Identifying Decision-Relevant Uncertainty: Expected Value of Information

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Outline

- Types of uncertainty
- The expected value of perfect information (EVPI)
  - Walters' sockeye salmon
- The expected value of partial information (EVXI)
  - Whooping crane restoration
- Discrete vs. continuous uncertainty
- How does this apply to STAC's work?

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Uncertainty

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A brief classification of uncertainty

- Linguistic uncertainty
  - Imprecision in our language, in our goals, in how we specify actions
  - Types: vagueness, context-dependence, ambiguity, underspecificity, indeterminacy of term
- Aleatory uncertainty
  - Uncertainty or variation that is outside our control or cannot be reduced
  - E.g., environmental stochasticity
- Epistemic uncertainty
  - Uncertainty that arises from the incompleteness of our knowledge
  - Reducible
  - Arises from: observation error, model uncertainty, subjective judgment, etc.

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Epistemic Uncertainty

- Decision-relevant uncertainty
  - Uncertainty that is relevant *to the decision maker*
  - Resolution of this uncertainty would lead to a different decision (*a different allocation of resources*)
- Decision-irrelevant uncertainty
  - Uncertainty that might affect the outcome of the decision, but *does not affect* the choice of action

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EVPI

The Expected Value of Perfect Information

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Expected Value of Perfect Information (EVPI): Sockeye Salmon

Hypotheses	Options: Do not Build	Options: Build Channel
H_0: No response	240	135
H_1: Good response	240	564
Avg	240	349.5

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Decision: build artificial spawning channels?
Net economic value of the sockeye fishery ($M)
Assume 50:50 likelihood on two models

In absence of new information:
EV("build") = 349.5

If you can resolve uncertainty:
EV = 402

EVPI = 402 – 349.5 = $52.5M

from Walters (1986)

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EVXI

The Expected Value of Partial Information

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Expected Value of Partial Information

Runge et al. 2011. Which uncertainty? Biol. Cons. 144:1214-1223.

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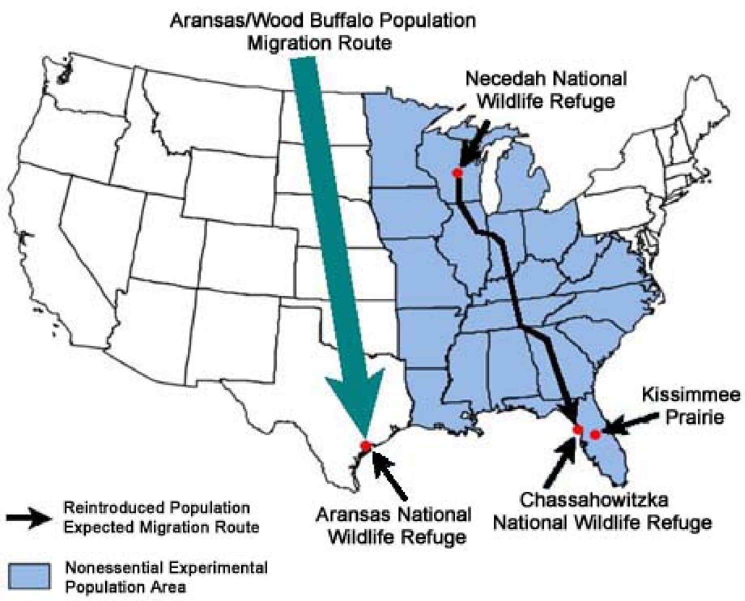

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Eastern Migratory Population

Year	Nests	Chicks
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	2	0
2006	6	2 (1 fledged)
2007	5	0
2008	11	0
2009	17	2 (0 fledged)

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Hypothesis	Weight	Strategy							Best Outcome
		Status quo	Kill flies: Bti & DD	Swap older eggs	Rest-ore mead-ows	April DD & burn	No salv-age	No Distur-bance	
Too Young									
Black flies									
Social									
Nutrient: NNWR									
Nutrient: winter									
Nutrient: both									
Egg Salvage									
Disturbance									
Expected Value									

