Environmental DNA works, now what?

Adam Sepulveda USGS Northern Rocky Mountain Science Center

Katherine O'Donnell USGS Wetlands and Aquatic Research Science Center

David Smith USGS Eastern Ecological Science Center

U.S. Department of the Interior
U.S. Geological Survey

Outline

≋USGS

I. Decision-Making When You Don't Have All the Facts

≋USGS

Superbowl: Seahawks vs Patriots

‘Worst play-call in Super Bowl history’ will forever alter perception of Seahawks, Patriots

By Mark Maske
Reporter

Feb. 2, 2015 at 7:41 a.m. MST

Ads by Google

Stop seeing this ad

- Seahawks were one yard from sealing a Super Bowl victory late in game
- Instead of running ball, Seahawks called pass play that backfired badly
- Decision has been decried on social media was worst play call in history

- 26 sec left
- 2nd down
- 1-yard line

Annie Duke
Thinking in Bets: Making Smarter Decisions When you Don't Have All the Facts

Malcolm Butler of the New England Patriots intercepts a pass intended for Ricardo Lockette late in the fourth quarter of Super Bowl XLIX. Photograph: Timothy A. Clary/AFP/Getty Images

USGS

Was it a bad decision?

- **Probability of interception = 2%**

- **Same decision, different outcome…**
  - **Seahawks win Super Bowl, best play ever!**

- **Bad outcome ≠ Bad decision**

- **Bad decision can result in good outcome (dumb luck)**
  - **Decision: Drinking & driving**
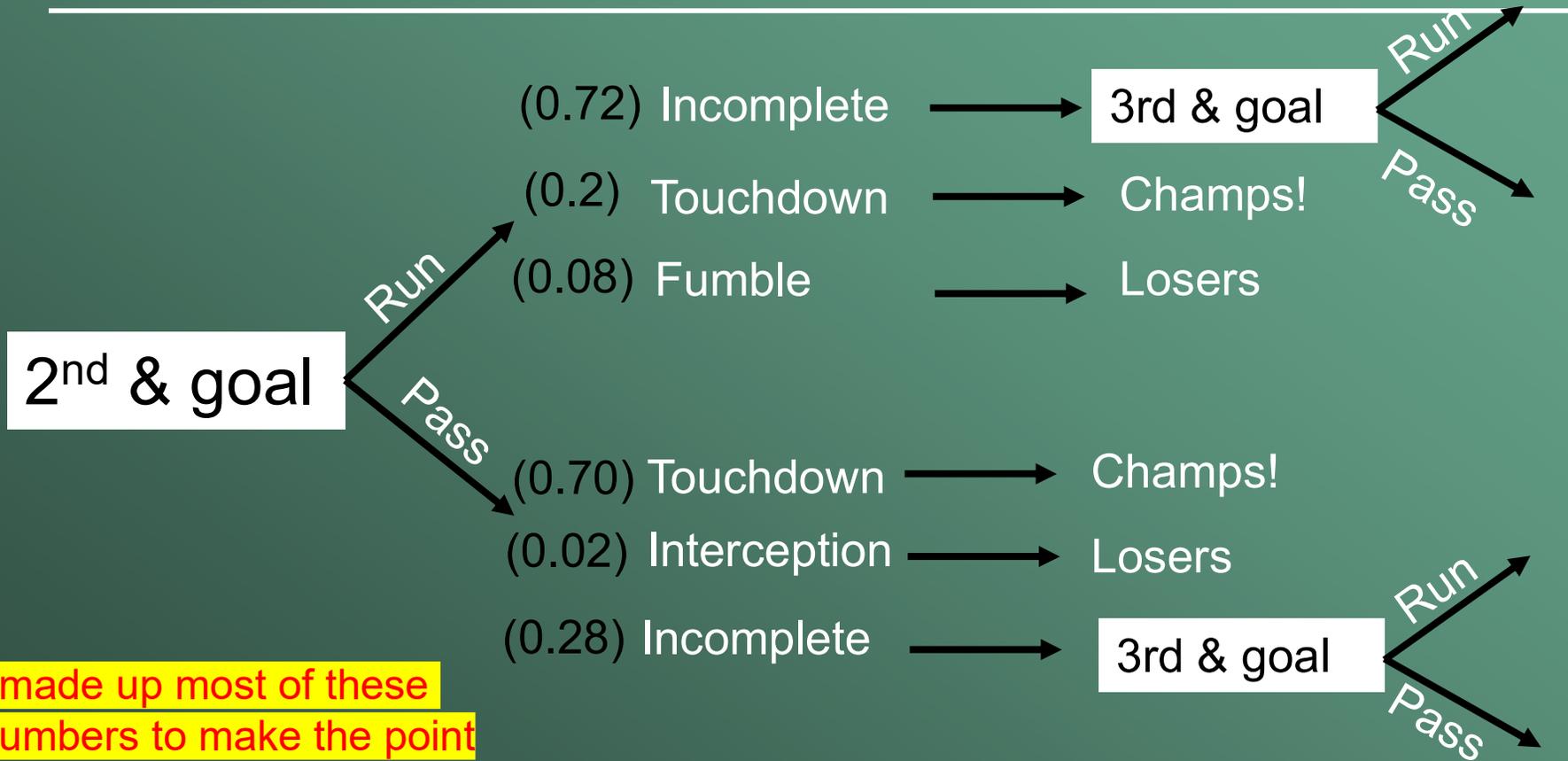 - **Outcome: Making it home safely**

≋USGS

What is a good decision?

