Evaluating Control of Priority Established Species:
Species- and site-based analysis of control efforts in the Great Lakes region

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Evaluating Control of Priority Established Species: Species- and site-based analysis of control efforts in the Great Lakes region: background

Objectives:

1. Identify priority established invasive animals and status of associated species control tools via literature reviews

2. Assess GLRI site-based control efforts

- what is being controlled where
- what are gaps (e.g. habitats, species) (and why?)

3. Integrate species and site-based assessments to identify species-specific management needs

- Develop decision support tools to identify suppression methods that have the highest probability of success (hence priority for investment)

Governance: Advisory committee building off research committee but ensure greater agency and tribal representation and participation

Objective 1. Identify priority established invasive animals and status of associated species control tools via literature reviews

- Literature reviews completed
- Manuscript on control tools submitted.

Done

Priority species

1. Waterflea (*Daphnia galeata galeata*)
2. Spiny waterflea
3. Fishhook waterflea
4. Bloody red shrimp
5. Golden clam
6. Faucet snail
7. Chinese mystery snail
8. Banded mystery snail
9. New Zealand mudsnail
10. Red swamp crayfish
11. Rusty crayfish
12. Round goby
13. Freshwater tubenose goby
14. Tench
15. Ruffe
16. Western mosquitofish
17. Rudd
18. Common carp
19. Flathead catfish
20. Goldfish

Exclusions:
Existing collaborations or working groups

- *Dreissenid mussels*
- *Phragmites*
- *Invasive carps*
- *Sea lamprey*

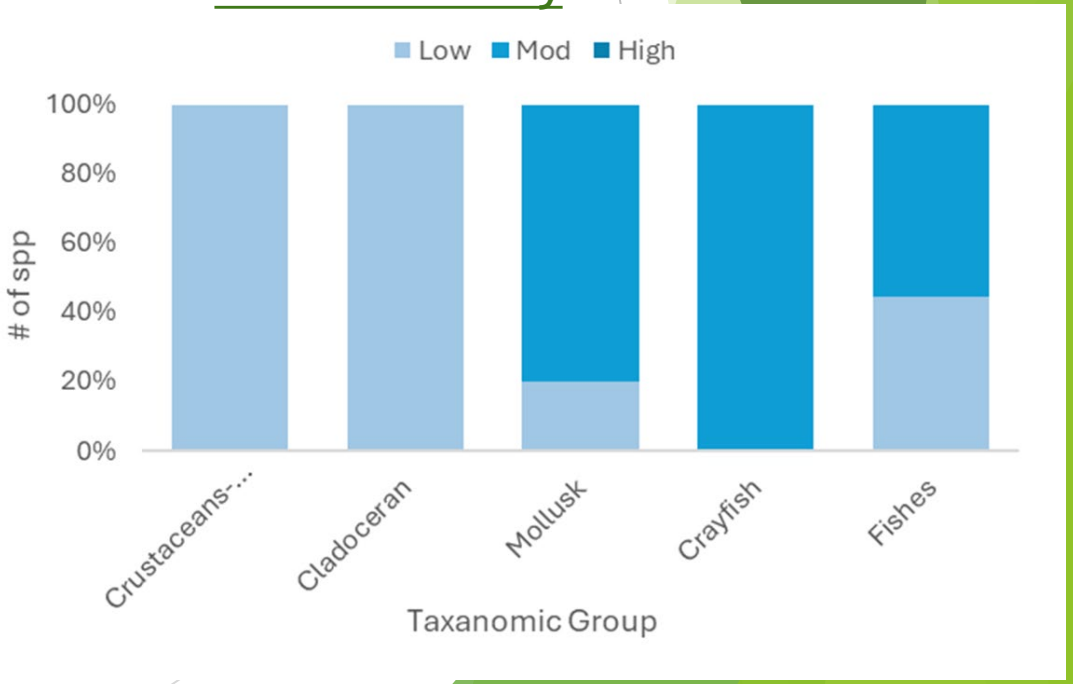
Key conclusions in manuscript

- Define “control” = management strategy taken to reduce or suppress the distribution, abundance, spread, and impacts of an invasive species within a defined geographic area
- Operational control implies the continuous application of any technique used alone or in combination that results in a reduction or alteration of a target population
- Compiled & evaluate operational control tools for 20 priority invasive aquatic animals in the Great Lakes, reviewing mechanical, physical, chemical, and biological methods, and assessing their effectiveness and limitations

We found that

- None of the reviewed species had high availability of control tools
- Species with moderate availability of control tools tended to have higher impact scores and broader distribution.
- Across taxa, eradication is rarely feasible; instead, integrated control studies show that combining multiple tools in a **site-specific**, adaptive framework offers the greatest potential for achieving long-term ecological benefits.

Tool availability



Objective 2: Assess GLRI site-based control efforts

Aim:

- Identify what is being controlled where (using GLRI funded projects)
- Identify any gaps in management efforts (e.g. habitats, species) (and why?)
- Aim was to identify where we want and what we want to manage and if we have the tools to do so effectively?

