a populations). Goby's vocalizations can be used to attract females for removal, however the number needs to be increased for the method to be practical.	(GLFC 1992) (State of Michigan n.d.)
Chemosensory Cues (Chemical Alarm Cues)	Alarm Cues: Sea lamprey showed avoidance behaviour when presented with conspecific cues	Flesh from dead lamprey activate an alarm cue in adult lamprey. These chemosensory cues are used to deter adult lamprey from spawning grounds (Imre et al., 2014)
	Sex Pheromones: Attracted Bighead and Silver carps in experimental testing. No synthesized Round Goby pheromone was successful in attracting reproducing females.	Attractants would need to be used within a trapping and removal program to be effective. (Little 2014; State of Michigan n.d.)
Sterile Male Release	Reduced the number of Sea Lamprey larvae in streams (this needs another control, not successful enough on its own)	No longer a common practice – very expensive and less effective than other strategies. (Twohey et al., 2003)

Fishes Case Study: Sea Lamprey, Asian Carps, Eurasian Ruffe, and Round Goby Continued

Barriers	Physical: Completely blocked the spawning migration. Low-head and vertical slot barriers are still very commonly used in Great Lakes tributaries for Sea Lamprey. Native fish are able to navigate over or around the barriers, while lamprey are not.	Various types of barriers have been installed in tributaries to limit access of adult sea lamprey to spawning grounds. (Swink 1999)
	Electrical: Smith-Root downstream-deterrence electrical barrier with voltage gradient up to 5V/cm effective in preventing Round Goby movement in Michigan stream. Chicago Area Waterway electric barriers are critical in the control of Asian carp movement.	(State of Michigan n.d.; Cudmore et al 2012)
Piscicides	TFM: 90% of lamprey are killed, sea lamprey population in the Great Lakes went from 1 million to 80,000 Could be used to treat entire waterbodies for Eurasian Ruffe. Shown to repel ruffe from an area therefore the entire system would have to be treated, increasing the risk of non-target impacts.	Mononitrophenol, 3-trifluoromethyl-4-nitrophenol (TFM) and Bayer 73 are the lampricides used for treatment of Great Lakes tributaries and streams where sea lamprey are known to spawn. Kraker 2012; Dawson, Bills, & Boogaard 1998)
	Bayluscide: Effectively used to control concentrated populations of benthic fish species such as Sea Lamprey and Eurasian Ruffe.	
	Rotenone: Could be used to treat entire waterbodies for invasive fishes. Shown to repel ruffe from an area therefore the entire system would have to be treated, increasing the risk of non-target impacts (1/24 level needed to kill rainbow trout and 1/40 amount needed to kill yellow perch).	Not ideal due to nonspecific targets. (GLFC 1992)
	Antimycin: 1/3 of level that kills yellow perch and rainbow trout need to control Eurasian Ruffe.	(GLFC 1992; Dawson, Bills, & Boogaard 1998)
Predator Stocking	Was not effective with Eurasian Ruffe, Bullheads appear to be the only species that consistently eat ruffe. Predators stocked preferentially fed on their native prey species.	(Minnesota Sea Grant n.d.)

Fishes Case Study: Sea Lamprey Successes

- Lampricide
- Barriers
- Traps
- Pheromone/alarm cues

Emergent Plant Case Study: European Frog-bit, Water Chestnut, and Water Soldier

Management Tactic	**Results**	**Notes**
Mechanical	Hand pulling/raking: Effective for smaller patches but not for large populations. Must be done in spring or early summer (before seeds are produced) and must be continually done until the whole population is eradicated (may take many years). Voyageur Provincial Park has seen a 95% reduction in seed bank after 4 years.	Labour intensive Raking has large impacts on whole ecosystem (Ontario Parks 2013)
	Mechanical harvester: Good for up to 2 meters in depth. In 7 days, two acres of area covered and 192 cubic yards of water soldier removed.	Expensive and could increase the spread of some plants, should be done before mid-summer to lower the risk of spread. (McGowan 2016)
	Shading: Shading the waterbody decreases the water temperature and can effectively remove European frog-bit (70-100% shade) because frog-bit prefers warmer waters. 100% reduction of water soldier.	Reduces all plant life under shade (Zhu et al. 2014) (McGowan 2016)
	Ultrasound: A non-focused 20-kHz sound field frequency could be a management technique for water chestnut, has shown some effectiveness at damaging plant cell tissue.	(Wu & Wu 2006)
Biological control	Grass Carp: Effectively feeds on European Frog-bit	Not legal in Canada, high non-target impacts
	Leaf beetle (*Galerucella bimanica*): Field testing shows preference towards water chestnut over native species. However there is potential for non-specificity.	(Ding et al 2006)

Emergent Plant Case Study: European Frog-bit, Water Chestnut, and Water Soldier Continued