- **Process** to make educated guess
  - Desired outcome
  - Alternatives
  - Probabilities of outcome given alternatives

- **Process** increases odds of good outcome when you don't have all the facts
  - Poker, not chess!

≋ **USGS**

Seahawks decision process

(0.72) Incomplete → 3rd & goal *Run / Pass*

(0.2) Touchdown → Champs!

(0.08) Fumble → Losers

2nd & goal

Run

Pass

(0.70) Touchdown → Champs!

(0.02) Interception → Losers

(0.28) Incomplete → 3rd & goal *Run / Pass*

Decision	Upside	Downside
Run	0.92	0.08
Pass	0.98	0.02

≋USGS

II. Uncertainty in environmental (e)DNA & invasions
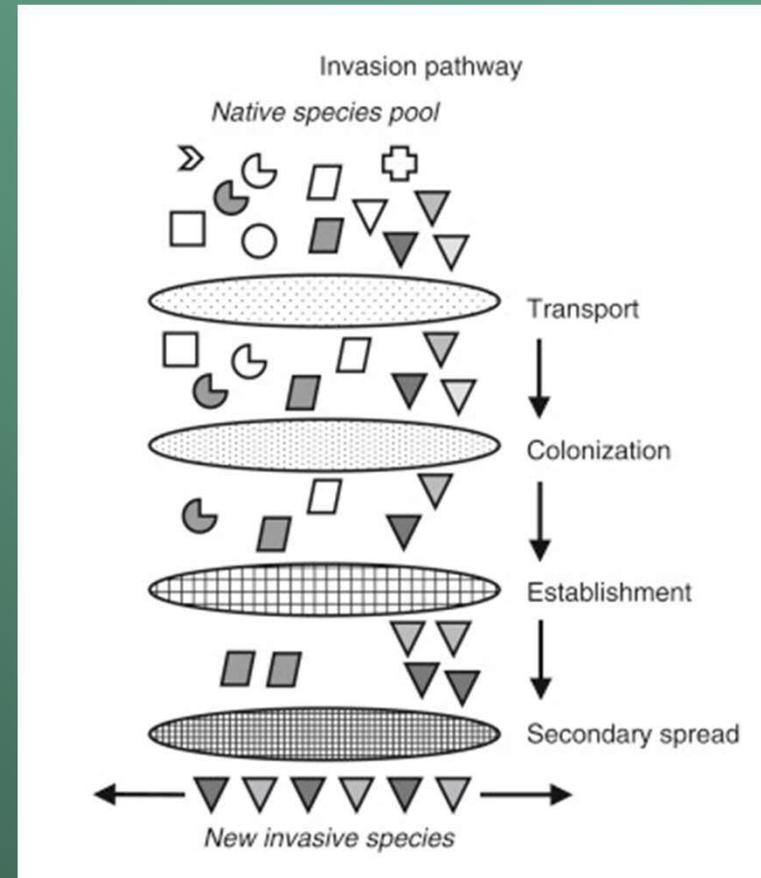
USGS

eDNA sampling

- **Highly sensitive**
  - **Only detects DNA**

- **Outcome uncertainty**
  - **eDNA often indicates species presence**
  - **But not always**
    - **Space-time mismatch**

Photo: USGS

USGS

Invasion process

- **Most introductions fail**

- **Outcome uncertainty**
  - **Failed introductions**
  - **Boom-bust**

Invasion pathway

Native species pool

Transport

Colonization

Establishment

Secondary spread

New invasive species

Sorte 2016

USGS

Decision problem

- **Given uncertainty, what rapid response actions should managers take after early detections?**
  - **Focus: eDNA sampling**
  - **Generalizable: all methods**

