

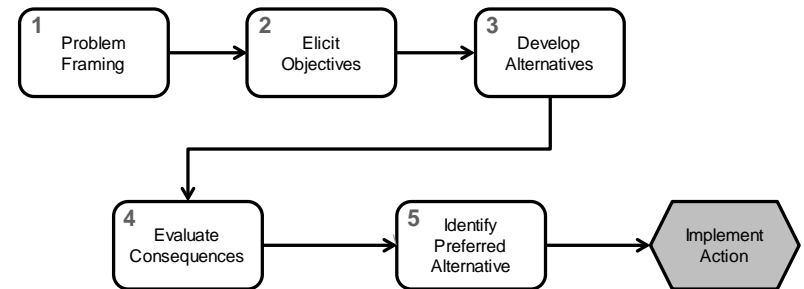
A draft framework for evaluating coral interventions: Structured decision making

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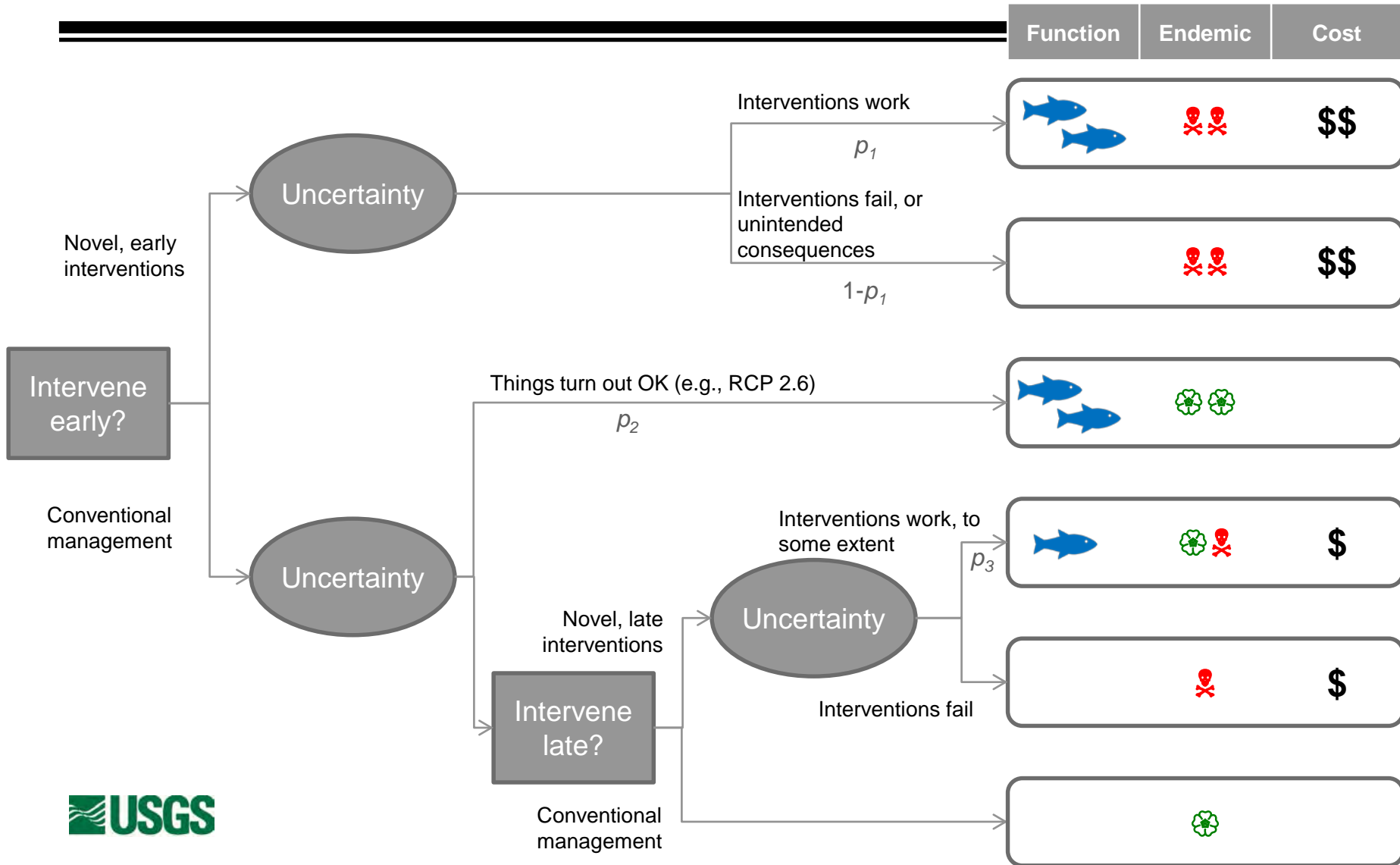
The National Academies of Science, Engineering, and Medicine
Interventions to Increase the Resilience of Coral Reefs
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When last we met...