Predicted Reproductive Success

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Hypothesis	Weight	Strategy							Best Outcome
		Status quo	Kill flies: Bti & DD	Swap older eggs	Rest-ore mead-ows	April DD & burn	No salv-age	No Distur-bance	
Too Young	9.4%	0.25	0.22	0.24	0.24	0.26	0.22	0.18	0.26
Black flies	29.1%	0.07	0.20	0.13	0.12	0.12	0.20	0.10	0.20
Social	11.9%	0.07	0.10	0.11	0.14	0.14	0.11	0.19	0.19
Nutrient: NNWR	22.8%	0.07	0.09	0.14	0.29	0.29	0.10	0.12	0.29
Nutrient: winter	5.9%	0.07	0.09	0.13	0.14	0.16	0.10	0.12	0.16
Nutrient: both	6.6%	0.07	0.09	0.14	0.24	[illegible]	[illegible]	[illegible]	25
Egg Salvage	4.4%	0.09	0.23	0.23	0.15	0.13	0.17	0.11	0.23
Disturbance	10.0%	0.09	0.15	0.25	0.13	0.11	0.11	0.15	0.25
Expected Value		**0.091**	**0.147**	**0.155**	**0.185**	**0.183**	**0.148**	**0.129**	**0.232**

Expected Value of Perfect Information: 0.047

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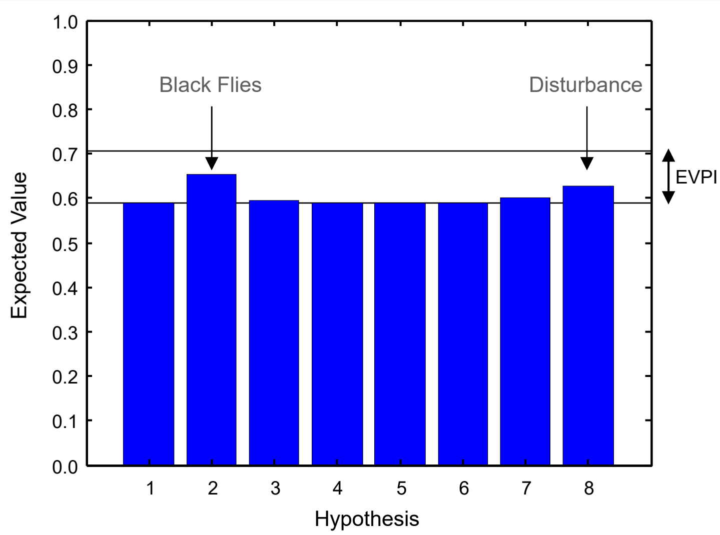
Partial EVPI



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Expressing Epistemic Uncertainty

Discrete vs. Continuous Expression

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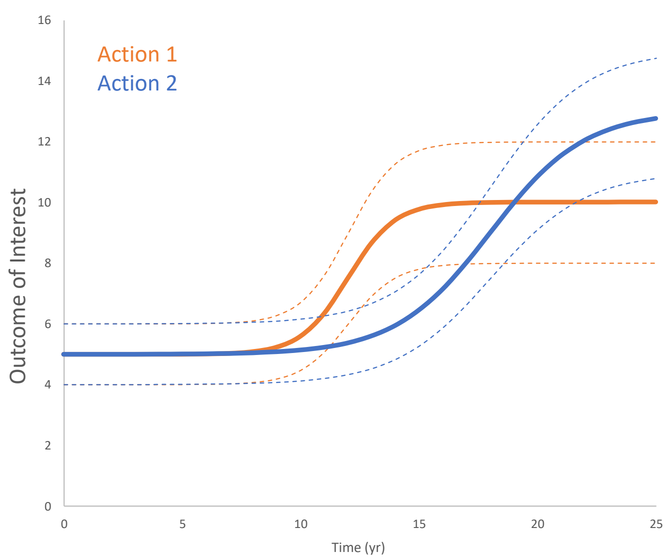

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VOI & STAC CESR

What does this mean for us?