≋USGS

III. Quagga/Zebra mussels & eDNA
Jordanelle Reservoir, Utah

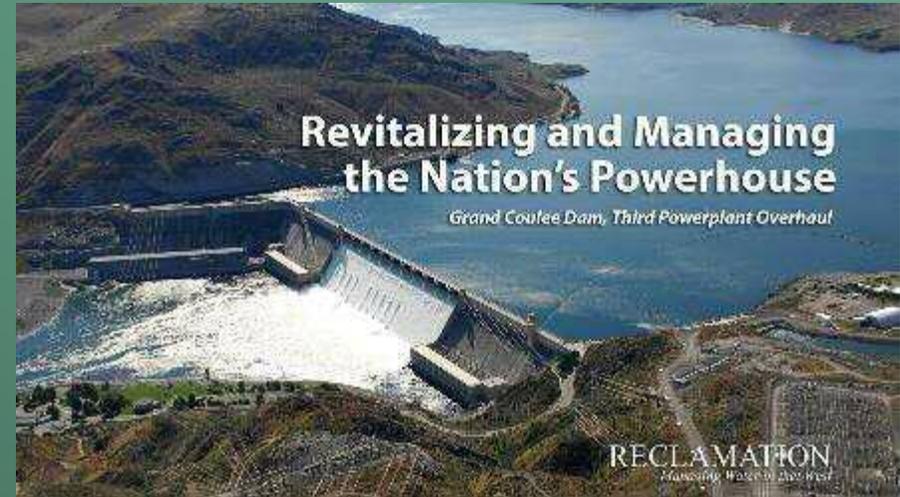# QZ mussels are costly problem

Table 1. Summary of Potential Damage Costs for Dreissenid Mussels Statewide

Stakeholder Group	Montana	
	Lower Bound	Upper Bound
Annual Costs		
Mitigation Costs		
Irrigation	$29,250,000	$60,499,000
Hydropower	$10,431,000	$25,325,000
Recreational Boating	$13,951,000	$13,951,000
Thermoelectric Power	$7,930,000	$8,272,000
Public Supply	$7,397,000	$7,716,000
Self-Supply Domestic	$550,000	$3,004,000
Mining	$2,170,000	$2,264,000
Industrial	$476,000	$497,000
Livestock	$93,000	$193,000
Aquaculture	$159,000	$166,000
Mitigation Cost Total	**$72,407,000**	**$121,887,000**
Lost Revenue		
Tourism	$17,800,000	$89,001,000
Recreational Fishing	$3,867,000	$19,337,000
Property Tax Revenue	$2,190,000	$3,776,000
Lost Revenue Total	**$23,857,000**	**$112,114,000**
Total Mitigation + Lost Revenue	**$96,264,000**	**$234,001,000**
One-Time Investment Loss		
Private Property [1]		
Property Value Loss Total	**$288,498,000**	**$497,410,000**

[1] Does not include the potential loss in value to irrigated farmland.

Nelson 2019

Revitalizing and Managing the Nation's Powerhouse

Grand Coulee Dam, Third Powerplant Overhaul

RECLAMATION
Managing Water in the West

USGS

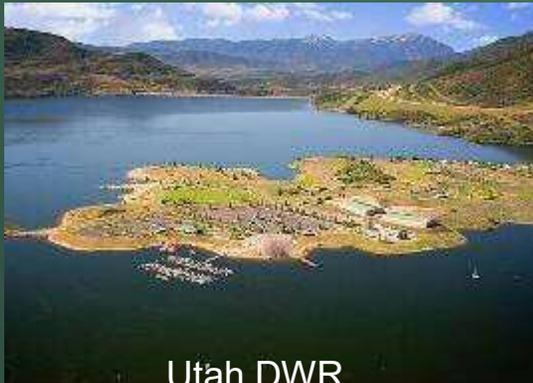# Jordanelle Reservoir (mussel-free)

Utah DWR

Dam
- Hydropower
- Water storage
- Water delivery

Utah DWR

Large reservoir
- EDRR difficult & costly

Google maps

Recreation & Municipal water
- Salt Lake City

Large potential costs to any action

State agency eDNA monitoring

- **Utah Dep. Wildlife Resources**
  - **Starting eDNA early detection program**

- **Pro-active, not reactive**
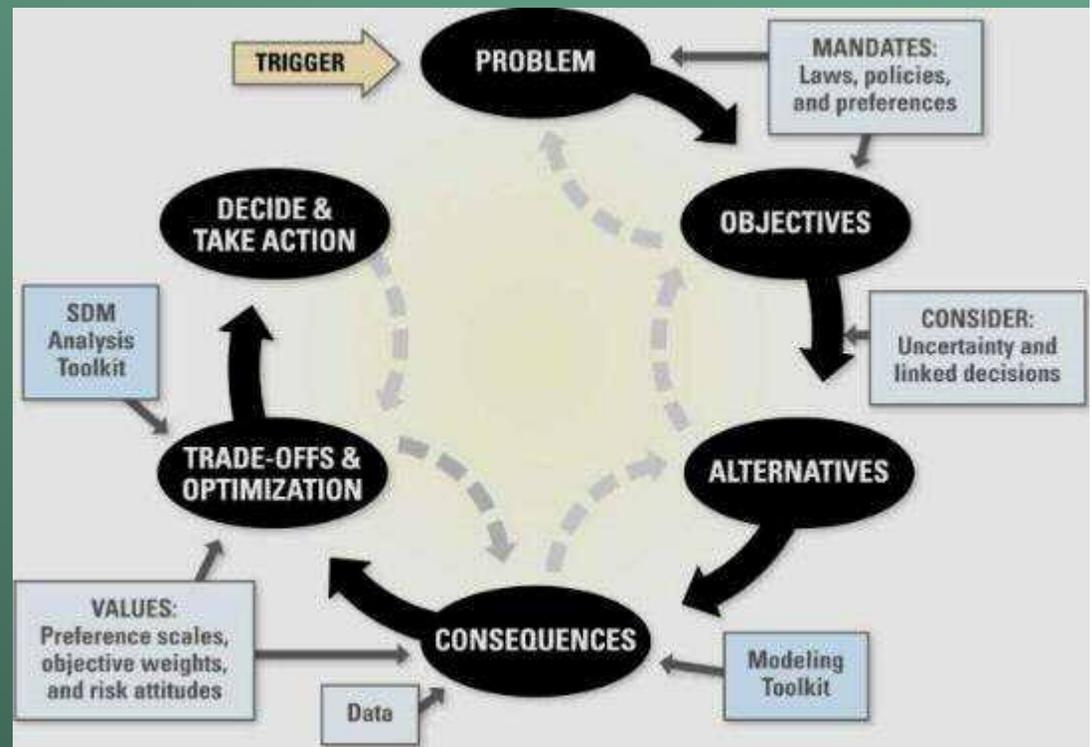 - **Identify actions given eDNA detections**