Herbicide	Diquat: Fall applications had greatest success for controlling Water Soldier. No treatments resulted in eradication however it was effective at controlling larger populations. Highly reliant on variability in water temperature, turbidity, hardness, alkalinity, pH and density of plant biomass. Duration of exposure impacts efficacy.	More effective in non-flowing water. Fairly expensive. (Catling et al. 2003) (McGowan 2016)
	Cyanatryn: Useful for European frog-bit in flowing water as it is a slow release granule	(Catling et al. 2003)
	Triclopyr: May be more effective than diquat at controlling European frog-bit as it translocates throughout the plant.	(Madsen, Owens, & Getsinger 1998)
	Imazamox: Used to treat water chestnut in large acreage populations in the Seneca River and the Oswego River.	(Yablonski 2016)

Submergent Plant Case Study: Hydrilla and Eurasian Water Milfoil

Management Tactic	**Results**	**Notes**
Biological Control	Fungal pathogens: Use of a fungal pathogen to decrease EWM saw a reduction of EWM biomass increment levels 90%. The study found it to be more successful when used in addition to herbicides.	(Sorsa, Nordheim & Andrews 1988)
	Milfoil Weevil: Useful in passively controlling low density sites but not a feasible long term eradication solution. May be more effective at controlling hybrid milfoil species.	It is very difficult to rear enough weevils to make a large impact. (Groves *et al.* 2010)
	Grass Carp: Use of sterile triploid Grass Carp is considered one of the most successful methods of control of Hydrilla in the southern United States. Not a feasible solution for aquatic invasive plants in Canada due to legal restrictions of stocking Grass Carp.	
Mechanical	Mechanical removal of submergent invasive plants is only suggested to quickly remove biomass to allow for other management tactics to be successful.	

Submergent Plant Case Study: Hydrilla and Eurasian Water Milfoil Continued

Herbicide Application	Triclopyr: In two instances triclopyr was used to effectively reduce/ eradicate EWM populations; Washington saw a 99% reduction (with an increase in native species biomass)	(Turner, Madsen & Netherland 1997)
	Fluridone: Inhibited growth and reduced biomass at rates of 12, 24 and 48 ug/l in laboratory experiments. 48 ug/l prevented regrowth.	(Netherland, Getsinger & Turner 1993)
	Endothall: Requires 12-72 hours of exposure to be effective but can reduce biomass by ~90%	(Shearer & Nelson 2002)
	Diquat: Non-selective, but studies have found that submersed plants can develop tolerance to Diquat (dependent on species) Hydrilla was fairly unaffected but EWM showed reduction	Skogerboe, Getsinger, & Glomski 2006)
	Flumioxazin: Used in Florida. It is usually mixed with other herbicides and best applied early morning when the PH of the water is lower than 8.0 because this is when it degrades.	(Mudge & Haller 2010)
	Bispyribac-sodium: Requires long exposure times and therefore is only effective in whole lake treatments	(Glomshi & Netherland 2008)
	Imazamox : Effective for control of hydrilla growth; requires long exposure times and is only effective in whole lake treatments to reduce dilution.	(Netherland 2011)

Riparian Plant Case Study: Phragmites

Management Tactic	**Results**	**Notes**
Biological control	Stem-mining moth (*Archanara geminipuncta*): Completing host-range work and petition being prepared to realease *Archanara* spp. in Canada	(Smith 2017, unpublished scoping document)
Mechanical	Mowing: Will not affect root system and may stimulate growth if used alone Cutting must occur several times and for consecutive years to control the plant	Should be conducted in late July/ early August Low cost and minimal expertise needed (OMNRF 2011)
	Compressing or Rolling: Not for use as a standalone method but works well as a pre-treatment before prescribed burns	For use when the plant is dead (OMNRF 2011)
	Prescribed Burning: Not effective on its own, must be used after an herbicide treatment to prevent increased growth	Best used a minimum of two weeks after herbicide treatment and after mowing or rolling (OMNRF 2011)
	Hand Pulling: Ineffective	Very labour intensive and only advisable for small stands when seed pod is not full (OMNRF 2011)
	Flooding: Plant must be cut to as low as possible before flooding occurs, and is only effective when water levels are maintained 1.5m taller than the stand for at least 6 weeks.	Should occur in late summer and can only be used if water level is easily controlled (OMNRF 2011)
	Tarping: Works best when the area of stand is in direct sunlight (allows for heat to kill off the plants as well as lack of sun)	Non-target impacts will be high, the tarping process kills all plant matter and soil biota under the tarp - only use if site remediation is possible. (OMNRF 2011)

