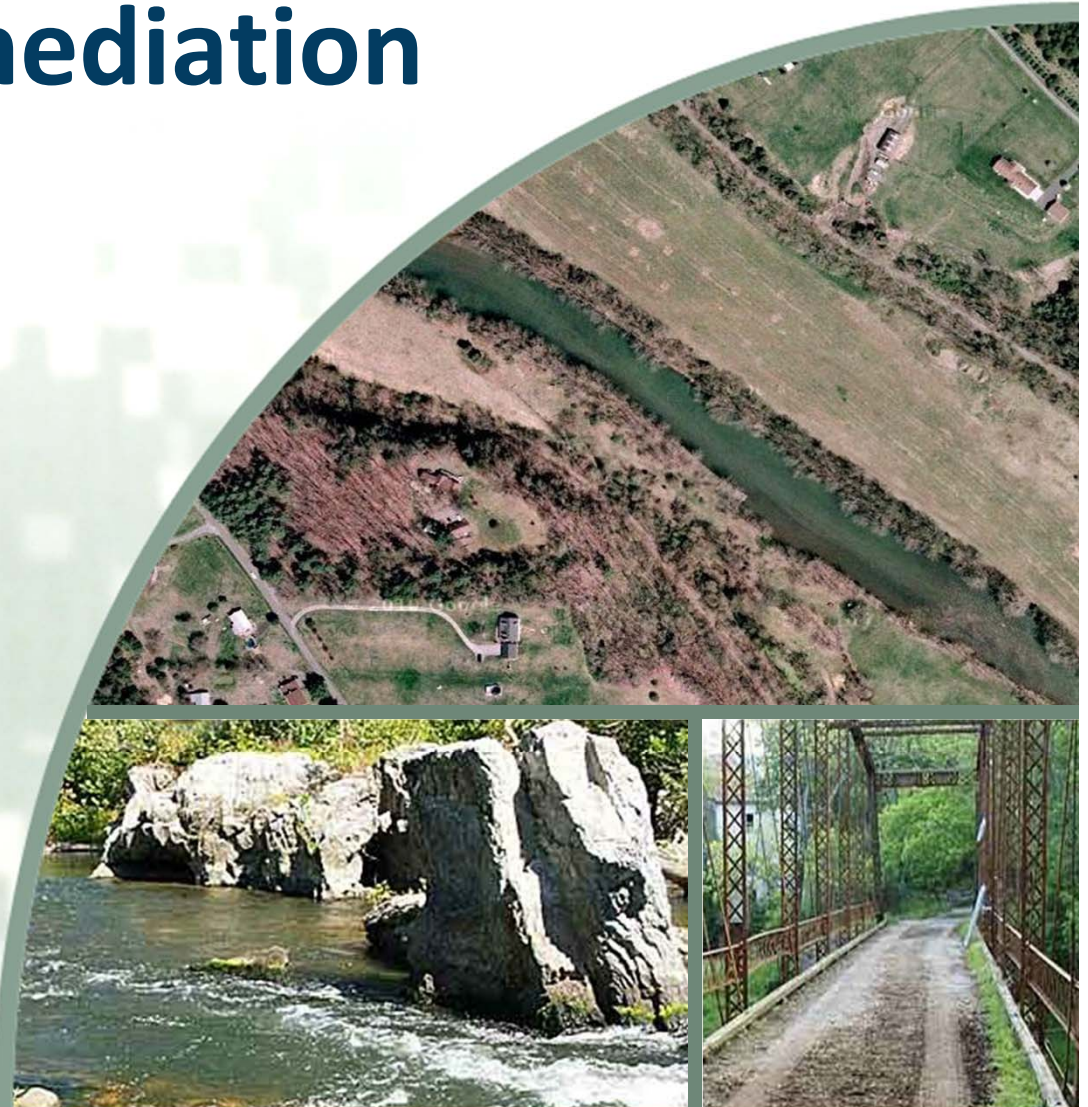


Enhanced Adaptive Management Approach for South River Remediation

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Sagar Thakali
Josh Collins

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Environmental Laboratory
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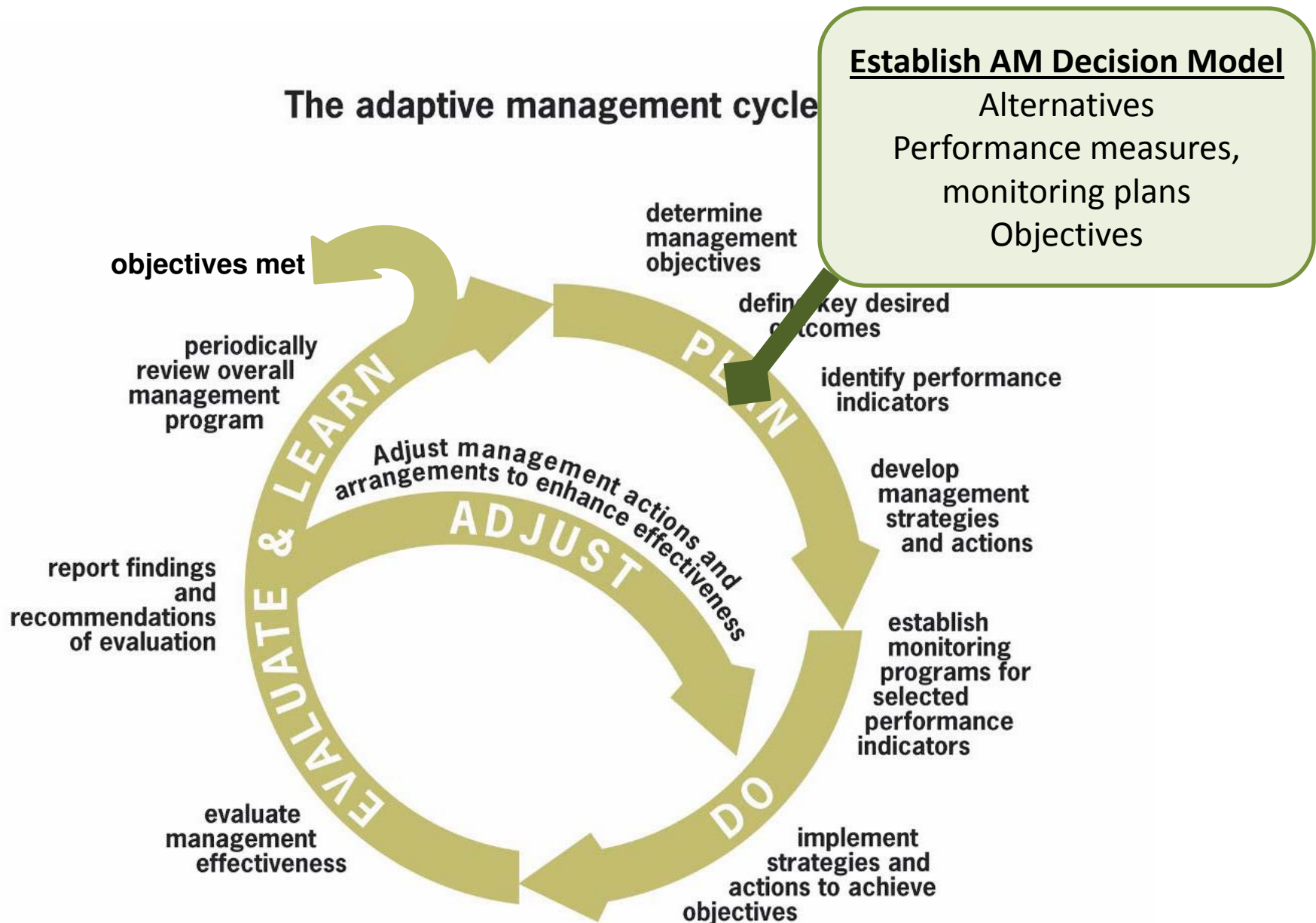
Agenda

- Overview
- (1) Archiving anticipated effects
- (2) Capturing different perspectives
- (3) Catalog improved understanding
- (4) Future use

Overview

- Adaptive Management?
 - “structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring” (Wikipedia, 2016)
 - Common problems include “paralysis by analysis” (no action) and “trial and error” (no learning)

The adaptive management cycle



EAM Decision Model

- Spreadsheet Tool
 - Not a black box
 - Doesn't generate "answers" but is a way to organize existing information, and visualize uncertainty and preferences
 - Can be used for an initial ("what if") comparison for a novel approach in the future

EAM Decision Model

- What do I hope to accomplish?
 - “look under the hood”
 - Demonstrate how it stores predicted effects
 - Show how it can be used to visualize why a feature changes the value of an approach (for one group vs. another)
 - Provide some hypotheticals about its use in the future

Note – Follow along according to your level of interest.

Structure of the Tool

	A	B	C	D	E	F
1				Reset Progress		
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

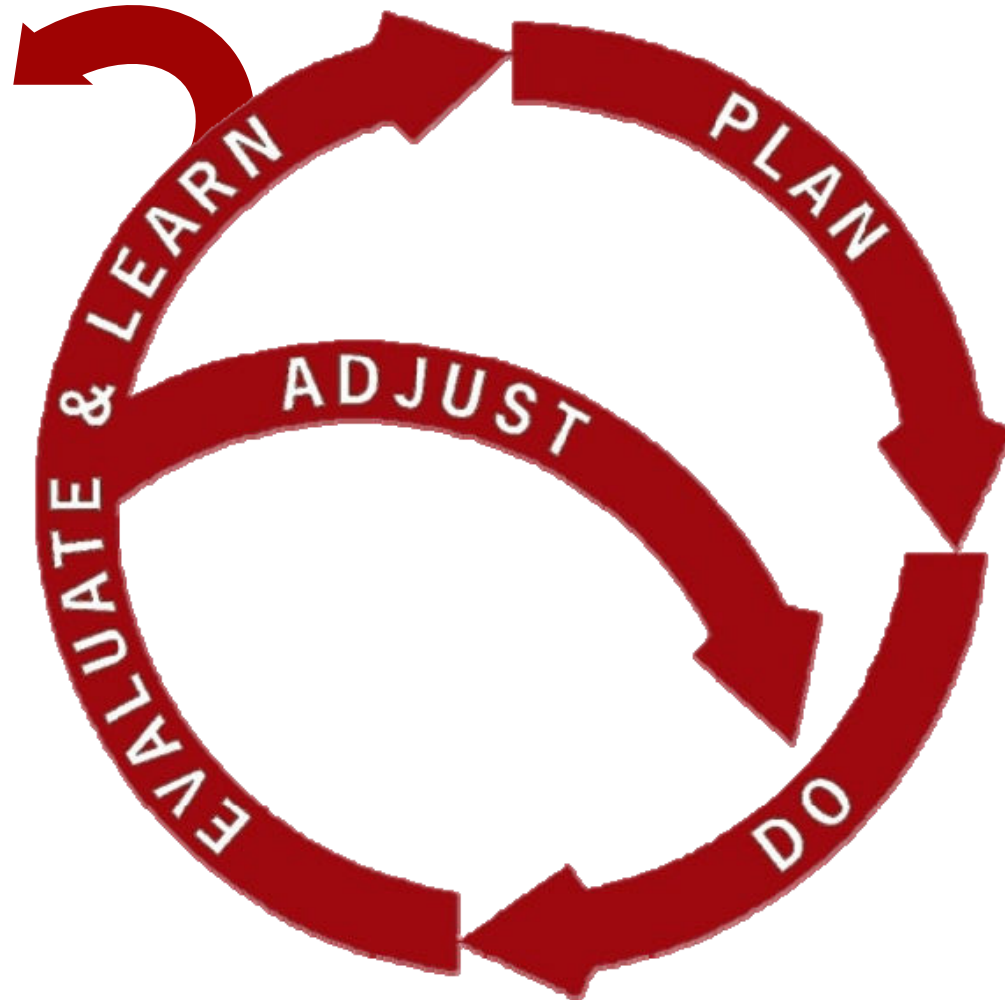
	STEP	TAB	STATUS	
1	Weighting	mini-SMARTER	10/19/16 11:26 AM	Go To
2	Weight Check	Weight Report		Go To
3	Alternative Creation	Data Input Instruction	10/19/16 12:05 PM	Go To
4	Data Input	Alt_X tabs	10/19/16 12:09 PM	Go To
5	Value Function Check	MCDA Model		Go To
6	Run	MCDA Model	10/19/16 12:09 PM	Go To
7	Output Generated	OUTPUT	10/19/16 12:09 PM	Go To