- **Decision process template**

≋USGS

IV. Decision model

Structured decision making

Decision-maker &
stakeholder driven

- Utah Division of Wildlife
  Resources & State Parks
- Central Utah Water
  Conservation District
- US Bureau of
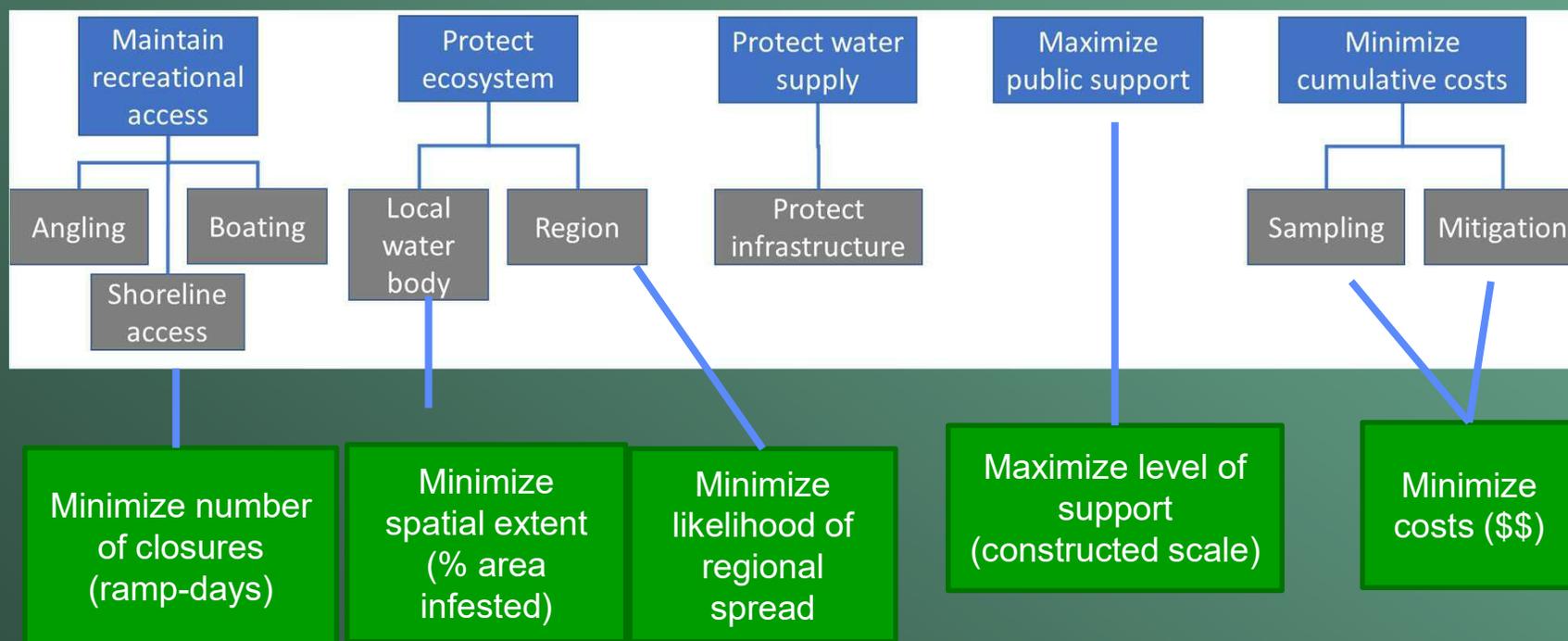 Reclamation

USGS

Problem statement

- **What are appropriate actions to take following >1 eDNA detections of QZ mussel DNA at Jordanelle?**