But

- Effort hampered by data availability, and spatial position of funded projects (GIS project mapper) provided no incites in target habitat types
- Expert elicitation used to identified a set of habitat types where the priority species are present and management desirable

Expert elicitation...
Identifying species x habitat scenarios

- Developed a species habitat matrix
- Experts asked to score and rank species/habitat combinations

Asked:

- Given adequate tools, which species in what habitats would you most like to control?
- Consider which species have the greatest negative impacts - where is the greatest need, which habitats are the most sensitive?
- Assume "*a perfect world*".
- Asked not to consider feasibility or whether tools exist

Additional assumptions

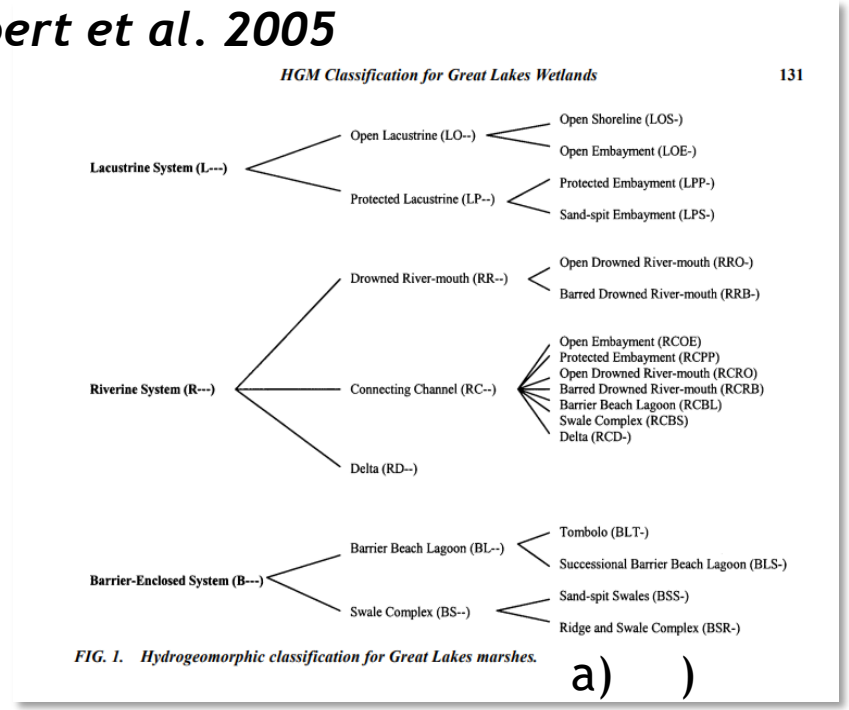
- Assumption is control is desirable (i.e., not doing cost benefit analysis on whether to control, or risk assessment of which species to control)
- Control endpoint: population reduction that provides ecological benefit
- Scale of control: specific habitats (sites) within the basin that are high priority or basin wide scale;
- Information about habitats/scale will informs the potential environmental (and social) constraints on control implementation.
- Information on purpose of management – can help inform the level of necessary suppression.

- Eg: Control rusty crayfish on spawning reefs with the purpose of enhance native fish reproductive success

Expert elicitation

- Habitat list adapted from a classification scheme developed by Albert et al 2005 for GL coastal wetlands
- Developed species x habitat matrix
- Convened two workshops to introduce the species x habitat matrix and solicit expert feedback
- 21 experts polled, representing...
  - states/provinces (13)
  - federal agencies (3)
  - tribal nations (1)
  - NGOs (4)

Albert et al. 2005



Facilitate expert elicitation process to identify regional priority scenarios

(i.e. species x habitat)

Habitat list adapted from a classification scheme developed by Albert et al 2005 for GL coastal wetlands

Whole system		**Offshore** *(pelagic & benthic habitats)*	**Lacustrine system** *(hydrological connection to GL)*		**Riverine** *(flowing water with variable connection to GL)*			**Barrier enclosed system** *(no connection to GL)*	**Finer scale features**	**Other**
Whole Great Lake	**Whole inland lake**	**Open water**	**Protected lacustrine** *(protected embayment)*	**Open Lacustrine** *(open shoreline or open embayment)*	**High gradient** *(fast flowing)* **tributaries**	**Low gradient** *(slow flowing, meandering)* **tributaries**	**Delta**	**Enclosed coastal wetlands/lakes**	**Spawning reefs**	**Slowing the spread:** *Controlling source populations and invasion front*

Species x Habitat Matrix

Species ↓ Habitats →

		Whole system		Offshore (pelagic and benthic habitats)	Lacustrine system (hydrological connection to GL)		Riverine (flowing water with variable connection to GL)			Barrier enclosed system (no connection to GL)	Finer scale features
Scientific name	Common name	Whole Great Lake	Whole inland lake	Open water	Protected lacustrine (protected embayment)	Open Lacustrine (open shoreline or open embayment)	High gradient (fast flowing) tributaries	Low gradient (slow flowing, meandering) tributaries	Delta	Enclosed coastal wetlands/lakes	Spawning reefs
Bythotrephes longimanus	spiny waterflea	9	10	10	0	0					3
Cercopagis pengoi	fishhook waterflea	5	0	0	0	0					
Daphnia lumholtzi	a waterflea	5	0	0	0	0					
Faxonius rusticus	Rusty Crayfish	2	10		3	3	3	10	8	4	8
Procambarus clarkii	Red Swamp Crayfish		4		2	0	0	2	2	3	
Hemimysis anomala	bloody red shrimp	7	0		0	0					0
Gambusia affinis	Western mosquitofis		0		2			0	1	0	
Gymnocephalus cernuus	Ruffe			9	5	5	0	0	10		7
Proterorhinus semilunaris	Freshwater tubenose		0	0	6	1	2	3	6		4
Tinca tinca	Tench		0		0	0		0	0		
Carassius auratus	Goldfish		3		4	3		3	3	5	
Cyprinus carpio	Common Carp	8	6		5	5		6	9	7	
Neogobius melanostomus	Round Goby	5	1	0	7	2	0	4	6		9
Pylodictys olivaris	Flathead Catfish		0	0	0	0		0	0		
Scardinius erythrophthalmus	Rudd		0		0	0		0	0	0	
Bithynia tentaculata	Faucet snail		1		7	0	0	1	5	7	1
Cipangopaludina chinensis	Chinese mystery sna		9		3	0	0	1	3	6	
Corbicula fluminea	Golden clam		3	0	0	0	0	3	0	0	0
Viviparus georgiana	Banded mystery sna		9		3	0	0	1	3	5	0
Potamopyrgus antipodarum	New Zealand mudsn		0		0	0	6	6	0	0	1
										Total Votes	422

Notes: Use this box to record any comments or questions, including whether any other species-habitat combination should have been included, or whether any listed here should be removed. Provide justification for your suggestions.