Utilizing survey results as input weights

Utilizing three illustrative scenarios
as alternative approaches

PROGRESS	Weight Instructions	mini-SMARTER	Weight Report	Data Input Instructions	Alt_1	Alt_2	Alt_3	MCDA Model	Data Output	Alt_Template	+
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Objectives Met



Establish AM Decision Model

Alternatives
Performance measures,
monitoring plans
Objectives



- Specified criteria follow from Remedial Action Objectives
- Characterized indicators and measureable metrics
- Develop strategies and actions
 - anticipate performance

Alternative Scenarios:

- 1) Baseline: natural recovery with bank soils and vegetation in place, greenway connectivity unchanged, no disruptions or change to in-stream habitat
- 2) Extensive removal/bank clearing: aggressive soil removal with removal of all vegetation, 25% of banks stabilized (90% of loading), new planting, in-stream habitat features remain the same or are enhanced
- 3) IRM scenario: Balanced remedial objectives with preservation of trees and enhancement of riparian habitat, address 90% loading with 90% efficiency, in-stream habitat features remain the same or are enhanced

Use of a spreadsheet tool:

- 1) Necessitates specification of alternatives
- 2) Allows an archive of the source of predicted effects for different interventions
- 3) Captures uncertainty in each metric

Steps for creating and scoring alternatives in the spreadsheet:

- 1) Choose number of alternatives
- 2) Name and describe
- 3) Score each in its data tab

“TWO” version, add third alternative

Value	Evaluation Criteria	Metrics	Estimated From:	Date/Model Version:	Lowest Possible	Lowest Probable	Highest Probable	Highest Possible
	Protect human health and the environment							
	Adult Small Mouth Bass Tissue MeHg							
		Mean Tissue MeHg in the reach			0.700688504	0.915893953	1.19719637	1.3691255
		Projected Tissue MeHg downstream			0.45	1.66	2.87	3.22
	Riparian & Aquatic Habitat Development							
		Riparian vegetation (amount)			0	2.083333	61.19792	100
		In stream habitat feature (canopy cover, woody debris, rootwads, undercuts, high-value substrate) area			0	0	12	15
		Rapid Bioassessment Protocol			0	72	97	125
		Wolman pebble count			0	5.965	9.5	50
		Fish functional capacity index			0	0.55	0.62	1
		Benthic invertebrate community (measures of diversity and evenness)			0	17	44	45
	Achieve media cleanup objectives							
	Surface Water Hg							
		Mean surface water tHg in the reach			8	10	13	19
		Mean surface water MeHg in the reach			0.06	0.07	0.09	0.13
		Projected progress toward meeting the TMDL target			210.5263158	263.1578947	342.1052632	500
	Remediate the source(s) of release							
	Reduction in Hg transport and Exposure							
		Sediment tHg at the BMA			0.508	0.846	1.407	1.705
		Sediment MeHg at the BMA			0	0	0	0
		Porewater tHg at the BMA			0.1935	0.658275	2.467125	70.0617
		Porewater MeHg at the BMA			0.009	0.13905	1.145475	11.997
		Asiatic Clam tHg accumulation at the BMA			13.18961	15.99118	46.70844	67.9644
		Asiatic Clam MeHg accumulation at the BMA			10.43154	14.16019	41.60939	52.6651
	Bank stability							
		Rate of erosion/deposition			0	0	0	0
	Bank Loading Control							
		Estimated percent reduction from CSM			70	75	80	85
	Long-term Effectiveness							
	Long Term Maintenance							
		Risk of storm-induced or extreme event remedy disruption (probability - 10 yr storm)			10	25	50	100
	Institutional Controls							
		Effectiveness of Outreach			0	46	87	100
	Other							
		Metric						
	Toxicity Mobility & Volume Reduction							
	Reduction in Hg mobility from biochar							
		Estimated percent reduction			0	80	85	90
	Off Site Soil Treatment							
		Percent contained			100	100	100	100

Lessons learned:

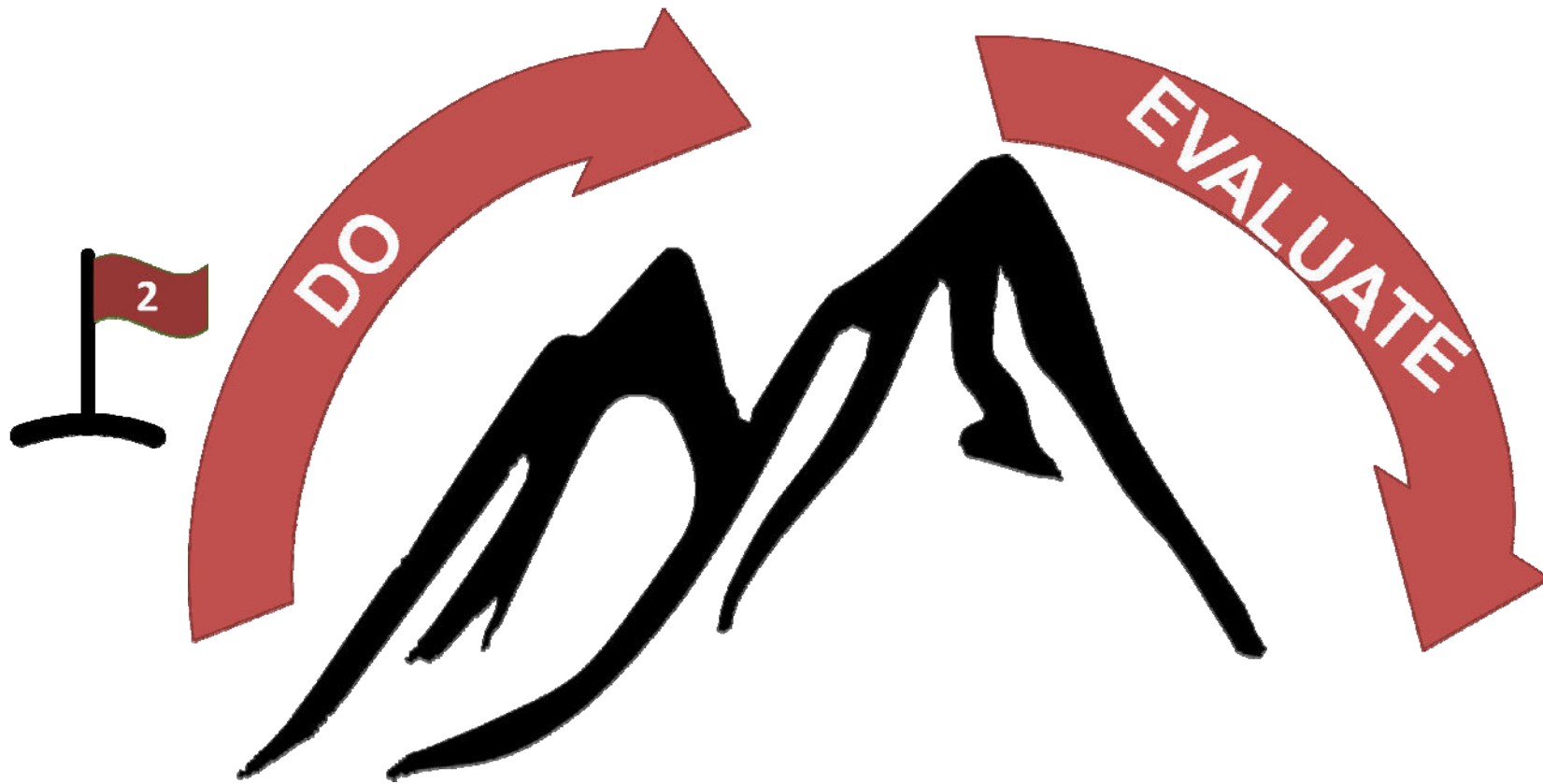
- Captures projected effects of potential action
- Specification of the uncertainty in the projections
- Identification which measurements are not “material” (i.e. don’t inform choice between actions)
- Characterization limits of certain metrics
 - Bank erosion measurements post stabilization within the range of measurement error



Archive our best understanding of the effects of our actions

- Criteria reflecting Remedial Action Objectives
- Identified metrics and indicators for criteria
- Evaluation of alternative approaches
 - sourced and referenced





- Consider stakeholder perspectives
- Identify features that contribute to objectives for each group
- Select implementation alternative that provides most value

Survey Responses

13 CRITERIA:

- Preservation or improvement of in-stream fish habitat
- Reduction in surface water mercury concentration
- Reduction in mercury loading into the river (from the eroding banks or other sources)
- Preservation of existing trees on the banks and the floodplain
- Preservation or improvement of wildlife habitat on the banks / floodplain
- Increased access to the river from the greenway (including river views)
- Other recreational use improvements (e.g. boating, fishing , swimming)
- Long-term effectiveness of the remedy
- Costs (construction, management, and monitoring)
- Feasibility to construct (including engineering design, permitting, and access)
- Need for long-term maintenance, risk of storm-related disruption of the remedy
- Duration of the construction as it affects quality of life for the community
- Greenhouse gas emissions during remedy implementation