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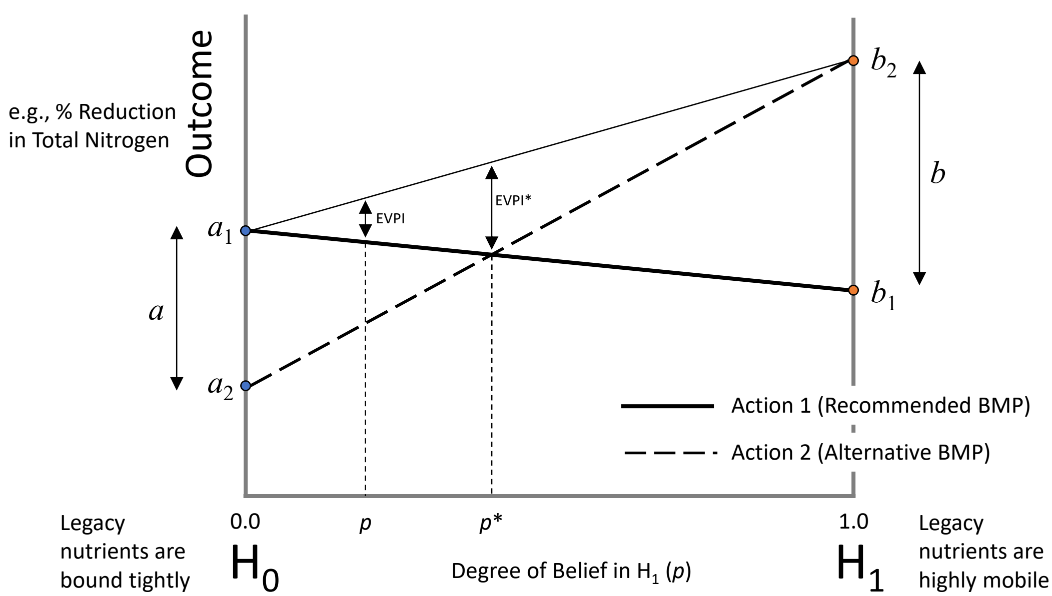
Expected Value of Perfect Information (EVPI)



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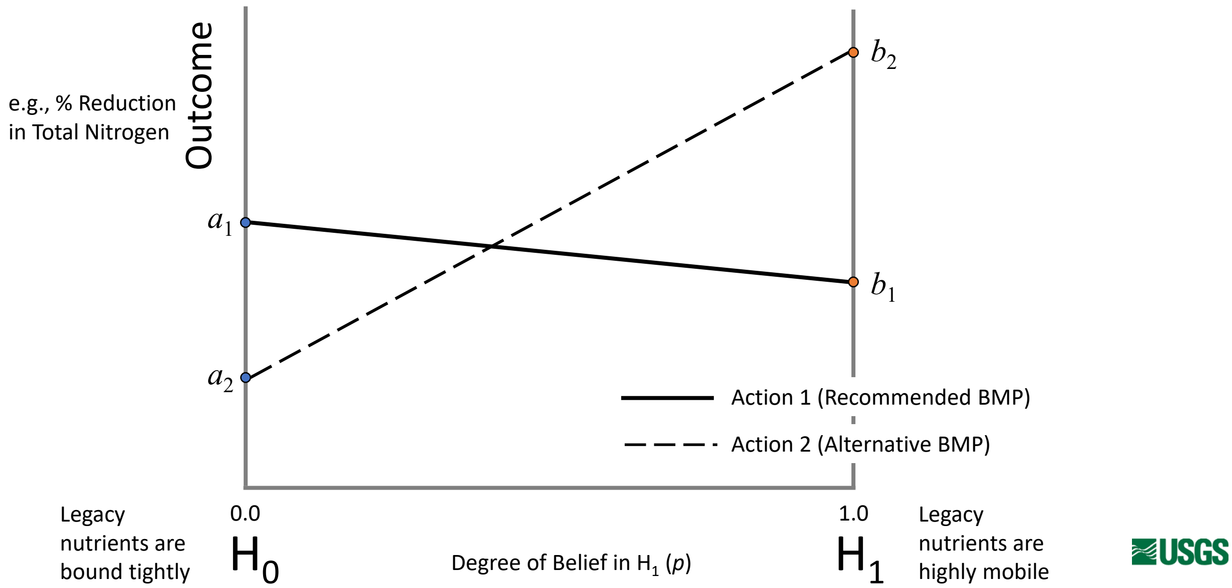
Expected Value of Perfect Information (EVPI)