Results -- Scenarios ranked by weight from expert elicitation (top 20 out of 220)

	A	B	C	D	E
		statement	species	habitat	taxa
1		The 1st ranked combination i	Â Neogobius melanostomusÂ	spawning_reefs	Fishes
2		The 2nd ranked combination	Procambarus clarkiiÂ	whole_inland_lake	Crayfish
3		The 3rd ranked combination	Bythotrephes longimanusÂ	spawning_reefs	Cladoceran
4		The 4th ranked combination i	Faxonius rusticus	spawning_reefs	Crayfish
5		The 5th ranked combination i	Gymnocephalus cernuua	slow_the_spread_control_strategies_to_minimize_range_expansion	Fishes
6		The 6th ranked combination i	Bythotrephes longimanusÂ	open_water	Cladoceran
7		The 7th ranked combination i	Cyprinus carpioÂ	enclosed_coastal_wetlands_lakes	Fishes
8		The 8th ranked combination i	Procambarus clarkiiÂ	protected_lacustrine_protected_embayment	Crayfish
9		The 9th ranked combination i	Faxonius rusticus	slow_the_spread_control_strategies_to_minimize_range_expansion	Crayfish
10		The 10th ranked combinatior	Procambarus clarkiiÂ	slow_the_spread_control_strategies_to_minimize_range_expansion	Crayfish
11		The 11th ranked combinatior	Faxonius rusticus	enclosed_coastal_wetlands_lakes	Crayfish
12		The 12th ranked combinatior	Proterorhinus semilunarisÂ	slow_the_spread_control_strategies_to_minimize_range_expansion	Fishes
13		The 13th ranked combinatior	Faxonius rusticus	protected_lacustrine_protected_embayment	Crayfish
14		The 14th ranked combinatior	Gymnocephalus cernuua	protected_lacustrine_protected_embayment	Fishes
15		The 15th ranked combinatior	Procambarus clarkiiÂ	open_lacustrine_open_shoreline_or_open_embayment	Crayfish
16		The 16th ranked combinatior	Gymnocephalus cernuua	open_lacustrine_open_shoreline_or_open_embayment	Fishes
17		The 17th ranked combinatior	Procambarus clarkiiÂ	enclosed_coastal_wetlands_lakes	Crayfish
18		The 18th ranked combinatior	Faxonius rusticus	whole_inland_lake	Crayfish
19		The 19th ranked combinatior	Â Neogobius melanostomusÂ	protected_lacustrine_protected_embayment	Fishes
20		The 20th ranked combinatior	Faxonius rusticus	open_lacustrine_open_shoreline_or_open_embayment	Crayfish

Results -- Habitat types appearing in the “top 20”

Each habitat in the top 20 by weight :

	habitat	n
	<chr>	<int>
1	enclosed_coastal_wetlands_lakes	3
2	open_lacustrine_open_shoreline_or_open_embayment	3
3	open_water	1
4	protected_lacustrine_protected_embayment	4
5	slow_the_spread_control_strategies_to_minimize_range_expansion	4
6	spawning_reefs	3
7	whole_inland_lake	2

Proposed list of scenarios – for decision framework

1	*Procambarus clarkii*	Whole inland lake Protected lacustrine/protected embayment
2	*Faxonius rusticus*	Whole inland lake Enclosed coastal wetland lakes
3	*Faxonius rusticus*	Protected lacustrine/protected embayment Spawning reefs Open lacustrine/open shoreline/open embayment
4	*Neogobius melanostomus*	Spawning reefs Protected lacustrine/protected embayment
5	*Bythotrephes longimanus*	Open water
6	*Gymnocephalus cernuua*	Protected lacustrine/protected embayment Open lacustrine/open shoreline/open embayment Slow the spread
7	*Cyprinus carpio*	Enclosed coastal wetlands