  - **Immediate (weeks)**
  - **Long-term (months to 8 years)**
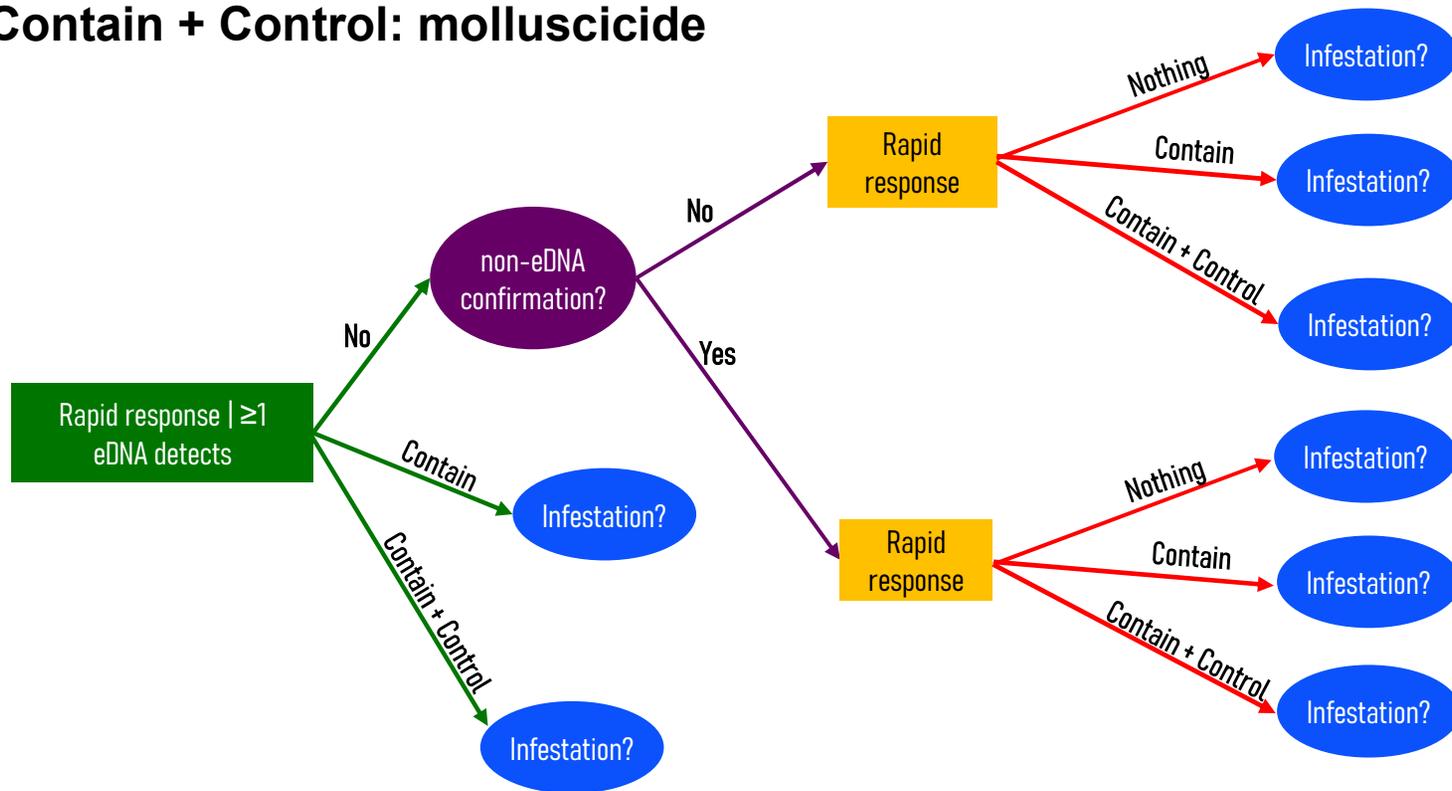
≋USGS

Objectives

Desired outcomes of decision
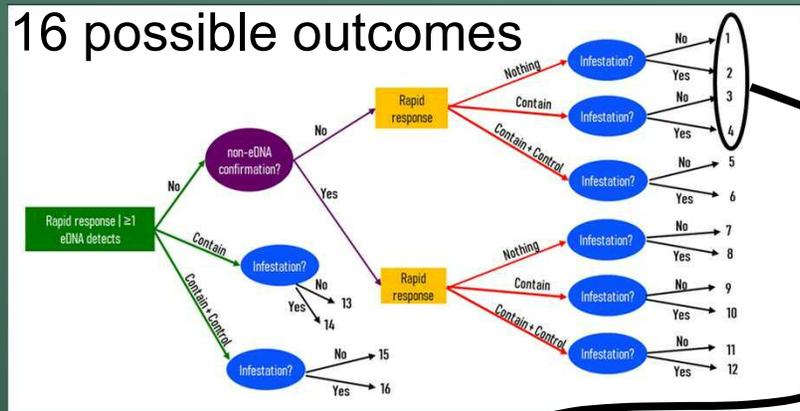
Alternatives

Contain: watercraft inspection stations
Contain + Control: molluscicide

Consequences

16 possible outcomes

Likely outcome for objective attributes = score
- empirical
- modeled
- literature
- expert opinion