Riparian Plant Case Study: Phragmites Continued

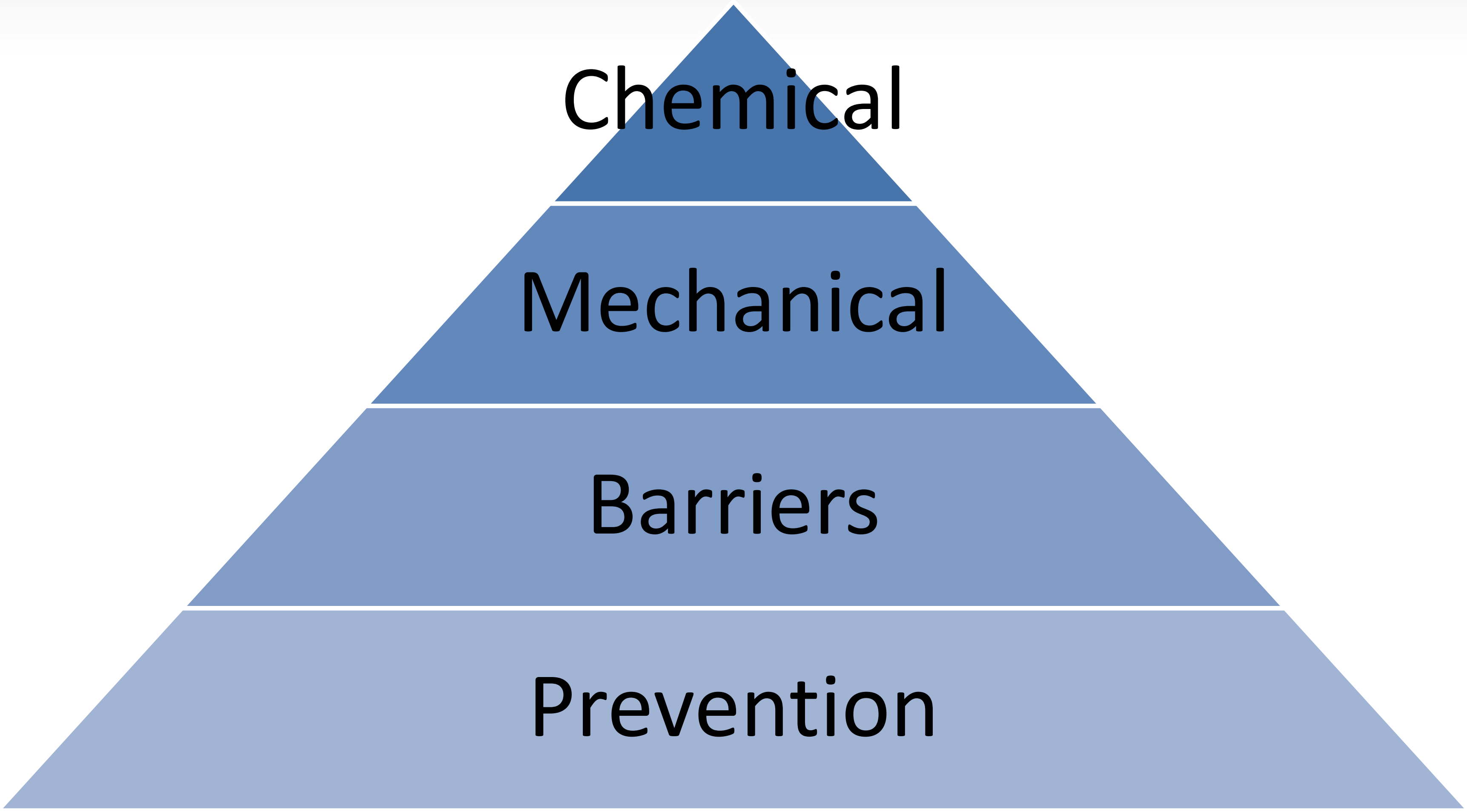
Herbicide Applications	Imazapyr is the most effective	Alternating imazapyr and roundup decreases chance of resistance and can reduce costs Not approved for use overwater, if the population is in a site that can be flooded herbicides are not permitted. (OMNRF 2011)
	WeatherMAX and VisionMAX are herbicides legal for use in Canada against Phragmites (not overwater). Surfactant should be added to increase uptake, treat when plants are 1.5m tall and touched up after 3 weeks.	Plants should be cut and burned after treatment (Collins 2017)
Wet Blade Technology	After mowing, herbicides are applied to the cut stems	(OPWG n.d.)
Herbivore Grazing	Reduces above ground biomass but does not affect root system. May cause an increase in stem density.	Should only be used to cheaply manage a small population to allow for other control methods. (OPWG n.d.)

Riparian Plant Case Study: Phragmites Continued

- Invasive Phragmites Control at Long Point Region and Rondeau Provincial Park
  - Emergency label expansion for Roundup Custom (active ingredient glyphosate)

Ontario Ministry of Natural Resources and Forestry

Integrated Pest Management



Ways to Improve

- Use of Ontario Invasive Species Act
- Emergency label expansion for pesticides/herbicides
- Knowledge of “next new invasive”
- Prevention methods

In partnership with:

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