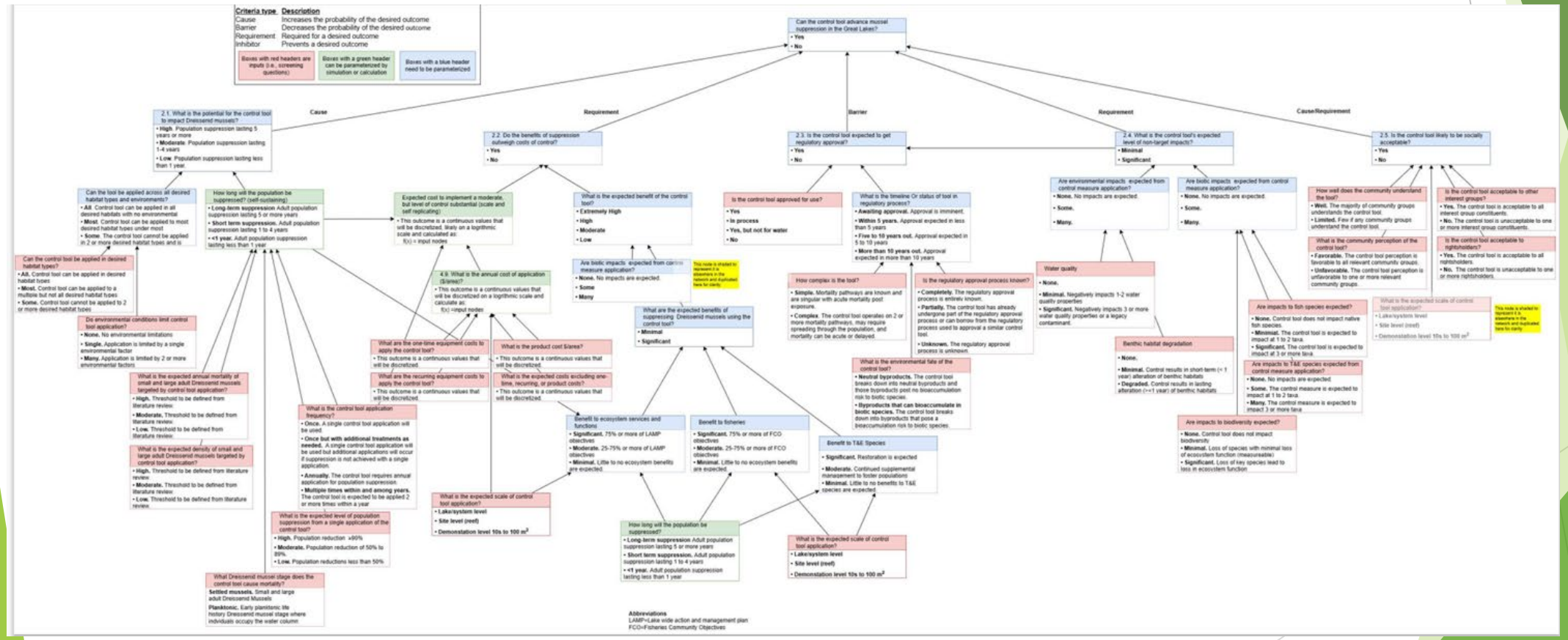
Obj 3... Integrate species & habitats to identify species specific management needs

a) Create a decision framework that identifies relevant evaluation criteria for “operational control” (i.e., requirements and inhibitors)

b) Apply a “pre-screening” process to hone-in on the most relevant control tools to evaluate for each priority scenario

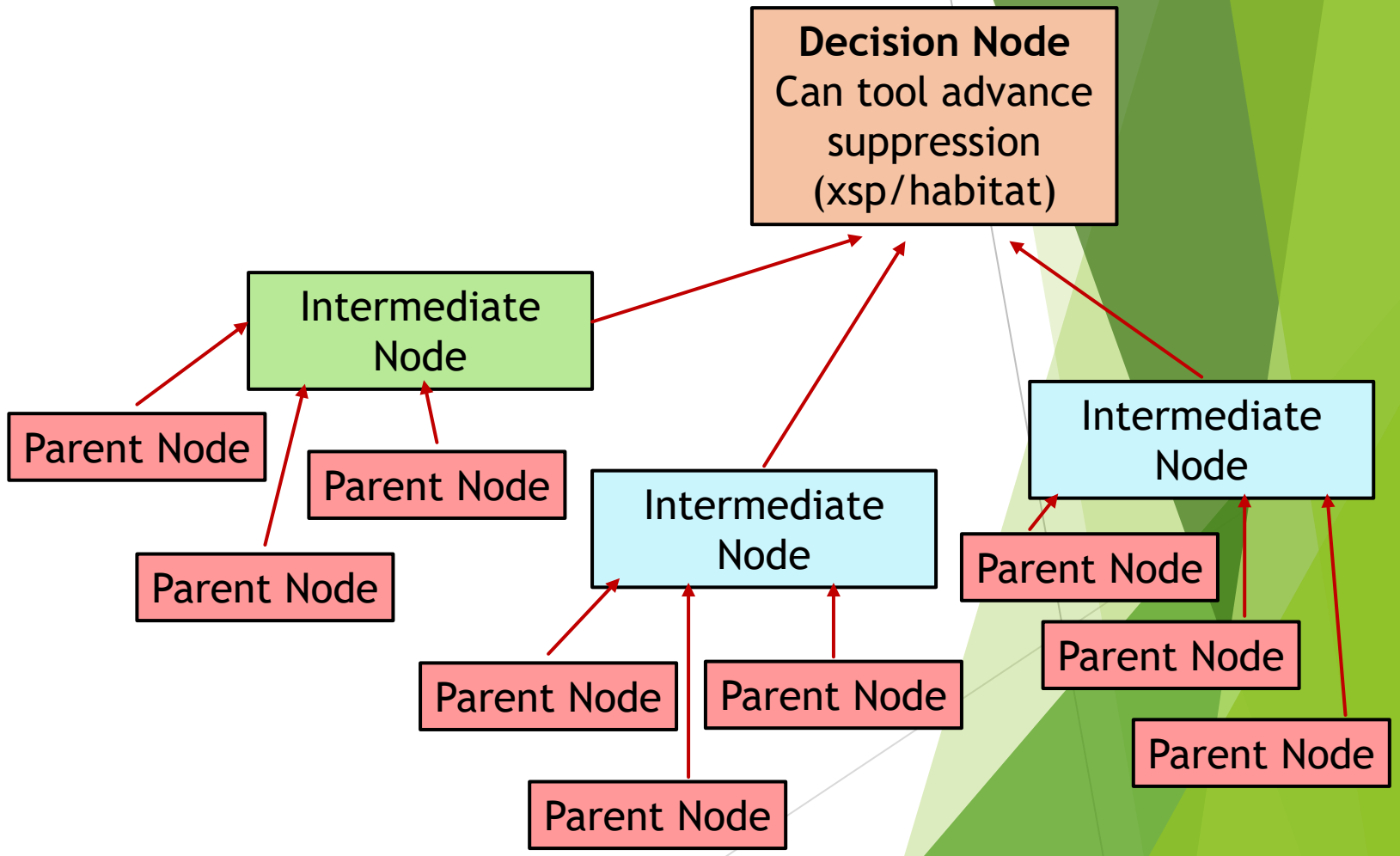
c) Employ the decision framework to identify, for a specific application of a tool, the probability of successful control and key research needs to optimize control (for a particular spp x habitat scenario)