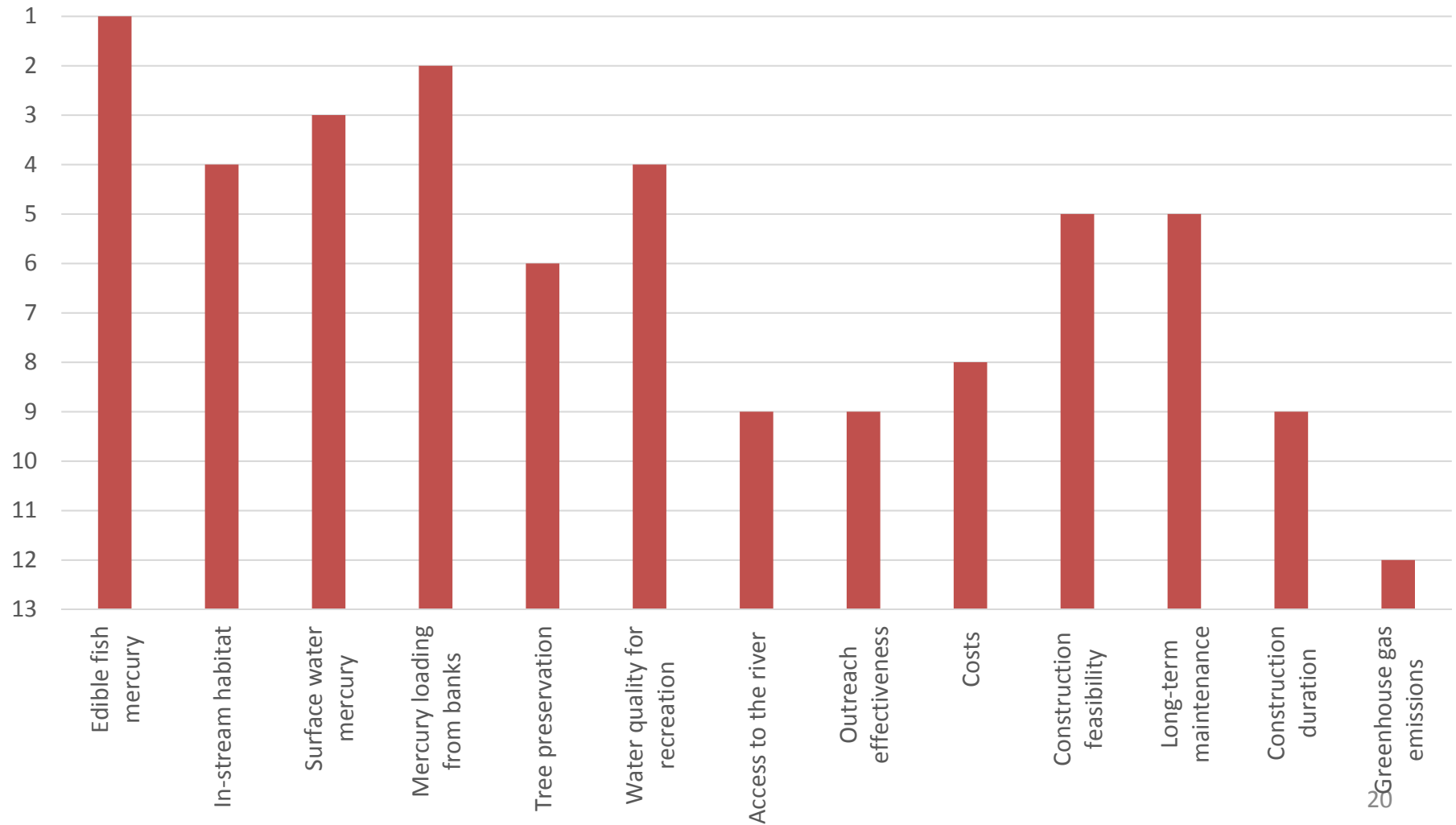
Groups

7 GROUPS:

- Academic
- Consultant (for DuPont and for Local and Regional Regulators)
- DuPont
- Non-governmental Organization (e.g. Friends of the Shenandoah, Shenandoah Riverkeeper, Trout Unlimited, etc.)
- Regulator for South River Hg Remediation (Federal and State, including VA DEQ, VA DOH, US EPA, etc.)
- Trustee (Federal and State, including FWS, VA DGIF, etc.) OR Landowner in remedial corridor (e.g. City of Waynesboro)
- Other interested party