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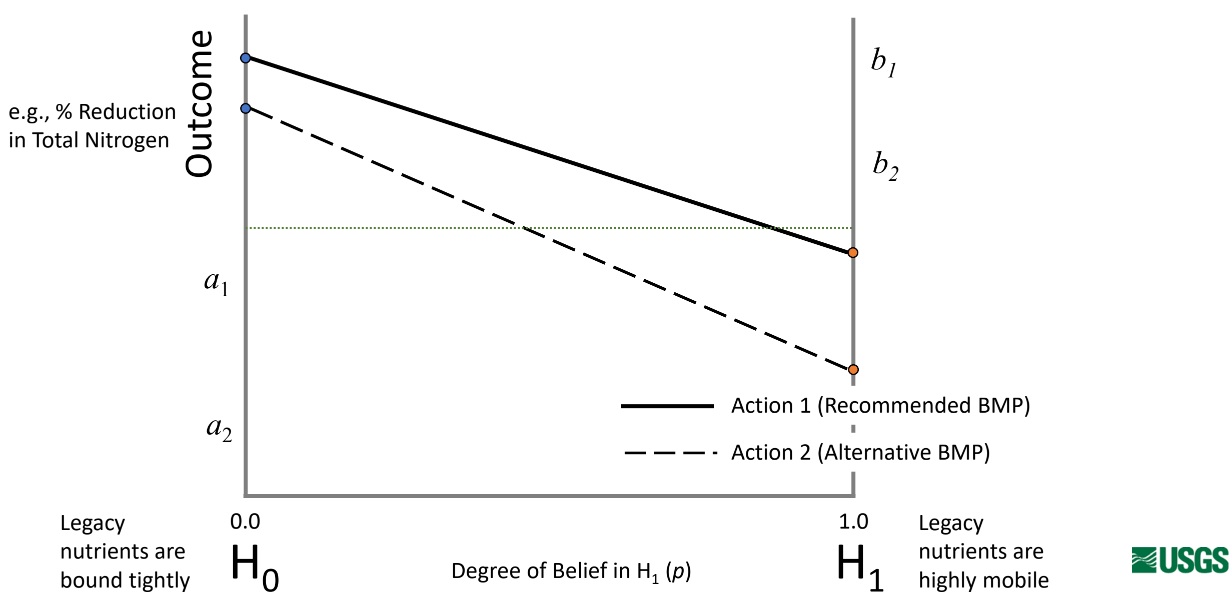
Expected Value of Perfect Information (EVPI)



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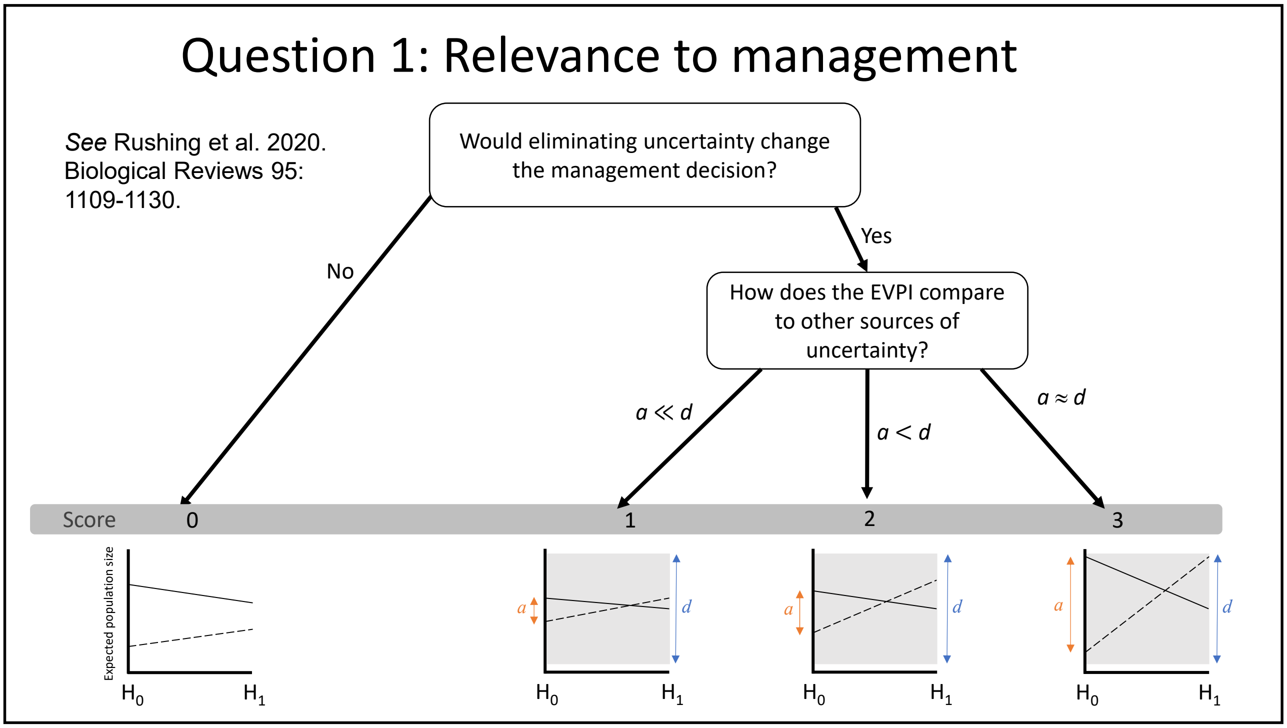
Question 1: Relevance to management
See Rushing et al. 2020. Biological Reviews 95: 1109-1130.
Would eliminating uncertainty change the management decision?
No
Yes
How does the EVPI compare to other sources of uncertainty?
a ≪ d
a < d
a ≈ d
Score
0
1
2
3
Expected population size
H0
H1
a
d