Adapting tool developed for invasive mussel collaborative (Mike Colvin USGS)



The tool - network

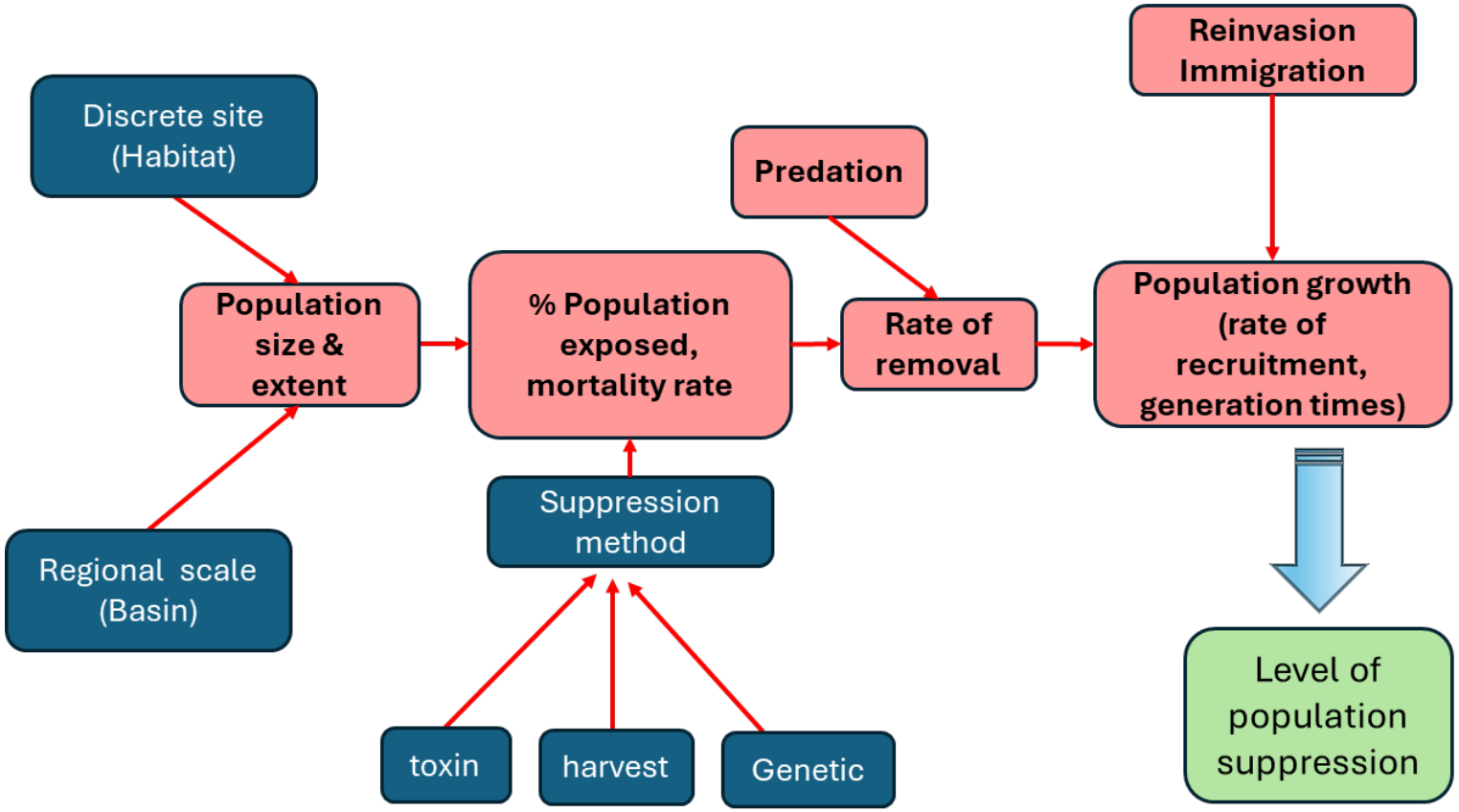
- Decision node: **can the control tool advance suppression of the** “target species” **in** x habitat **in the Great Lakes basin?**
- Parent nodes are elicited
- Intermediate (“child”) nodes are parameterized as a function of parent nodes
  - Mathematical function
  - Conditional probability

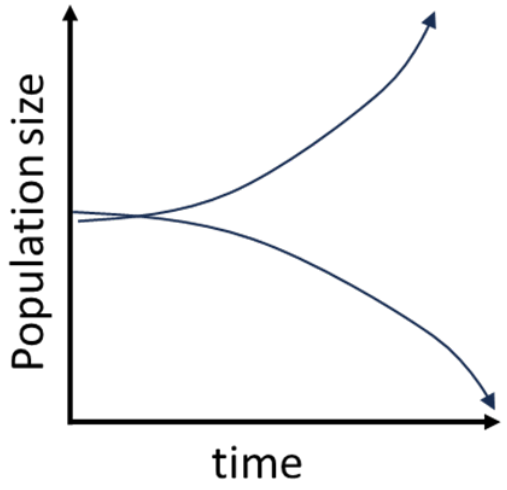


Intermediate nodes

- 2.1 What is the potential for the control tool to impact the target species?
- 2.2 Do the benefits of suppression outweigh the costs?
- 2.3 What is the control tool's expected level of impact on nontarget species?
- 2.4 Is the control tool expected to get regulatory approval?
- 2.5 Is the control tool likely to be socially accepted?