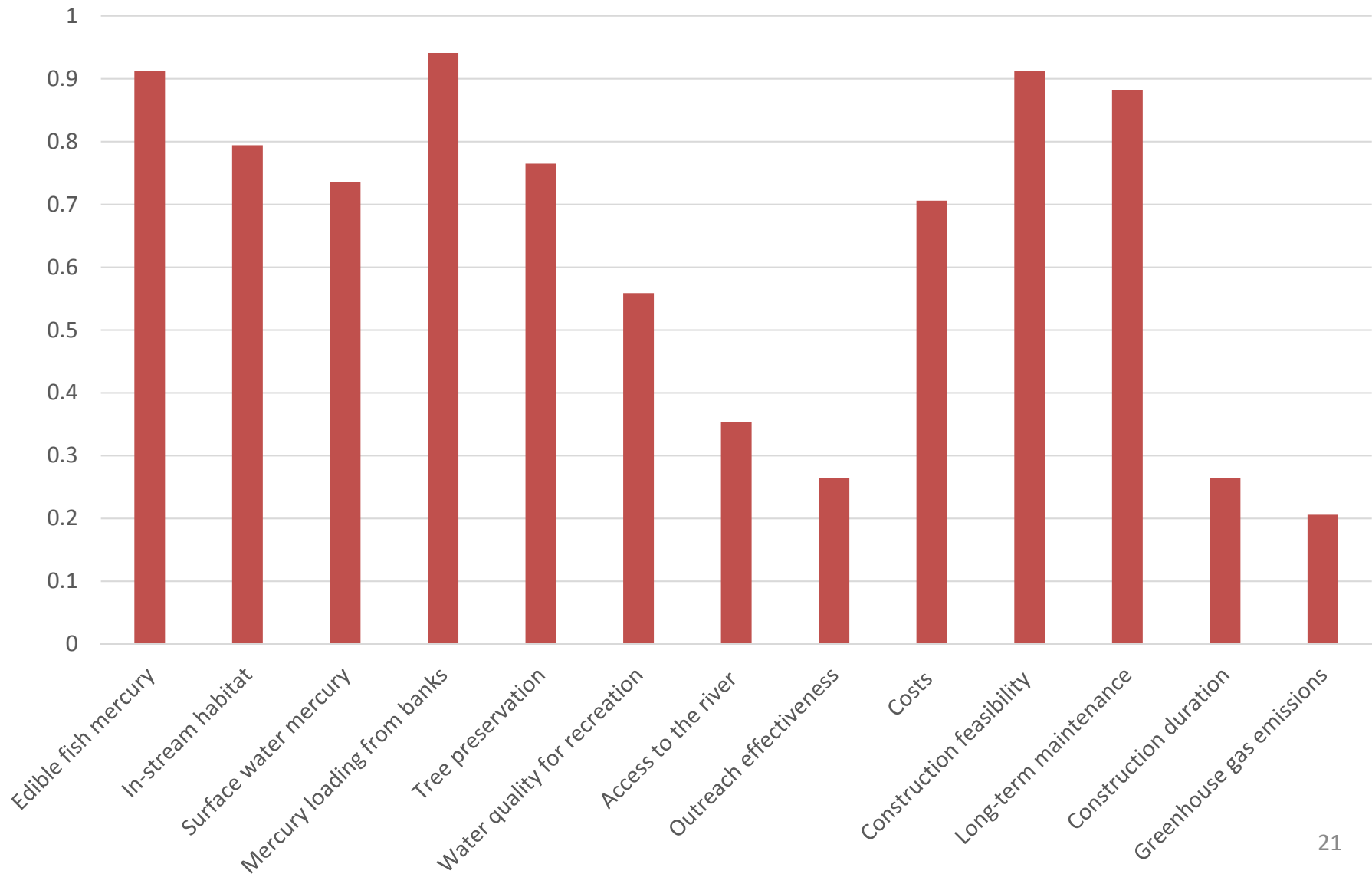
Responses

MODE



Responses

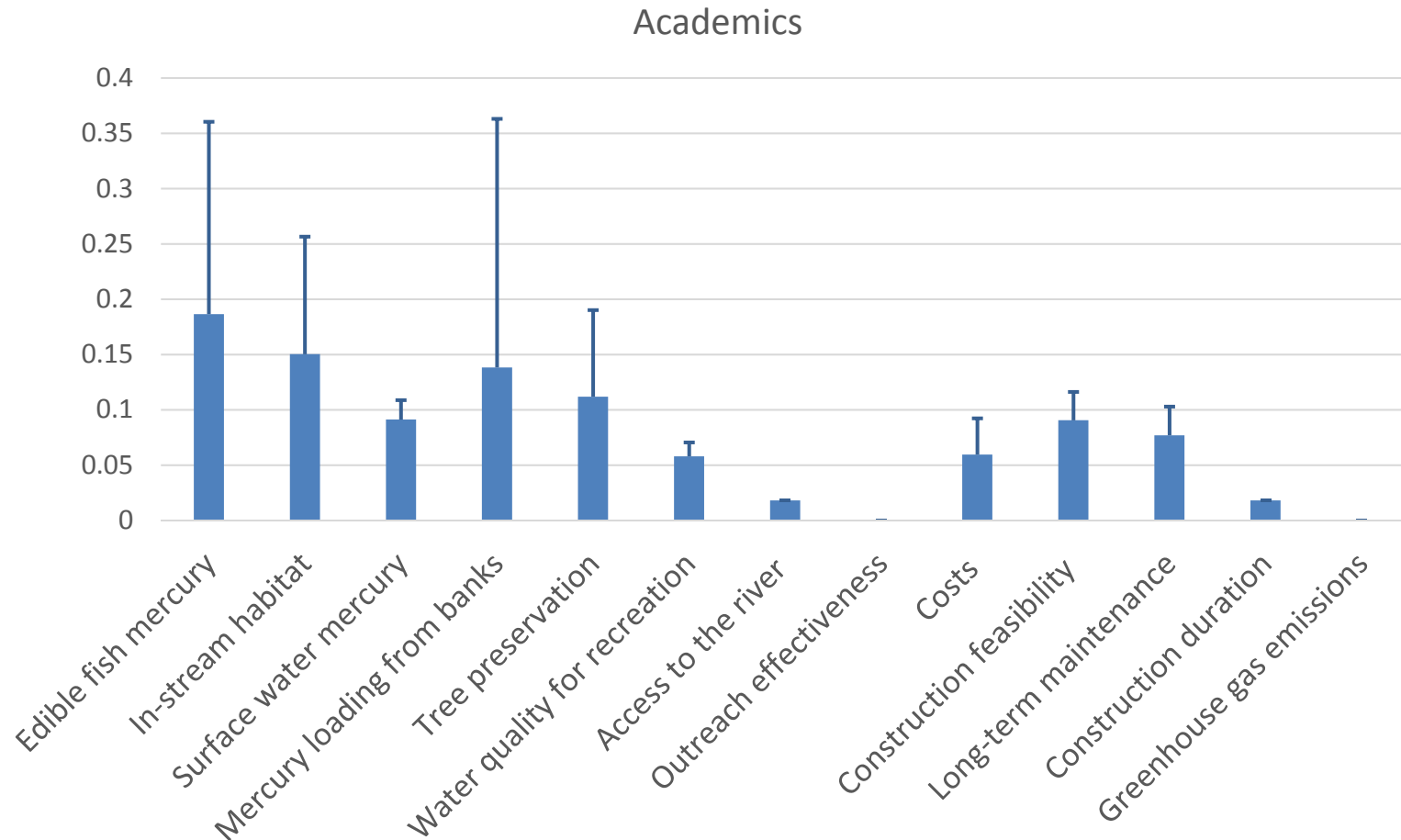
Frequency Included



Responses

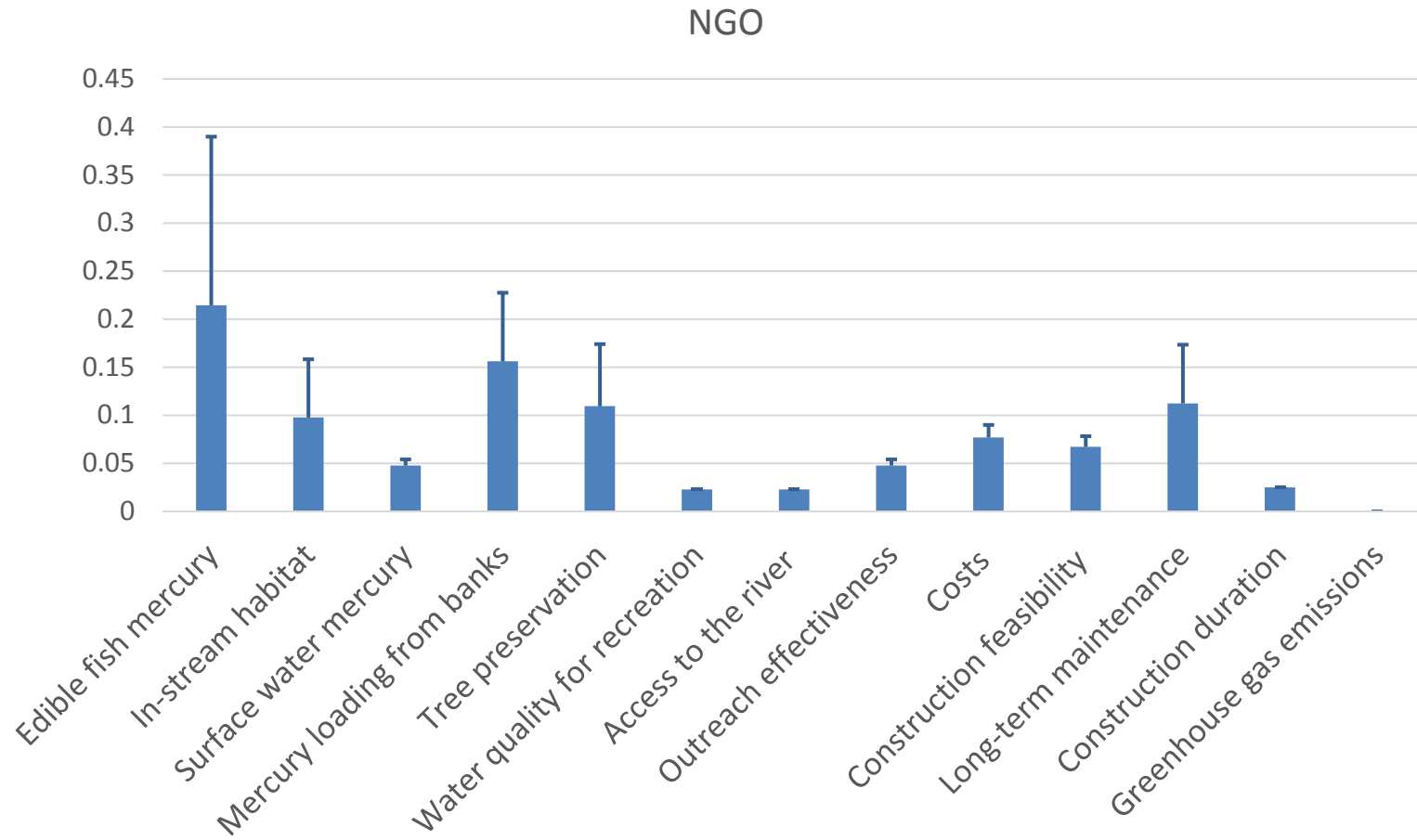
Group	Participation
Consultant (for DuPont or for Local and Regional Regulators)	10
Academic	5
Non-governmental organization	4
Regulator for South River mercury remediation	7
DuPont	4
Trustee OR Landowner	2
Other	2
SUM	34