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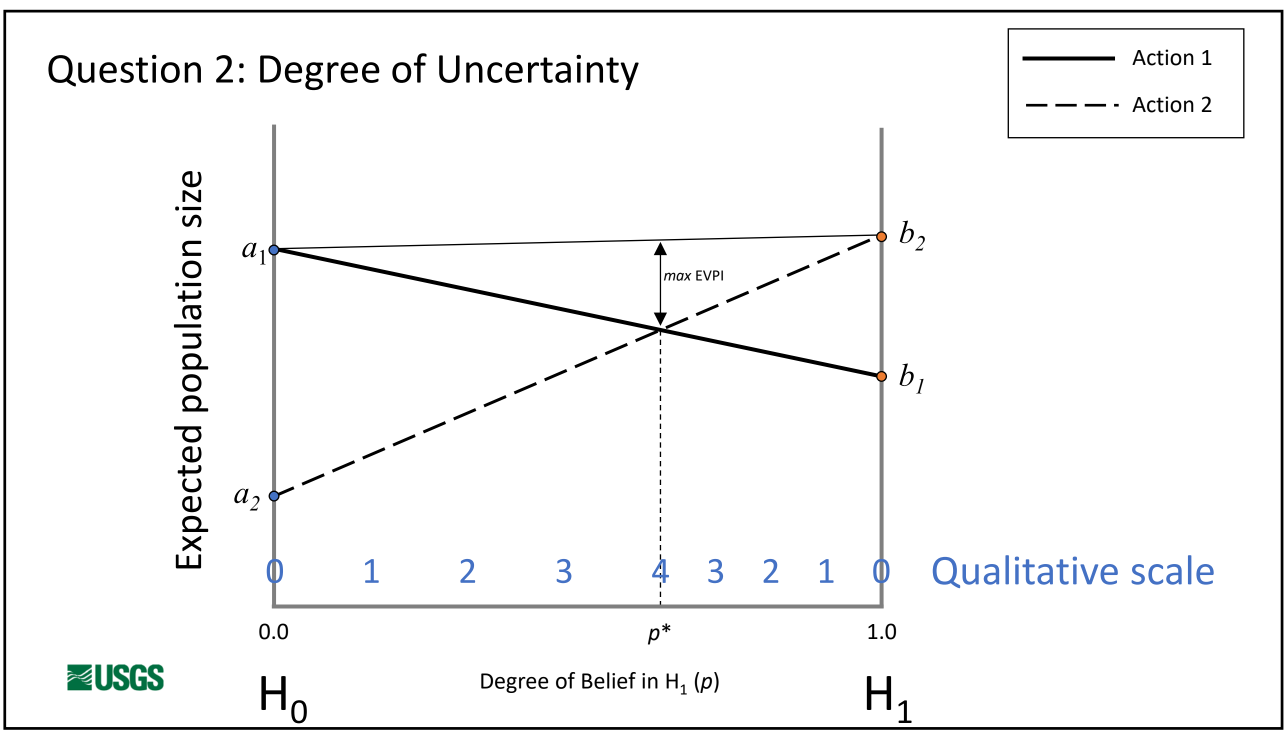
Question 2: Degree of Uncertainty
Action 1
Action 2
Expected population size
a1
a2
b1
b2
max EVPI
0 1 2 3 4 3 2 1 0
Qualitative scale
0.0
p*
1.0
Degree of Belief in H1 (p)
H0
H1
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Question 3: Reducibility

- How much can the relevant uncertainty be reduced?
  - Availability of existing data to reduce uncertainty
  - Feasibility of reducing uncertainty (power analysis)
  - Cost of reducing uncertainty

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Summary

- What's the relevant question for 2025?
  - A post-mortem on whether our predictions were right, or
  - An analysis of whether we should be taking different actions?
- These are very different framings
  - Which will identify different sources of uncertainty that matter
- Is this a useful framing for how STAC thinks about its work?

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