2.1 What is the potential for the control tool to impact <target species>?



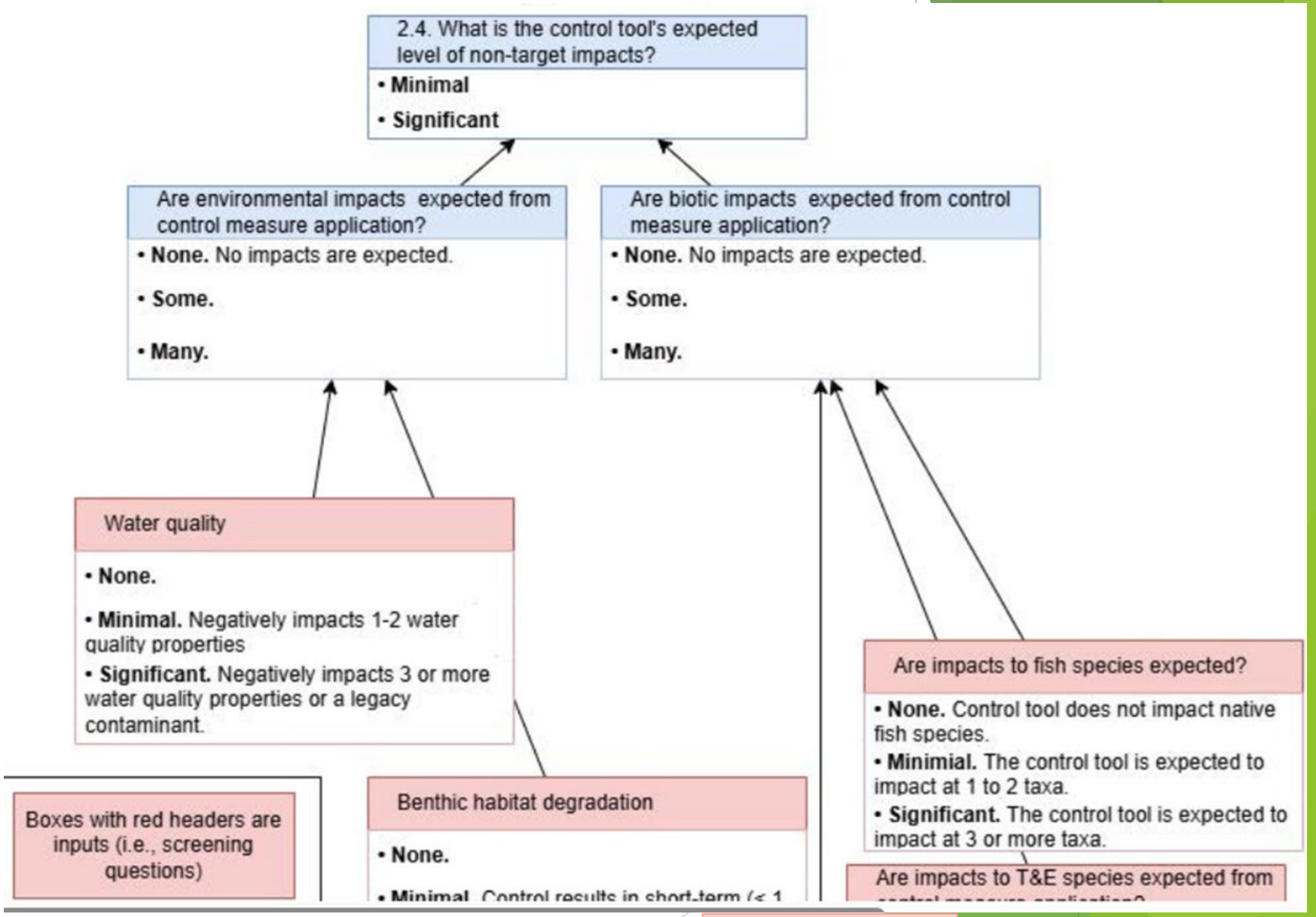


What is the level of population suppression?

(~6 parent input nodes into simple population model)

2.3 What is the control tool's expected level of nontarget impacts?

- 5 input parent nodes



Next steps

- Define parent and intermediate nodes
- Define conditional probability tables using expert elicitation
  - for each of the clusters of parent nodes -> intermediate nodes
  - For intermediate nodes -> decision node
- Elicit inputs on parent nodes from experts for the example control tools we're evaluating
- P(significant nontarget impacts | state parent node)
- P(significant nontarget | fish is high, TNE are min, Biodiversity is 0) =
- 1-(1-0.9)(1-0.4)(1-0)=1-(0.1)(0.6)=result=0.94

Parent	No impact	Minimal impact	High impact
Fisheries sp.	0	0.3	0.9
TNE species	0	0.4	0.8
Biodiversity	0	0.2	0.9