Group Responses

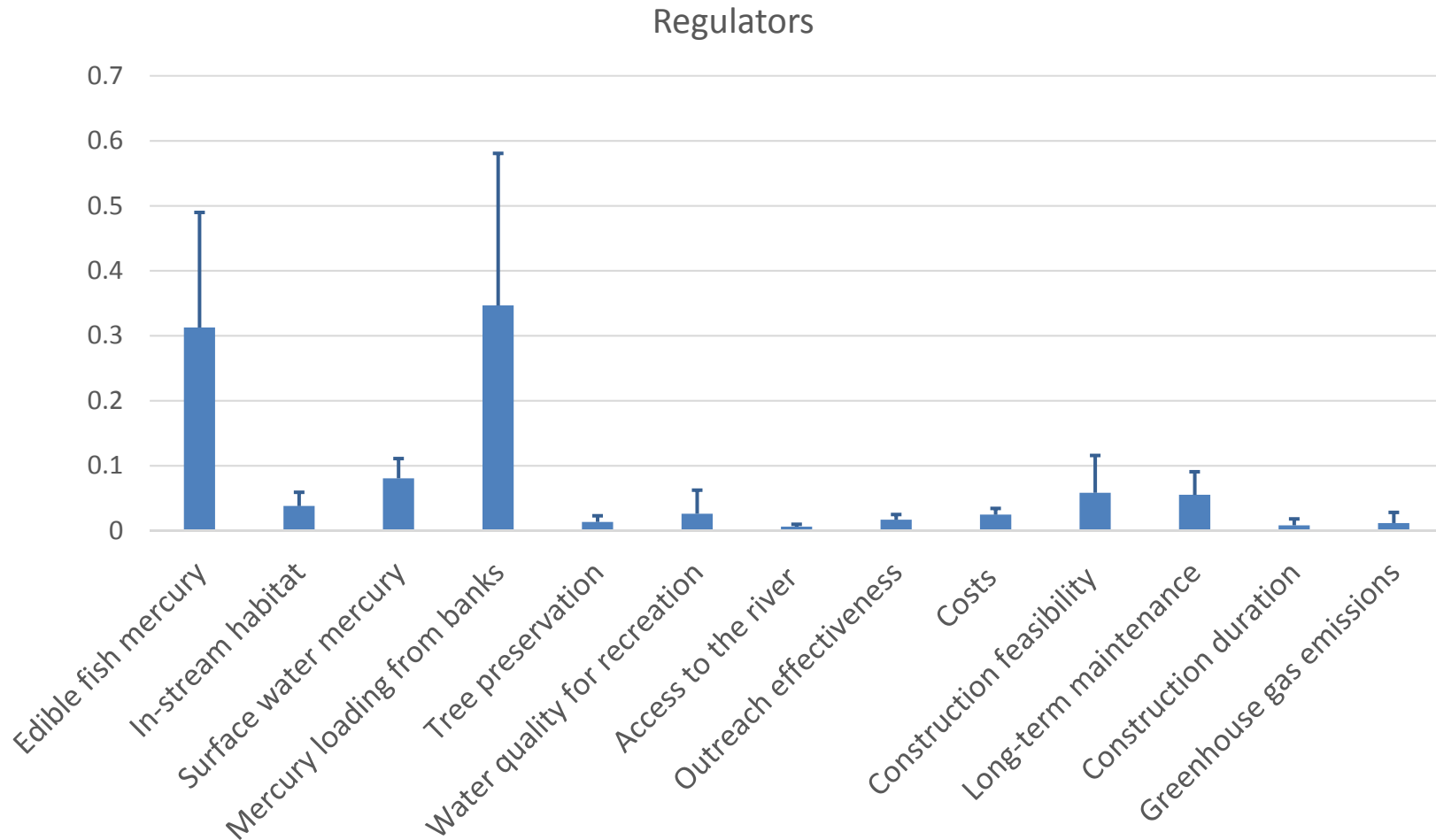


*Similar profile to Consultants

Group Responses

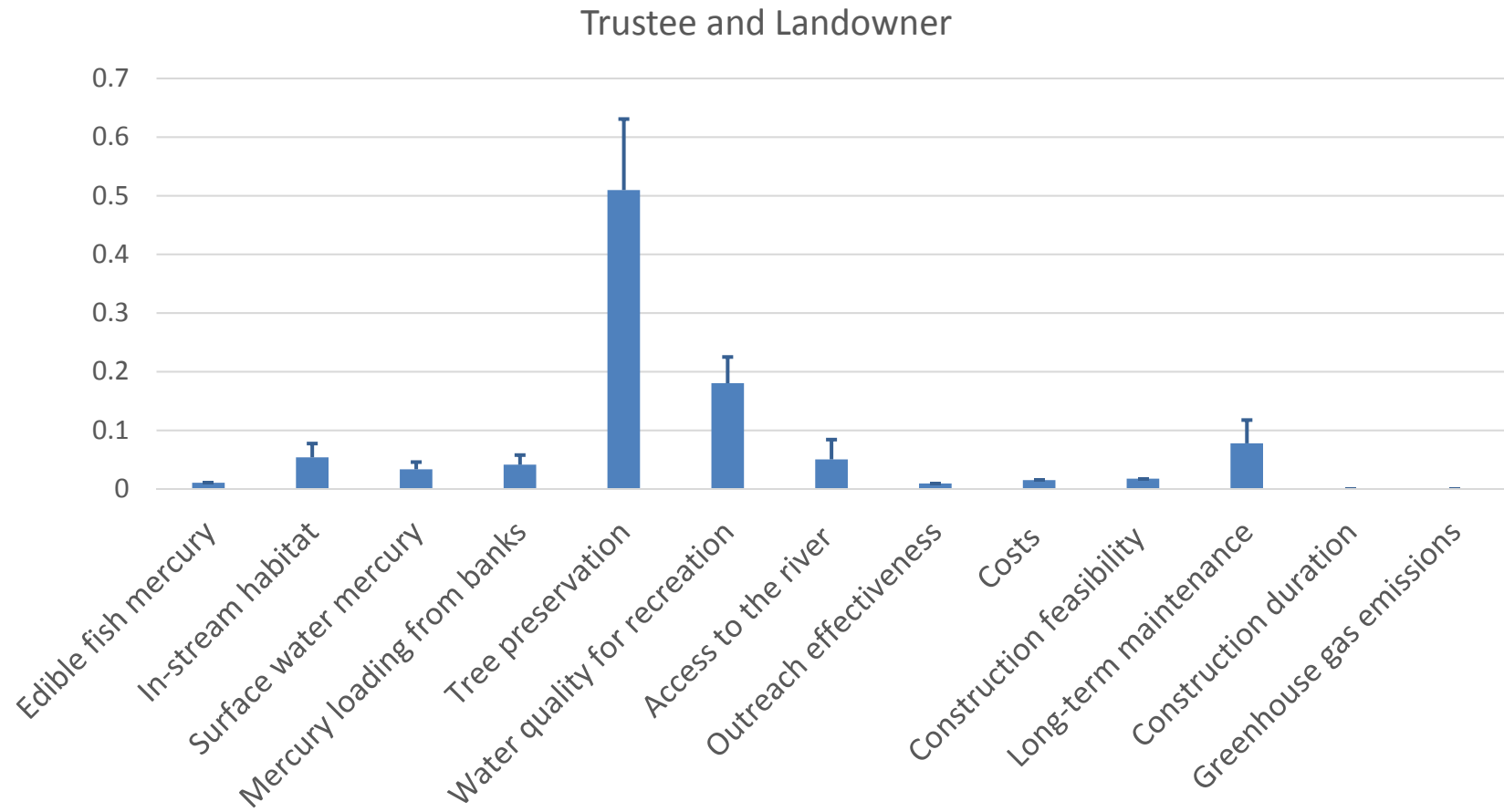


Group Responses

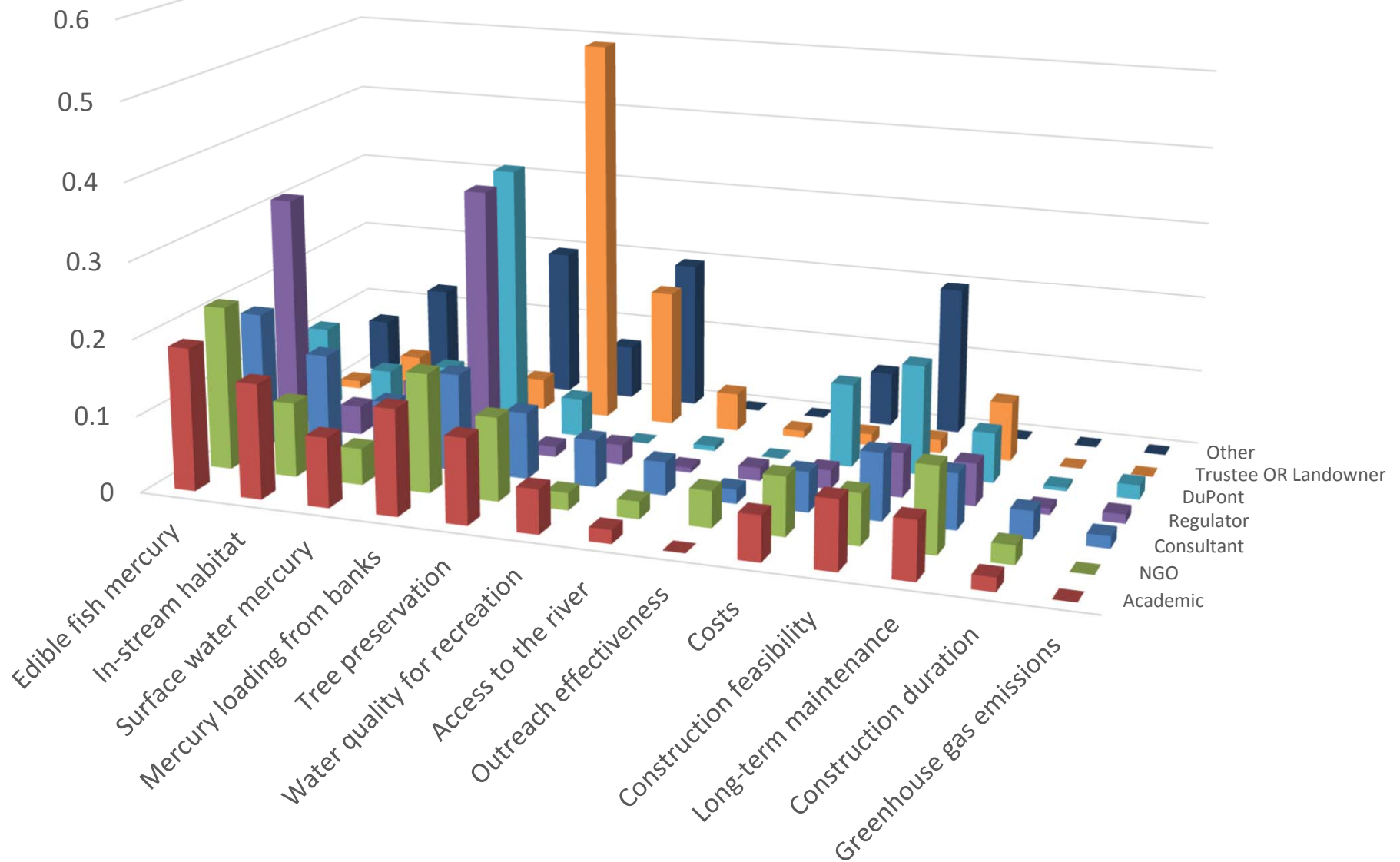


*Similar profile to DuPont respondents

Group Responses



Group Responses



Weight Survey Conclusions

- Several groups considering multiple criteria
- Others interested primarily in one aspect
- Collected or averaged response may be less representative of the perspective of groups

Altering weights in the spreadsheet:

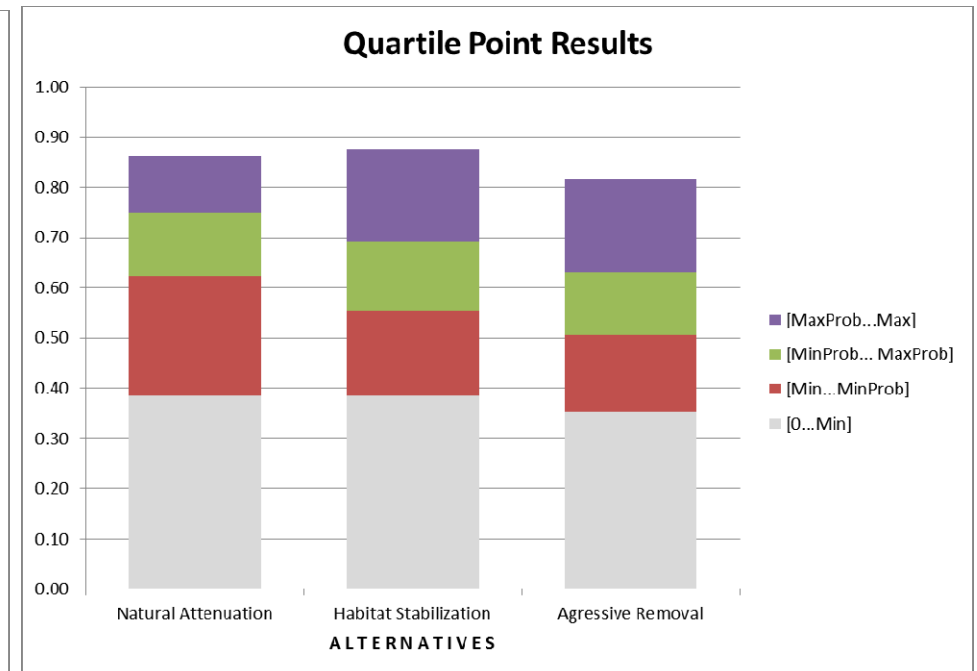
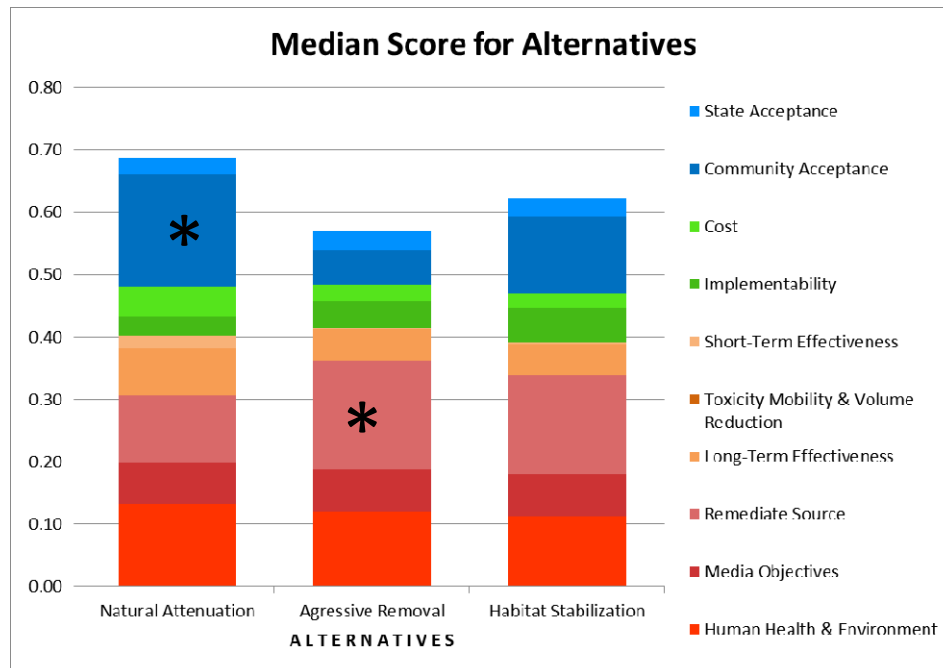
- 1) Consider trade-off between criteria and sub-criteria
- 2) Review relative weights
- 3) Check value functions
- 4) Run
- 5) Save output
- 6) Repeat as needed...

"THREE" version, change weights

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	The following is a modified SMARTER weighting procedure based on an interview protocol. Here we aim to collect responses electronically. Your responses will be used not only to provide tradeoff information on the main criteria, but also for all of the sub-criteria in the decision hierarchy.												
2	Reset Weighting												
3	Evaluation Criteria												
4	Which of these criteria is most important to the selection of a remedial action? Place the highest score (100) in that box. If that criterion is valued at 100 points, how many points would you give to the other criteria relative to 100? <i>The total number of points is not important.</i>	0.2372	Protect Human Health & Environment	0.0744	Media Cleanup Objectives	0.2034	Remediate Sources	0.08479	Long-term Effectiveness	0	Toxicity, Mobility & Volume Reduction		
5		0.0279	Short-term Effectiveness	0.0887	Implementability	0.0563	Cost	0.17804	Community Acceptance	0.04925	State Acceptance	sum	
6													
7													
8	Evaluation Criterion: Protect Human Health & Environment												
9	Which aspect of the "protective" criterion is most important to the selection of a remedial action? Place the highest score (100) in that box. If that aspect is valued at 100 points, how many points would you give to the other relative to 100?	0.188	Small Mouth Bass Tissue MeHg	0.0493	Riparian & Aquatic Habitat Development								
10													
11	Small Mouth Bass Tissue MeHg												
12	Which metric for Small Mouth Bass tissue MeHg is most important measurement of effectiveness? Place the highest score (100) in that box. If that aspect is valued at 100 points, how many points would you give to the other aspects of the criterion relative to 100?	1	Tissue MeHg in the reach	1	Tissue MeHg downstream								
13													
14	Riparian & Aquatic Habitat Development												
15	Which metric for habitat development is most important measurement of protection? Place the highest score (100) in that box. If that criterion is valued at 100 points, how many points would you give to the other aspects of the criterion relative to 100?	1	Riparian vegetation	1	In stream habitat features	0	Rapid Bioassessment Protocol	0	Wolman Pebble Count	0	Fish functional capacity index	0	Benthic Invertebrate community
16													
17	Media Cleanup Objectives												
18	Which metric for Surface Water Hg is most important measurement of media cleanup? Place the highest score (100) in that box. If that aspect is valued at 100 points, how many points would you give to the other aspects of the criterion relative to 100?	1	Mean surface water tHg in the reach	1	Mean surface water MeHg in the reach	0	Projected progress toward TMDL target						
19													
20													
21	Remediate Source of Release												
22	Which aspect of the "source remediation" criterion is most important to the selection of a remedial action? Place the highest score (100) in that box. If that aspect is valued at 100 points, how many points would you give to the others relative to 100?	1	Reduction in Hg transport	1	Bank Stability	1	Bank Loading Control						
23													