Outcomes →
Objectives

Branch	Protect water supply	Protect ecosystem		Maintain recreation	Maximize public support	Minimize costs	
	Mandate to meet demand	Spatial extent of the infestation in Jordanelle	Spread outside of Jordanelle	Number of closures	Level of support	Infrastructure retrofit costs	RR management & sampling costs
	% required supply delivered	% area infested	Utility	ramp-days	5 point scale	dollars (thousands)	dollars (thousands)
1	100	0	0.01	0	3	450	40
2	100	40	0.01	0	1	450	40
3	100	0	0.29	1077	4	450	2016
4	100	40	0.01	1077	2	450	2016

≈USGS

Tradeoffs & Optimize

Branch	Protect water supply	Protect ecosystem		Maintain recreation	Maximize public support	Minimize costs	
	Mandate to meet demand	Spatial extent of the infestation in Jordanelle	Spread outside of Jordanelle	Number of closures	Level of support	Infrastructure retrofit costs	RR management & sampling costs
	% required supply delivered	% area infested	Utility	ramp-days	5 point scale	dollars (thousands)	dollars (thousands)
1	100	0	0.01	0	3	450	40
2	100	40	0.01	0	1	450	40
3	100	0	0.29	1077	4	450	2016
4	100	40	0.01	1077	2	450	2016

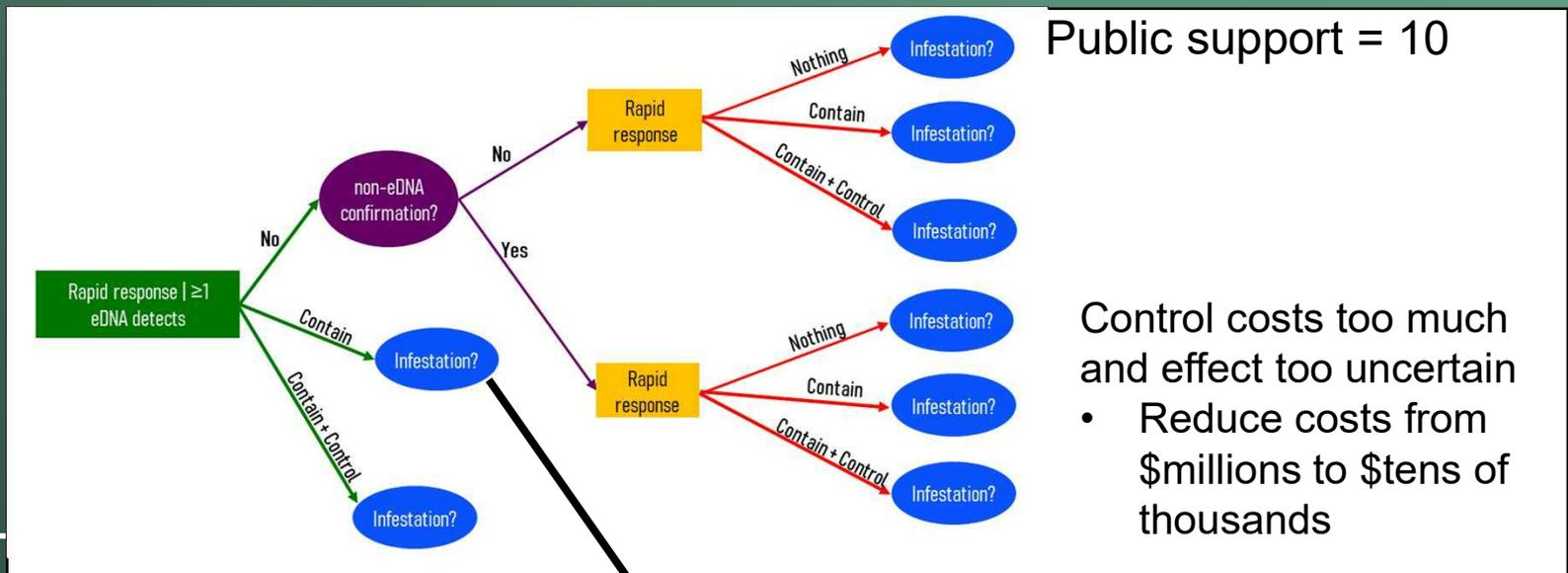## Reduce likelihood of QZ mussel spread to other lakes