Prescreen control strategies vs species/habitat scenarios

- 1. -- the control tool (when used alone) will have no effect on target populations, is not applicable for the species of interest or can not target majority of target population)
- 1 (b)- the rate of reinvasion would rapidly negate any suppression achieved through control actions negating any effects on target species population.
- 2 -- the cost to implement control is prohibitive (i.e., outweighs benefits)
- 3 -- the control tool is unlikely to receive regulatory approval
- 4 -- the control tool will have unacceptable non-target impacts
- 5 -- the control tool is socially unacceptable

Next Steps: Expert review of an initial prescreen

		piscicide	molluscicide	insecticide	natural biocide	sensory-based barriers	physical barriers	hand harvest/trapping	mechanical harvest	water quality	drawdowns	heating/freezing	gene technology -- RNAi	gene technology -- inherited	predation	pest/pathogen
		chemical				mechanical/physical							biological			
P clarkii	**Whole inland lake Protected embayment**	1	1	2,4,5	rapid breakdown & targeted delivery	1	1	2	2	3,4,5	3,4,5	3,4,5	?	x	1	x
F rusticus	**Whole inland lake Enclosed coastal wetlands**	1	1	2,4,5	rapid breakdown & targeted delivery	1	1	2	2	3,4,5	3,4,5	3,4,5	?	x	1	x
F rusticus	**Protected embayment Spawning reefs Open shoreline/open embayment**	1	1	2,4,5	rapid breakdown & bait or targeted delivery, CO2	1	1	1,2	1,2	3,4,5	3,4,5	3,4,5	?	x	1	x
N melanostomus	**Spawning reefs Protected embayment**	delivered as bait	1	1	delivered as bait	1	1	x	gobinator	3,4,5	3,4,5	3,4,5	?	x	x	x

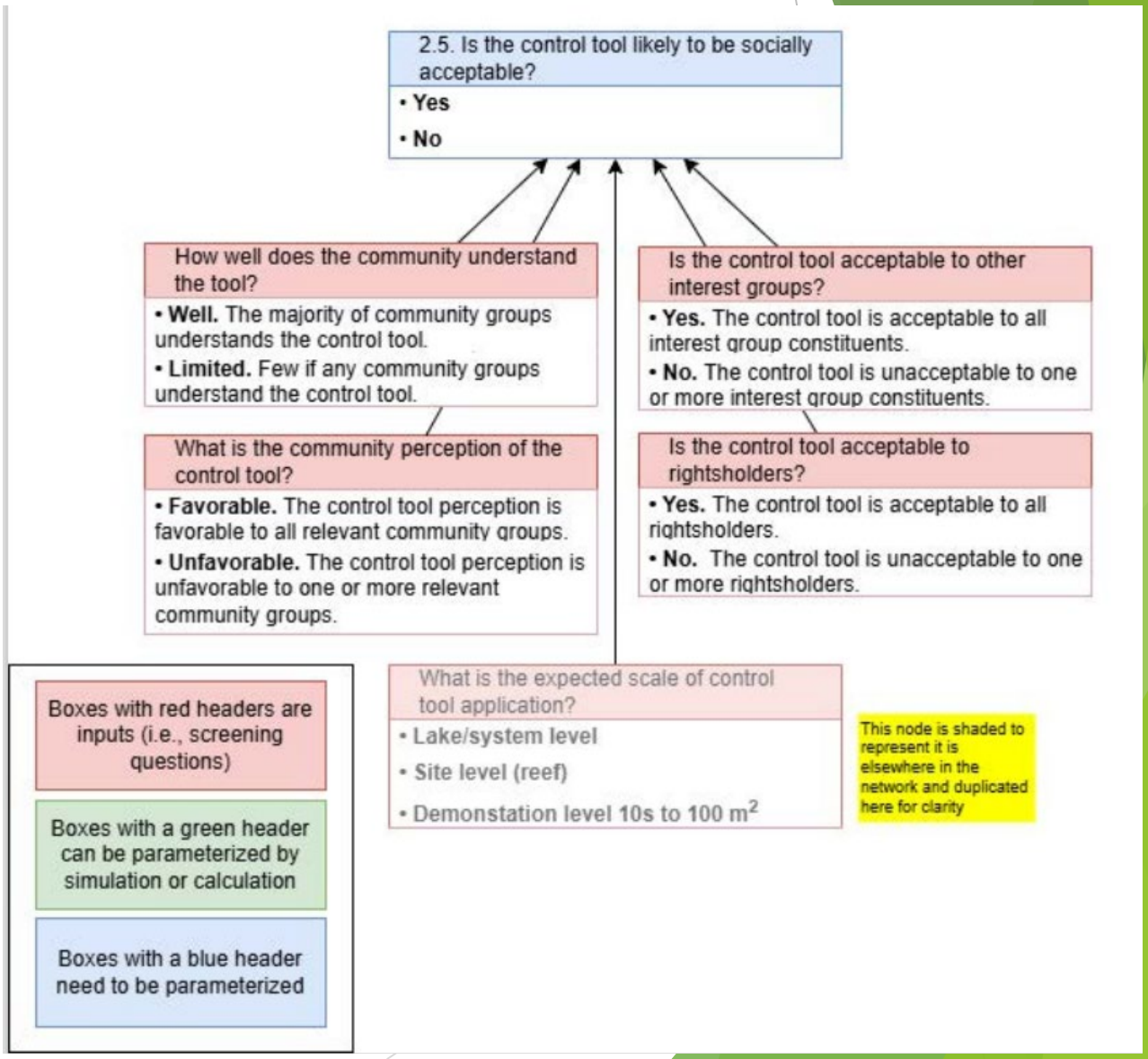
Questions

Cross walk control strategies vs species/habitat scenarios

- **Chemical control options**
  - Acute that kill
  - Chronic chemicals that reduce viability
- Piscicides
  - Antimycin
  - Rotenone
  - Niclosamide
- Molluscicides (oxidizing, copper)
- Insecticides
  - Pyrethrum
- **Physical and mechanical control options**
  - Barriers (general)
  - Sensory-based barriers (e.g., acoustic, stroboscopic, electric)
  - Physical barriers
  - Hand harvest
  - Mechanical harvest/removal
  - Water quality
  - Drawdowns/flooding
  - Other: heating/freezing
- **Genetic options**
- **Biological options**
  - Predation
  - Pest/pathogen
  - Pheromone
- **Environmental options**
  - Site restoration/modification