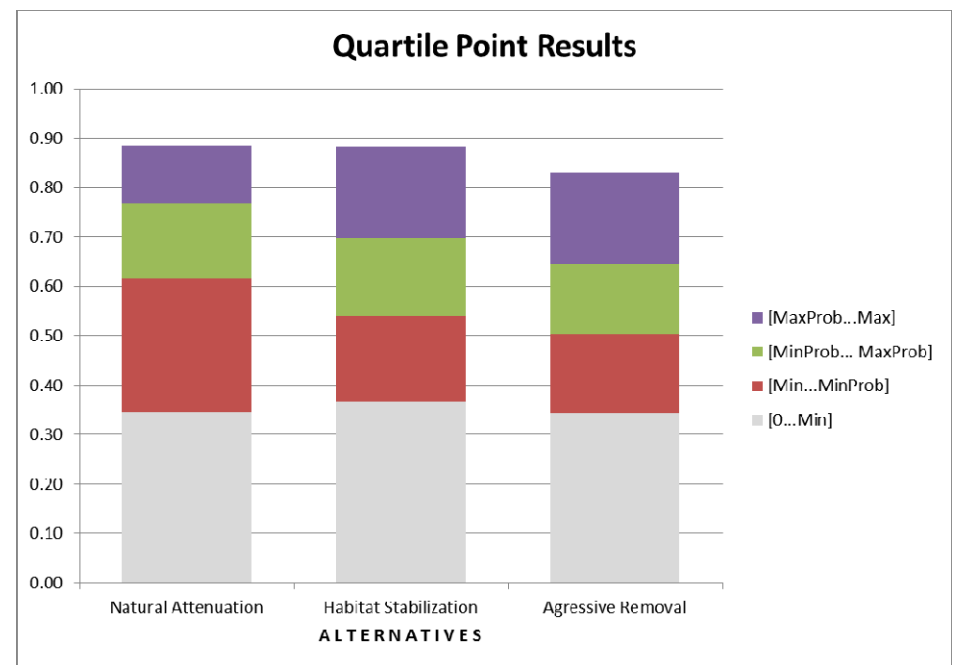
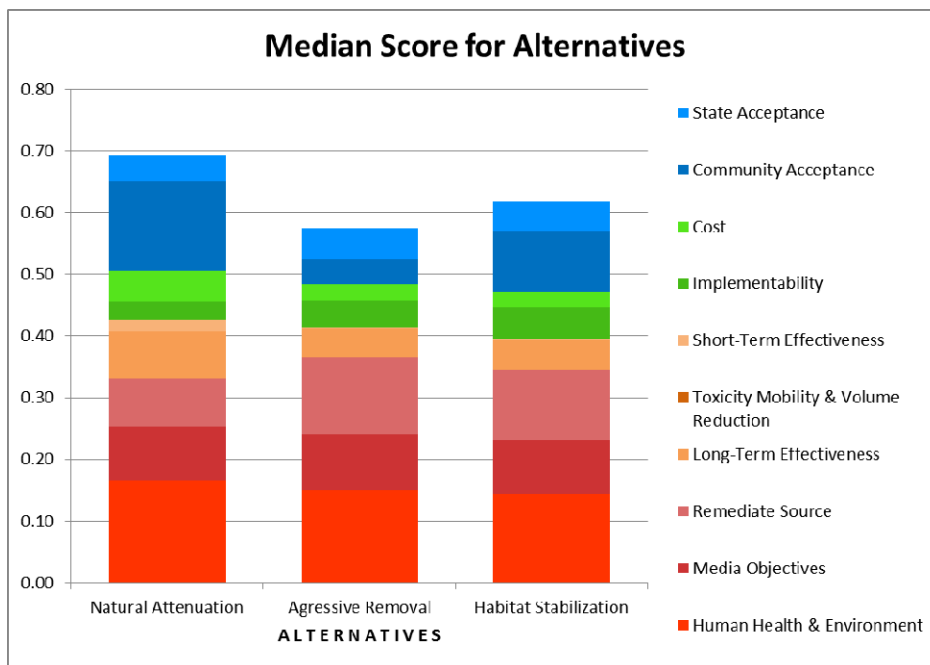
Outcome

“Relative Value” across the 7 groups



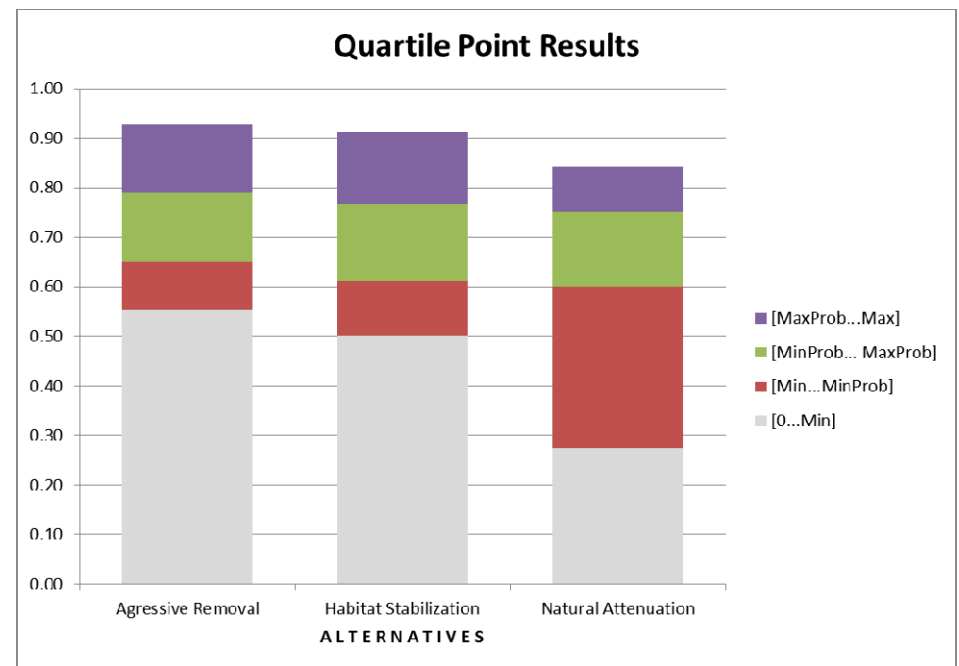
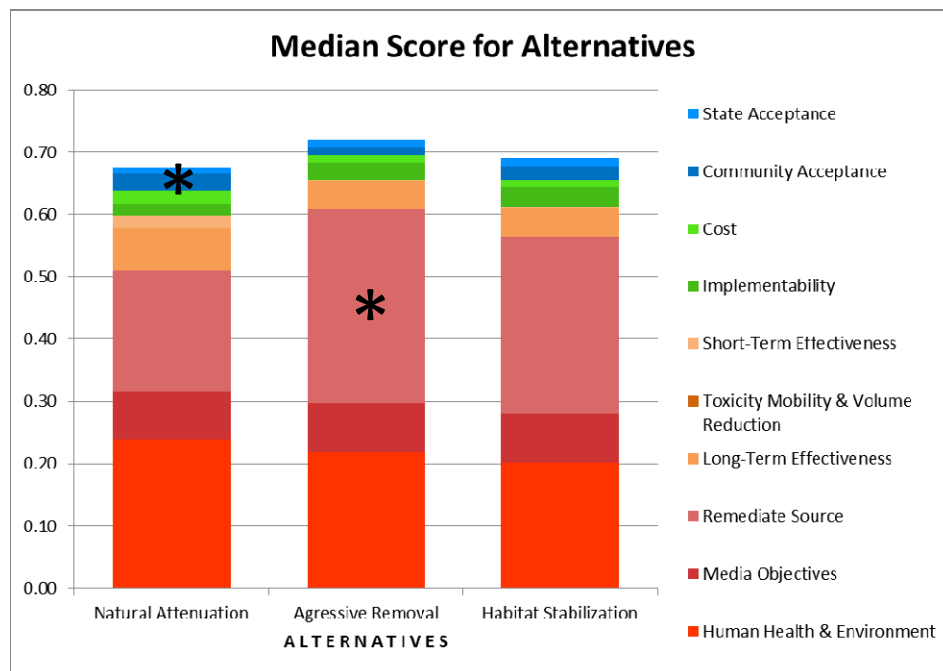
Outcome

“Relative Value” for Academic group



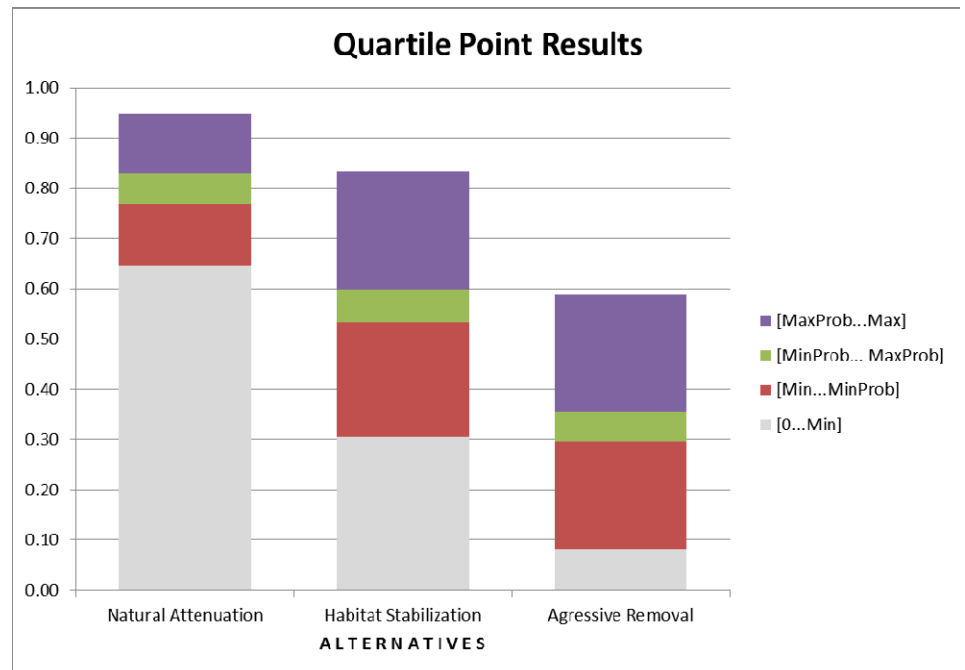
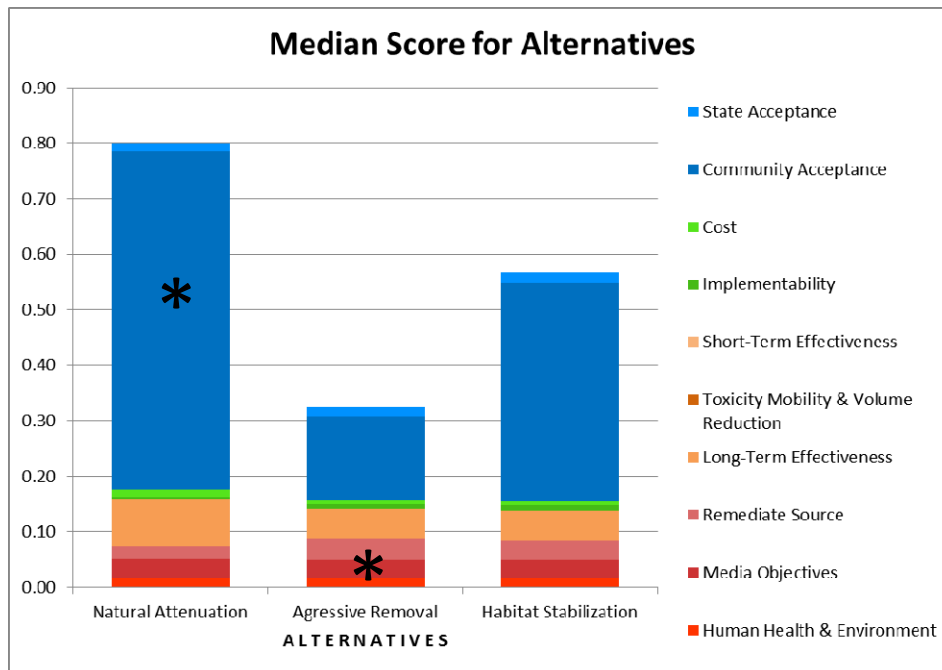
Outcome