- Close ramps → less recreation
- Watercraft inspection → lower public support

Tradeoffs & Optimize

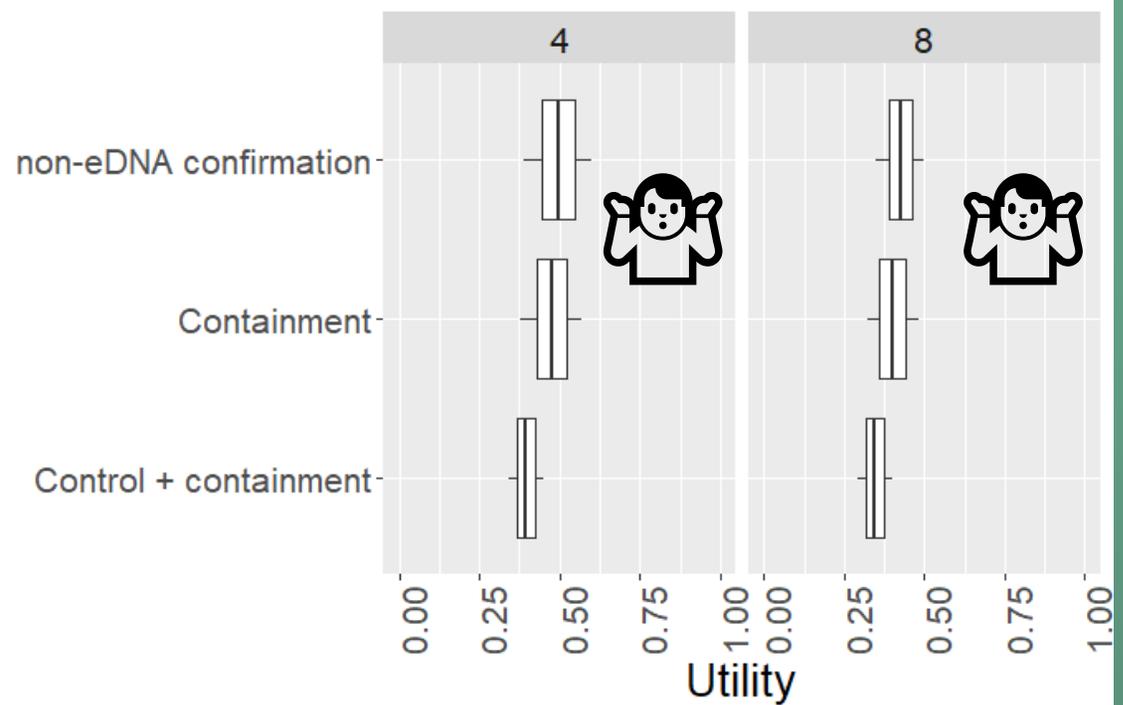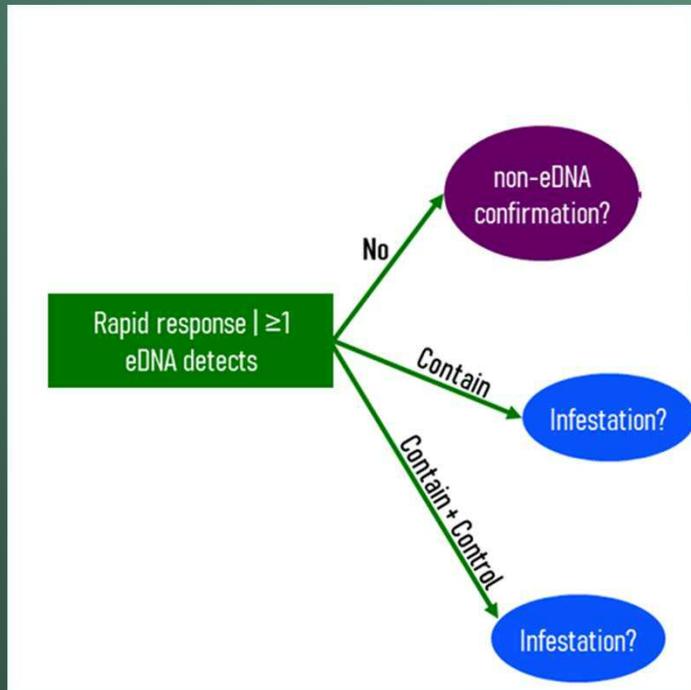- **Evaluate outcome sensitivity to assumptions**

	Protect water supply	Protect ecosystem		Maintain recreation	Maximize public support	Minimize costs	
	Mandate to meet demand	Spatial extent of the infestation in Jordanelle	Spread outside of Jordanelle	Number of closures	Level of support	Infrastructure retrofit costs	RR management & sampling costs
	% required supply delivered	% area infested	Utility	ramp-days	5 point scale	dollars (thousands)	dollars (thousands)
Weight	--	8	1	4	10	0	2