- An intervention is a decision, which has to be implemented by someone
- The field of decision analysis provides a framework for
 - Structuring decisions
 - Multiple-objective decision
 - Risk decisions
 - Information decisions
- A draft structured framework for coral interventions



A framework for intervention



Getting the Structure Right

Objectives & measures

Interventions being considered

System models

Objectives

- Fundamental objectives (desired future conditions pursued for their own sake)
 - Ecosystem function provided by coral cover
 - Conserve coral biodiversity (total & endemic)
 - Ecosystem services (fishing, tourism, coastal protection, carbon sequestration, cultural values) [see Oleson, Aug 2018]
 - Costs of management
- Means objectives (pursued only as a means to fundamental aims)
 - Do all the “risks” fall in this category (disease introduction; species invasions, spread of inserted genes)?

Interventions

- Classes [see Bay, Aug 2018; also van Oppen, Aug 2018]
 - Geo-engineering
 - Reef structures and stabilization
 - Ecological and environmental adjustments
 - Reproduction and recruitment
 - Probiotics and enhanced bleaching survival
 - Assisted evolution
 - Synthetic biology & genetic engineering
- Nuances
 - Which interventions and where?
 - When: early intervention, or later intervention when some of the uncertainties are resolved?
 - In what combinations?

Embedded Uncertainties

- Climate trajectory (RCP?)
- Possibility of regime shift (ecological tipping point, e.g., algal dominance)
- Possibility of disease introduction
- Possibility of other invasive species that undermine ecological function
- Likelihood of intervention success
- Time to development and deployment of interventions



Subsequent Steps

Challenges & Tools I

- Uncertainty related to probability of outcomes
 - Step 1: estimation of uncertainty (*empirical risk analysis, expert judgment*)
 - Step 2: propagation of uncertainty through a system model to outcomes (*Bayesian belief nets, etc.*)
 - Step 3: ranking of interventions (*utility theory*; requires input from decision makers regarding risk tolerance)

Challenges & Tools II

- Identification of actions based on environmental thresholds
 - Option 1: treat as a *decision tree*, and solve for the indifference point
 - Option 2: set this up as a state-dependent decision (e.g., *stochastic dynamic programming*)
 - Note: decision thresholds and ecological thresholds are not the same thing
- Selecting from a suite of management options, particularly in combination
 - Modern Portfolio Theory, and related tools

Coral Reef Interventions

- Hallmarks of this decision
 - Multiple objectives that may compete
 - Uncertainty that cannot be reduced
 - Uncertainty that can possibly be reduced
 - Complex portfolios of actions (in time and space)
- Complementary tools that may be needed
 - Forecasting tools (accounting for uncertainty)
 - Multiple objective tools
 - Risk analysis tools
 - Value of information tools
 - Portfolio tools

Suggested Steps

1. Develop an overarching structure for the analysis
 - Identify the objectives, interventions, system structure, and parameters (*structured decision making*)
2. Estimate all the parameters, with appropriate expression of uncertainty
 - *Empirical estimation, expert judgment*
3. Forecast the outcomes for each alternative
 - *BBN* or other framework that can integrate all the uncertainty
4. Grapple with the values tradeoffs
 - Multiple objectives (*multi-criteria decision analysis*)
 - Risk tolerances (*utility theory, multi-attribute utility theory*)
 - Time preferences (*discounting methods*)
5. Rank interventions (or design portfolios?)



Questions?