“Relative Value” for Regulator group



Outcome

“Relative Value” for Trustee/Landowner group



Outcomes Conclusions

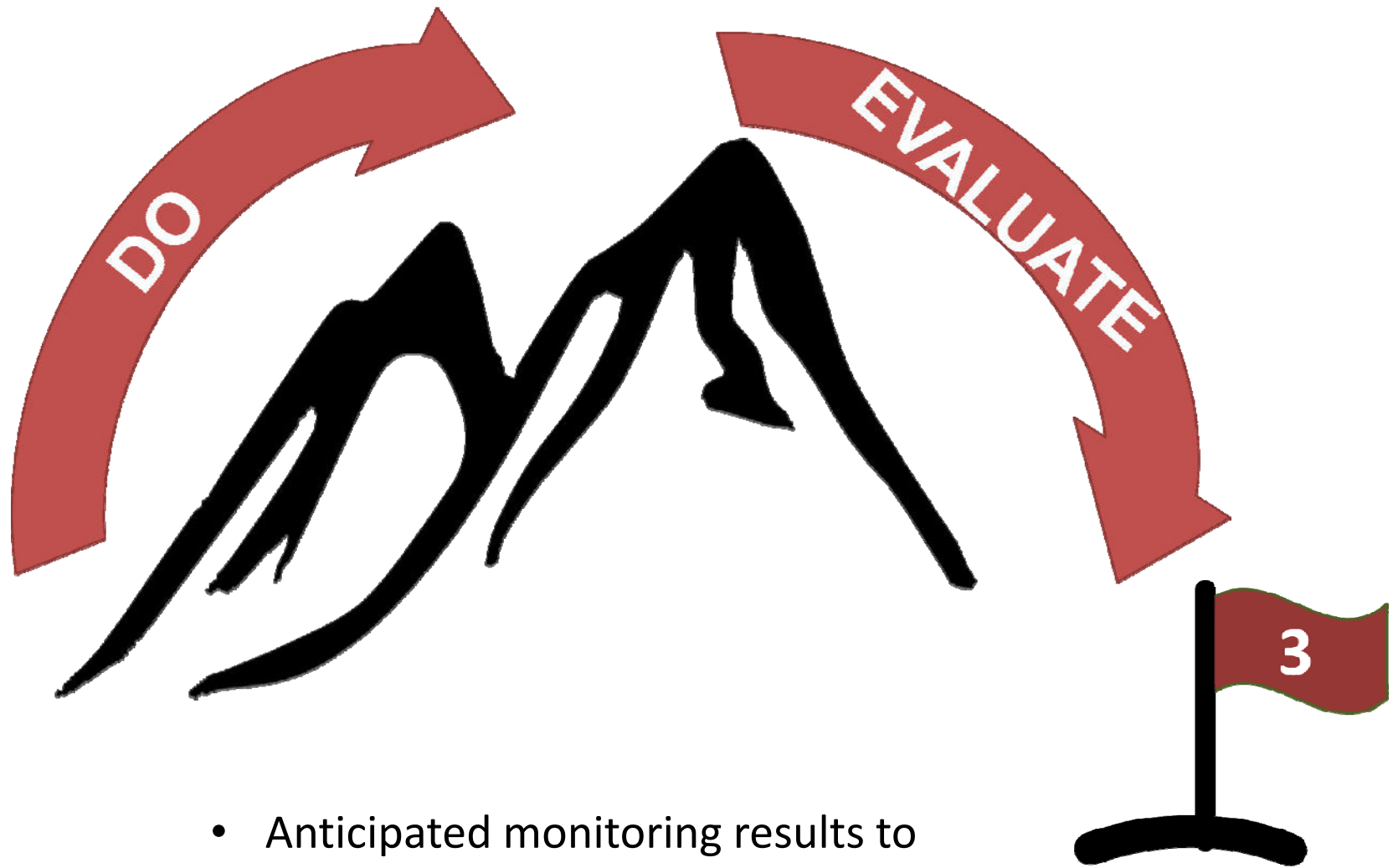
- Lack of intervention retains current habitat value which is critical to some groups
- Aggressive intervention provides value in minimizing loading from banks
- Intermediate solution provides a “thread the needle” alternative between the two options



Understand different perspectives and the value of design features

- Weight analysis by group
- Difference in value revealed
- Implications for selection of alternative





- Anticipated monitoring results to confirm or negate effectiveness
- Model refinement
- Reduction in initial uncertainty

Lessons learned (based on pilot):

- Update/develop mechanistic models to improve understanding and reduce uncertainty
- Capture unexpected events for future consideration
 - Watering schedule key for establishment
 - Mowing, maintenance alters erosion potential
 - Clean banks increases foot traffic
- Re-evaluate utility of monitoring endpoints
 - What uncertainty to they resolve?
 - How might it change future course of action?

“THREE” version, update inputs after implementation and monitoring

Value	Evaluation Criteria	Metrics	Estimated From:	Date/Model Version:	Lowest Possible	Lowest Probable	Highest Probable	Highest Possible
	Protect human health and the environment							
	Adult Small Mouth Bass Tissue MeHg							
		Mean Tissue MeHg in the reach			0.700688504	0.915893953	1.19719637	1.3691255
		Projected Tissue MeHg downstream			0.45	1.66	2.87	3.22
	Riparian & Aquatic Habitat Development							
		Riparian vegetation (amount)			0	2.083333	61.19792	100
		In stream habitat feature (canopy cover, woody debris, rootwads, undercuts, high-value substrate) area			0	0	12	15
		Rapid Bioassessment Protocol			0	72	97	125
		Wolman pebble count			0	5.965	9.5	50
		Fish functional capacity index			0	0.55	0.62	1
		Benthic invertebrate community (measures of diversity and evenness)			0	17	44	45
	Achieve media cleanup objectives							
	Surface Water Hg							
		Mean surface water tHg in the reach			8	10	13	19
		Mean surface water MeHg in the reach			0.06	0.07	0.09	0.13
		Projected progress toward meeting the TMDL target			210.5263158	263.1578947	342.1052632	500
	Remediate the source(s) of release							
	Reduction in Hg transport and Exposure							
		Sediment tHg at the BMA			0.508	0.846	1.407	1.705
		Sediment MeHg at the BMA			0	0	0	0
		Porewater tHg at the BMA			0.1935	0.658275	2.467125	70.0617
		Porewater MeHg at the BMA			0.009	0.13905	1.145475	11.997
		Asiatic Clam tHg accumulation at the BMA			13.18961	15.99118	46.70844	67.9644
		Asiatic Clam MeHg accumulation at the BMA			10.43154	14.16019	41.60939	52.6651
	Bank stability							
		Rate of erosion/deposition			0	0	0	0
	Bank Loading Control							
		Estimated percent reduction from CSM			70	75	80	85
	Long-term Effectiveness							
	Long Term Maintenance							
		Risk of storm-induced or extreme event remedy disruption (probability - 10 yr storm)			10	25	50	100
	Institutional Controls							
		Effectiveness of Outreach			0	46	87	100
	Other							
		Metric						
	Toxicity Mobility & Volume Reduction							
	Reduction in Hg mobility from biochar							
		Estimated percent reduction			0	80	85	90
	Off Site Soil Treatment							
		Percent contained			100	100	100	100