Public support = 10

Control costs too much and effect too uncertain
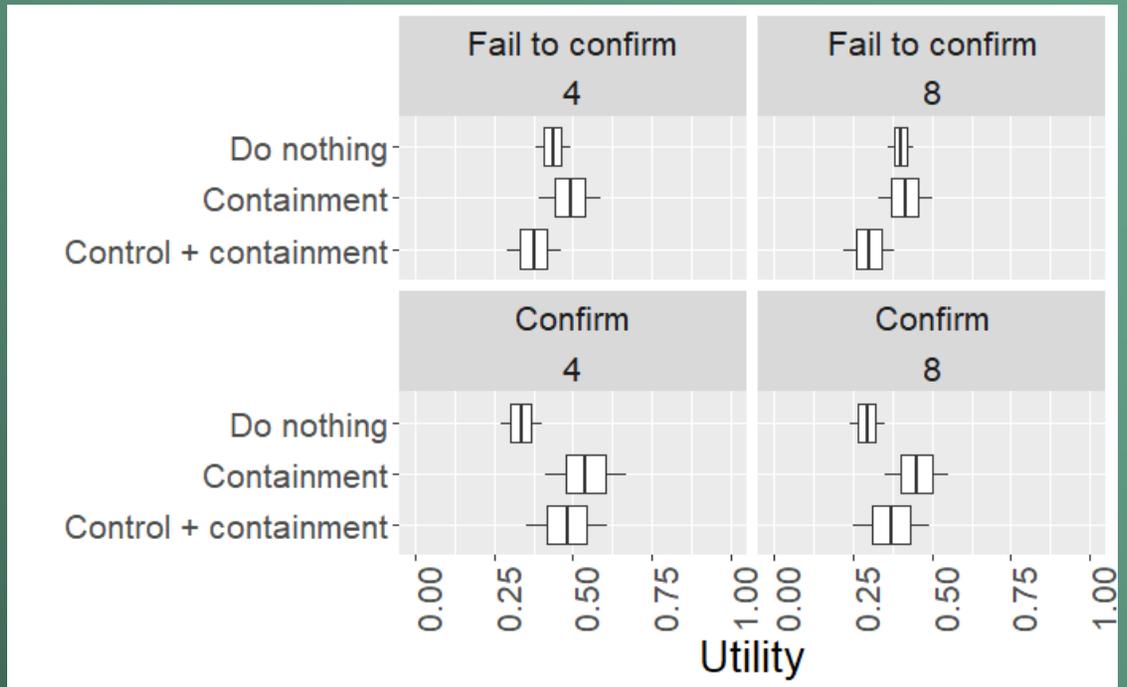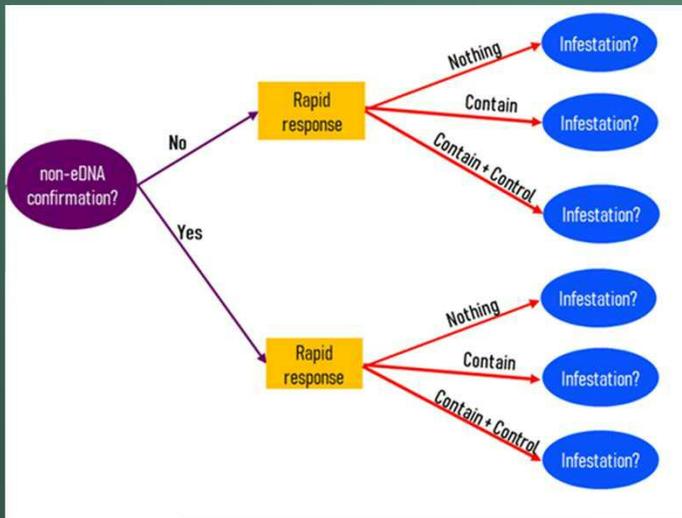- Reduce costs from $millions to $tens of thousands

Regional spread = 10

Preliminary results, Decision Pt 1

- Consequences by Year 4 and 8
- Box width= rapid spread & slow spread models

Preliminary results, Decision Pt 2

Decide & Take Action

- **Decision support not decision mandate**
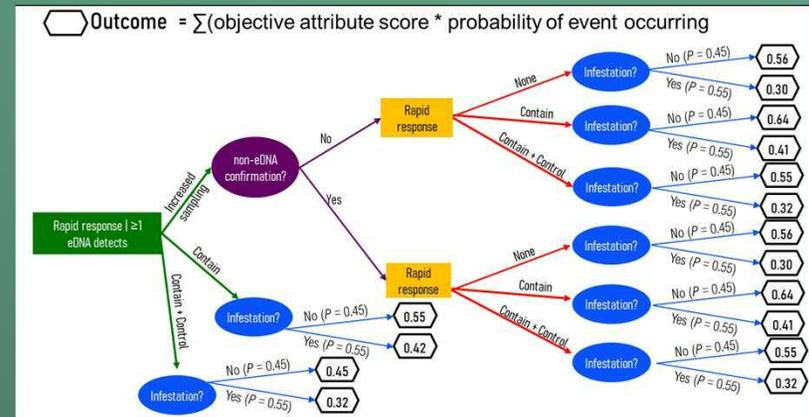- **Eyes open to tradeoffs**

≋ USGS

V.   Next steps

eDNA detections and EDRR

- **General template for decision process after eDNA early detections**

"Preliminary Information-Subject to Revision. Not for Citation or Distribution."

- **Test & refine Jordanelle model in different system**

- **Graphic user interface**
  - '**app**'

https://community.rstudio.com/

NEANs members

- **Case study like Jordanelle**

- **Willing decision-makers & stakeholders**
  - **Fall 2021**
  - **In person (~ 5 days)**
  - **Virtual (~ten, 2hr meetings)**

- **Benefits**
  - **Useful model specific to your system**
  - **Training in SDM**

≈USGS

Thank you

Adam Sepulveda

USGS Northern Rocky Mountain Science Center

asepulveda@usgs.gov

USGS