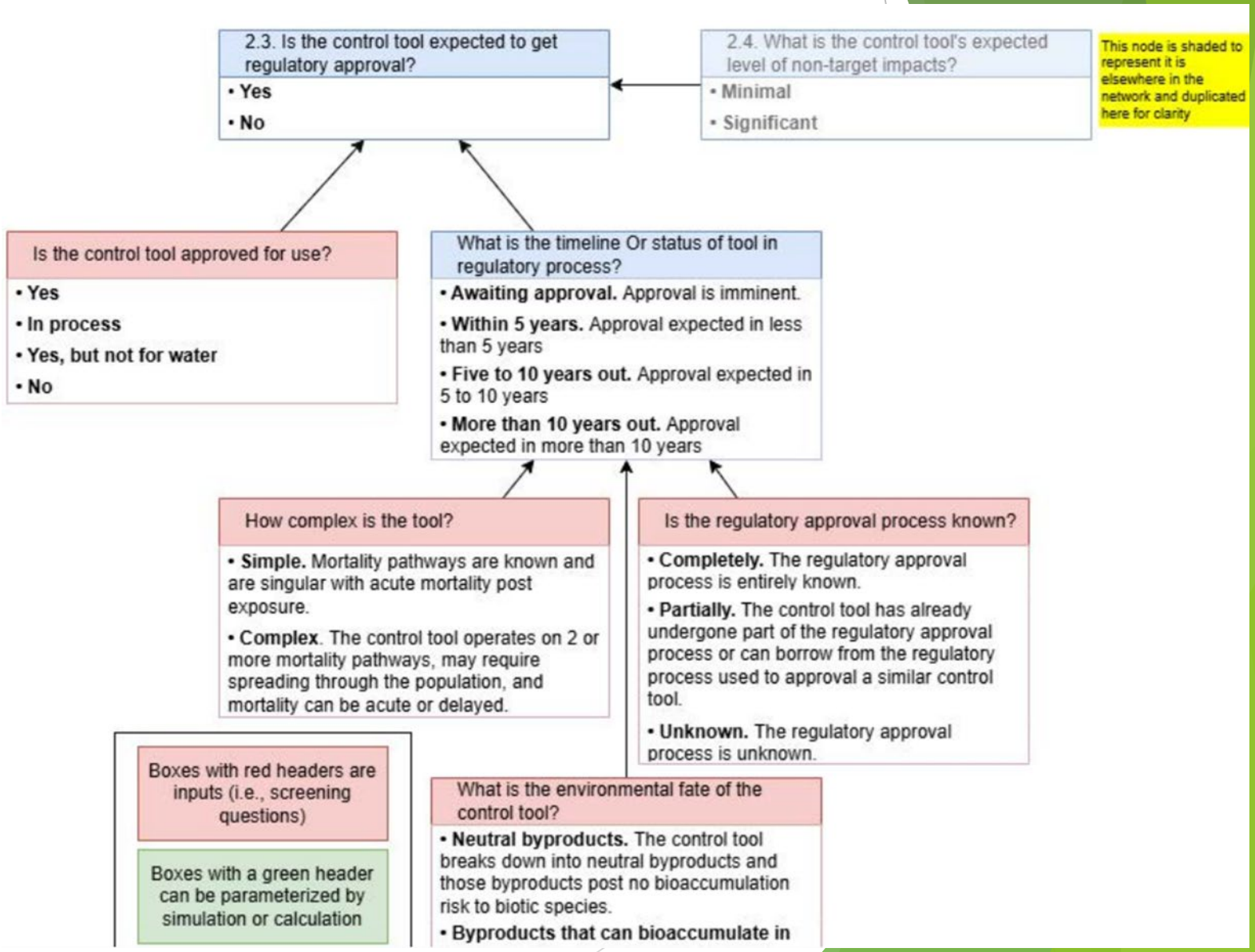
2.5 Is the control tool likely to be socially acceptable?

- 5 parent input nodes



2.4 Is the control tool expected to get regulatory approval?

- 3 parent input nodes into CPT
- Is the control tool approved for use?



2.2 Do the benefits of suppression outweigh the costs?

- What is the expected cost to implement a moderate level of control?
  - Annual cost of application (5 parent input nodes into cost model)
  - Duration of suppression (elicited in another node)

- What is the expected benefit of the control tool?
  - Nontarget impacts (elicited in another node)
  - What are the expected benefits of suppressing <target species> (5 parent input nodes into conditional probability table

Priority species

1. Faucet snail
2. Spiny waterflea
3. Fishhook waterflea
4. Golden clam
5. Round goby
6. Red swamp crayfish
7. Waterflea (*Daphnia galeata galeata*)
8. Chinese mystery snail
9. Banded mystery snail
10. Freshwater tubenose goby
11. Redbreast sunfish
12. Tench
13. Ruffe
14. Western mosquitofish
15. New Zealand mudsnail
16. Rudd
17. Rusty crayfish
18. Common carp
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