PROGRESS

Weight Instructions

mini-SMARTER

Weight Report

Data Input Instructions

Alt_1

Alt_2

Alt_3

MCDA Model

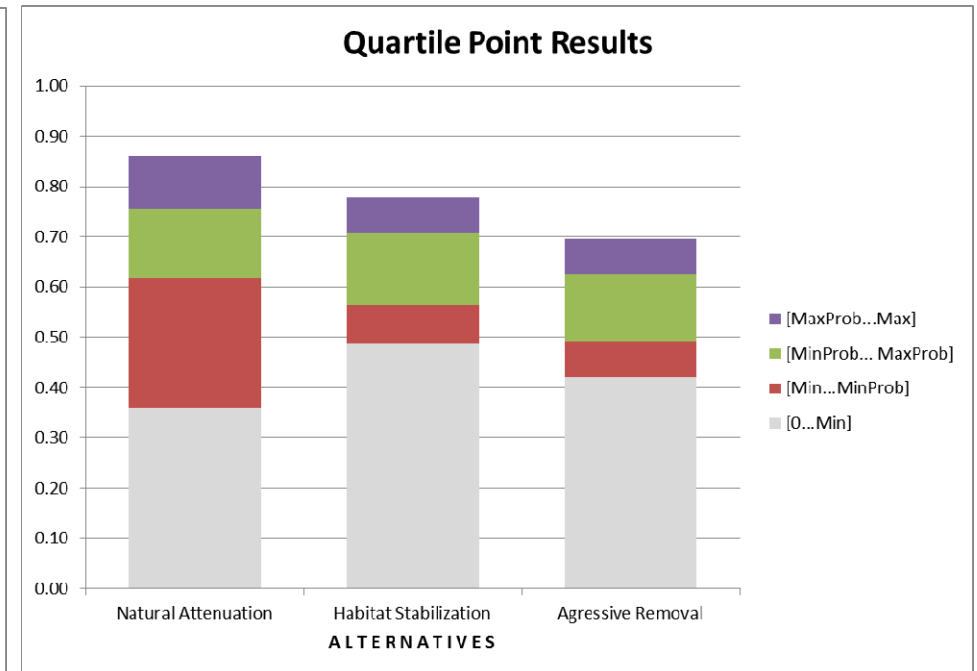
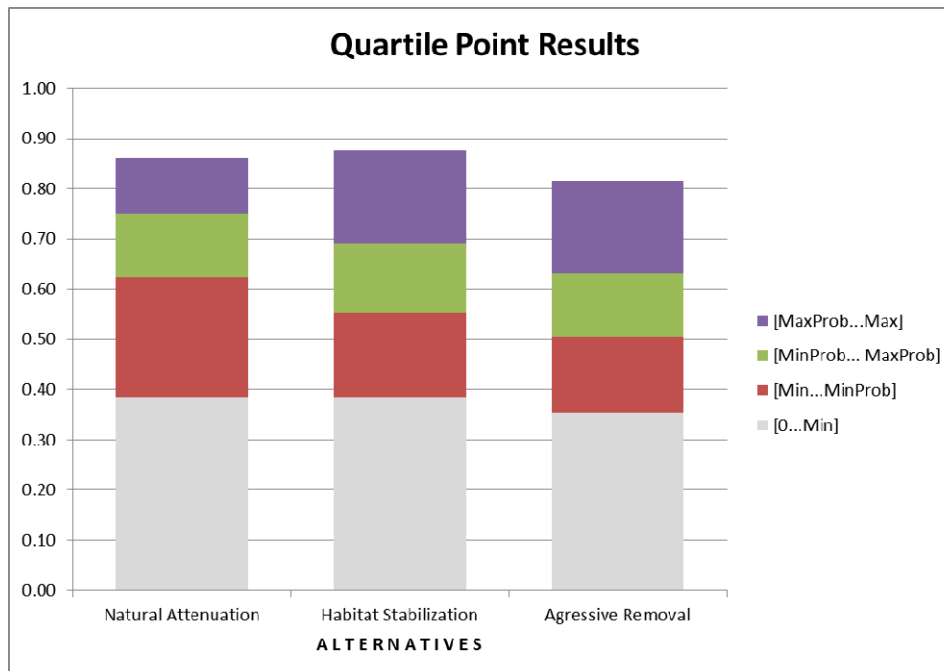
Data Output

Alt_Template

+

Visualization

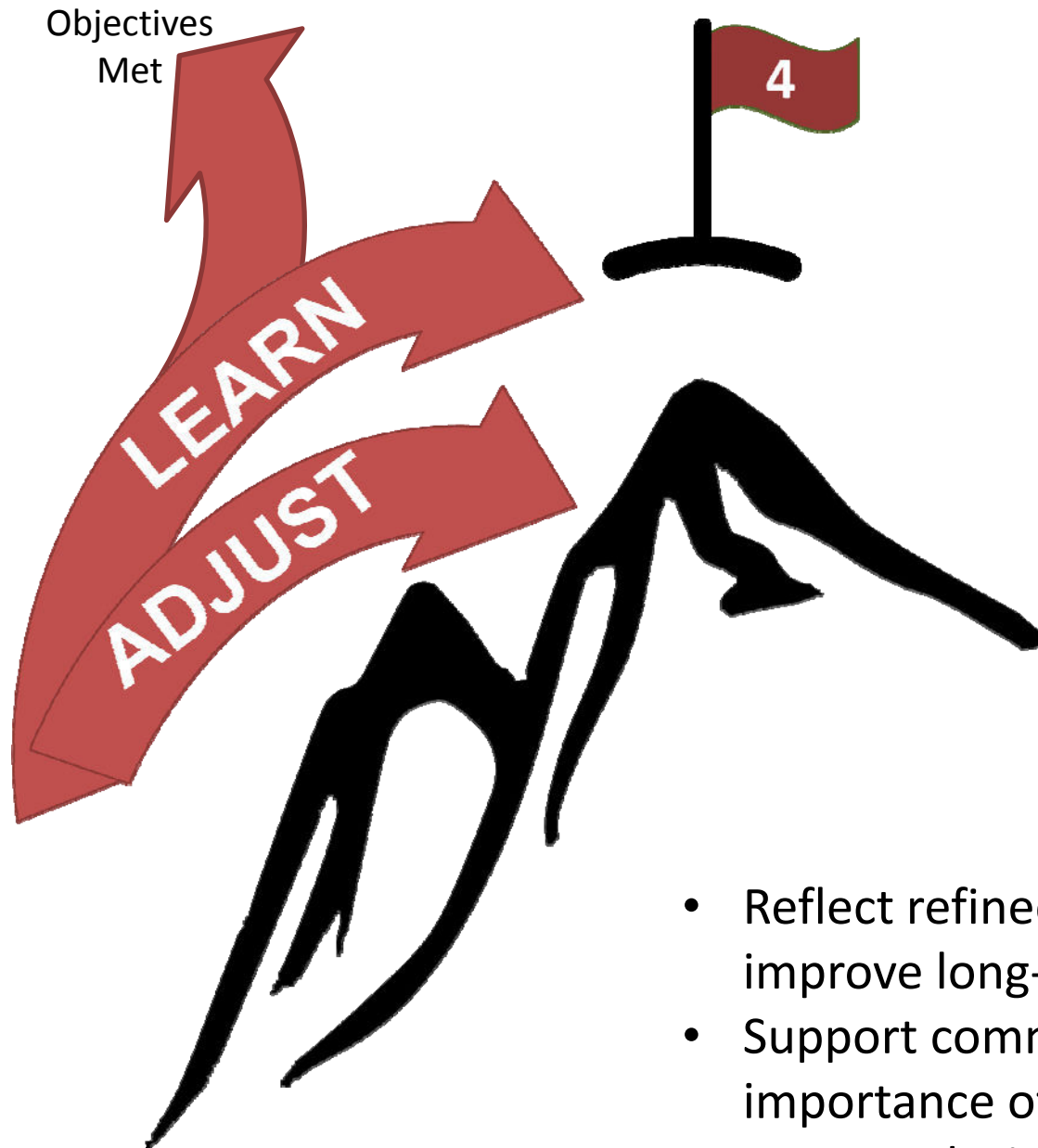
Shows the change in uncertainty in re-evaluation





Catalog improved understanding and demonstrate reduced uncertainty

- Anticipated monitoring results to confirm or negate effectiveness
- Model refinement
- Reduction in initial uncertainty



- Reflect refined technical predictions to improve long-term risk management
- Support communication about the importance of criteria and features
- Support design and consideration of novel alternatives

“POST” version, add “Pie in the Sky”

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	Remediate the source(s) of release							
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		Metric						
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	Reduction in Hg mobility from biochar							
		Estimated percent reduction			0	80	85	90
	Off Site Soil Treatment							
		Percent contained			100	100	100	100

PROGRESS

Weight Instructions

mini-SMARTER

Weight Report

Data Input Instructions

Alt_1

Alt_2

Alt_3

MCDA Model

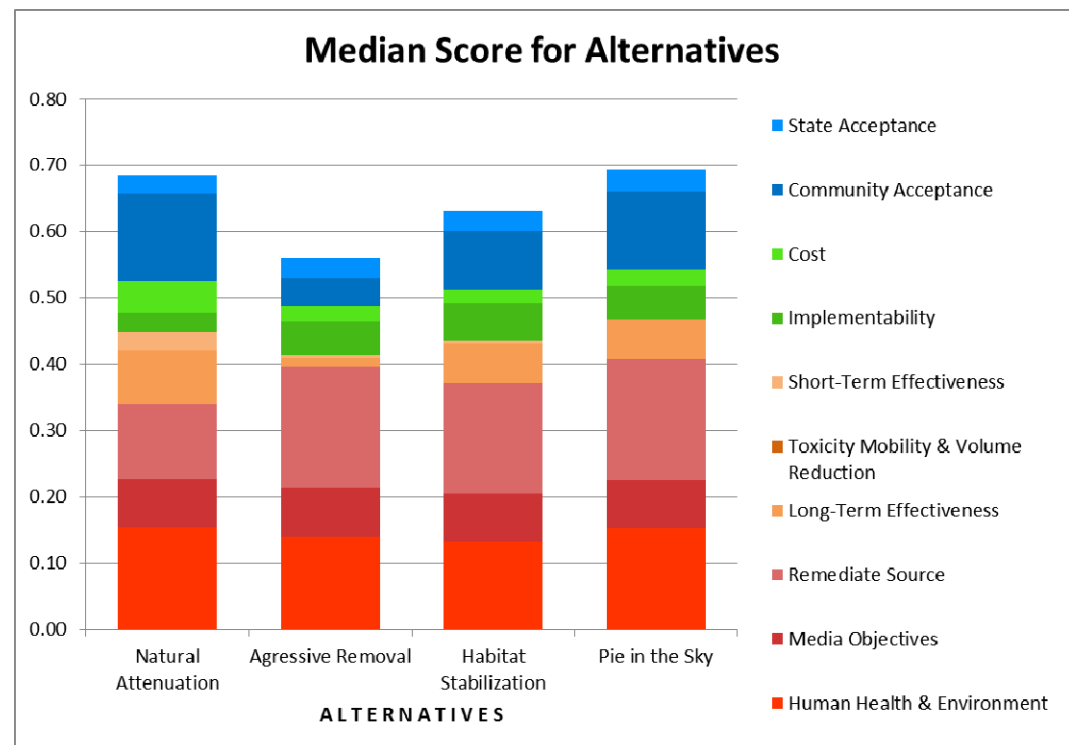
Data Output

Alt_Template

+

Future use:

- Develop hypothetical novel actions
- Initial evaluation, given different perspectives
- In retrospective analysis,
show how
understanding
of the system has
evolved





Use of the model in considering future action(s)

- Reflect refined technical predictions to improve long-term risk management
- Support communication about the importance of criteria and features
- Support design and consideration of novel alternatives

EAM Decision Model

- What did I hope to accomplish?
 - “look under the hood”
 - Parts of the tool, and their functions
 - Demonstrate how it stores predicted effects
 - Adding the alternative’s anticipated outcomes
 - Show how it can be used to visualize why a feature changes the value of an approach (for one group vs. another)
 - Looking at the value of “bank erosion” and “trees”
 - Provide some hypotheticals about its use in the future
 - Add “pie in the sky” alternative and see if it adds value for a perspective or group

EAM Decision Model

- Spreadsheet Tool
 - Not a “black box”
 - Doesn’t generate “answers” but is a way to organize existing information, and visualize uncertainty and preferences
 - Can to use for an initial (“what if”) comparison for a novel approach in the future



Establish AM Decision Model

Alternatives
Performance measures,
monitoring plans
Objectives

Remember that...

- Adaptive Management?
 - “structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring” (Wikipedia, 2016)
 - Common problems include “paralysis by analysis” (no action) and “trial and error” (no learning)

Conclusions

- Supports development of (increasingly certain) anticipated effects in time, under phased implementation
- Provides a framework on which to learn from current actions
- Focuses monitoring and research needs on the reduction of uncertainty
- Encourages preferred action under uncertainty