Structured Decision Making and Steelhead Conservation

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Outline

- Structuring Decisions
  - What is a decision?
  - What is a good decision?
  - How can we benefit from a structured process?
  - What is structured decision making?
  - Decisions worth thinking about
- The six kinds of decisions and steelhead conservation
- How to get started

What is a Decision?

- “Decisions are the only means you have to change your future life.” - Ronald Howard

- A decision is a conscious choice among two or more alternatives that allocate resources in the decision-maker’s control:
  - I decide to take a new job in a new city
  - A manager invests available funds in a particular habitat restoration strategy

- These seem like very different decisions, but the task is the same – we must choose a course of action from a set of ***alternatives*** based on some ***predictions*** of which alternative will best meet our ***objectives***

What is a Good Decision?

- One that achieves a good result? Or one that follows a process most likely to achieve a good result?
- Can a bad decision lead to a good outcome?
- The new hatchery manager tells his staff, "*I don't need data or any discussion. I have a gut feeling that if we adopt my new management plan, our outcomes will improve.*" He implements his plan and, indeed, outcomes improve.
- Was this a good decision? Would we expect this to be the best way to do things over time?

What is a Good Decision?

- We can’t perfectly control the outcome of our decisions, but we can control the way in which we make decisions
- Our goal should be a decision process that will improve – even maximize – the probability of a good outcome

How can we Benefit from a Structured Process?

A structured process for decision making can help us:

- deal with the challenges that make decisions hard
- account for all the important factors and relevant information
- explain to others how we reached a decision
- overcome our cognitive biases

Just like the scientific method helps us to overcome our cognitive biases in understanding how the world works, a structured decision process helps us to overcome our cognitive biases in decision making

What is Structured Decision Making?

- We all make lots of decisions every day, but some decisions are both more ***difficult*** and more ***important*** than others

- There is a huge amount of research and scholarship on human decision making, a field known as ***decision science***
- Arising from decision science is ***normative decision theory***, which is concerned with how people can make decisions most effectively

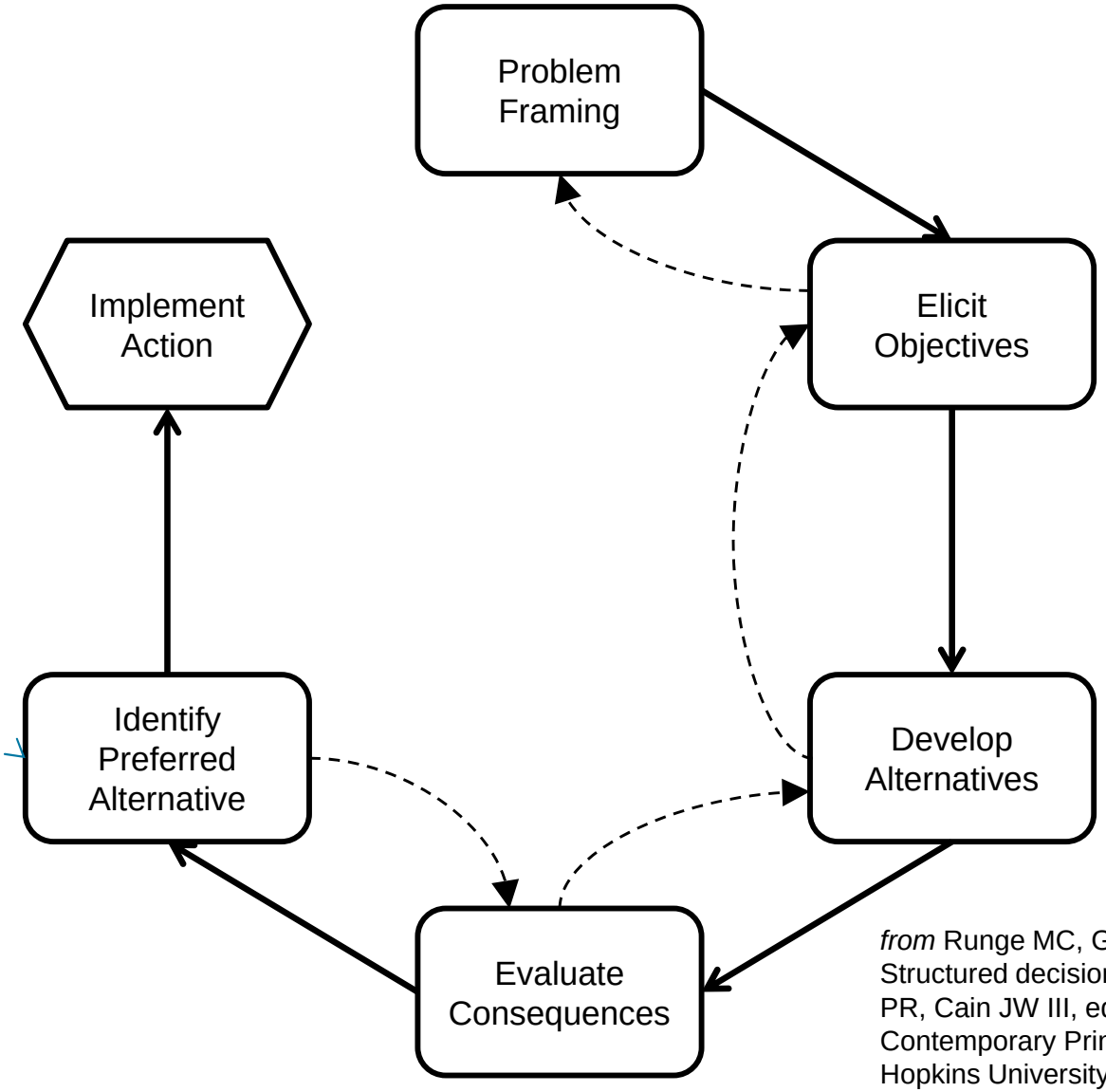
- Structured decision making is the application of this body of theory

What is Structured Decision Making?

PrOACT

- Defining the Problem
- Determining the Objectives
- Identifying Alternatives
- Forecasting the Consequences
- Evaluating the Trade-offs
- Taking additional steps: e.g., sensitivity analysis
- Making the decision and taking action
- Monitoring the outcome

What is Structured Decision Making?



from Runge MC, Grand JB, Mitchell MS. 2013. Structured decision making. Chapter 5 *in* Krausman PR, Cain JW III, eds. Wildlife Management: Contemporary Principles and Practices. Johns Hopkins University Press, Baltimore, Maryland.

What is Structured Decision Making?

Problem Decomposition

- All decisions are composed of a consistent set of component parts
- Breaking the problem into those parts helps us with complexity, and to identify what makes the decision hard
- We then have a whole arsenal of tools to bring to bear on those challenges

Values-Focused

- Our natural tendency is to be alternatives-focused: we start by asking what we can *do* rather than what we *want*
- This causes entrenchment, missed opportunities for creativity, and incomplete consideration of our values
- SDM requires us to focus on what we *want* first, before we consider what we can *do*

What is Structured Decision Making?

SDM in 31 words (Hugh Possingham):

- What do you want?
- What can you do?
- How do things you can do change what you want?
- Choose from things you can do to get what you want

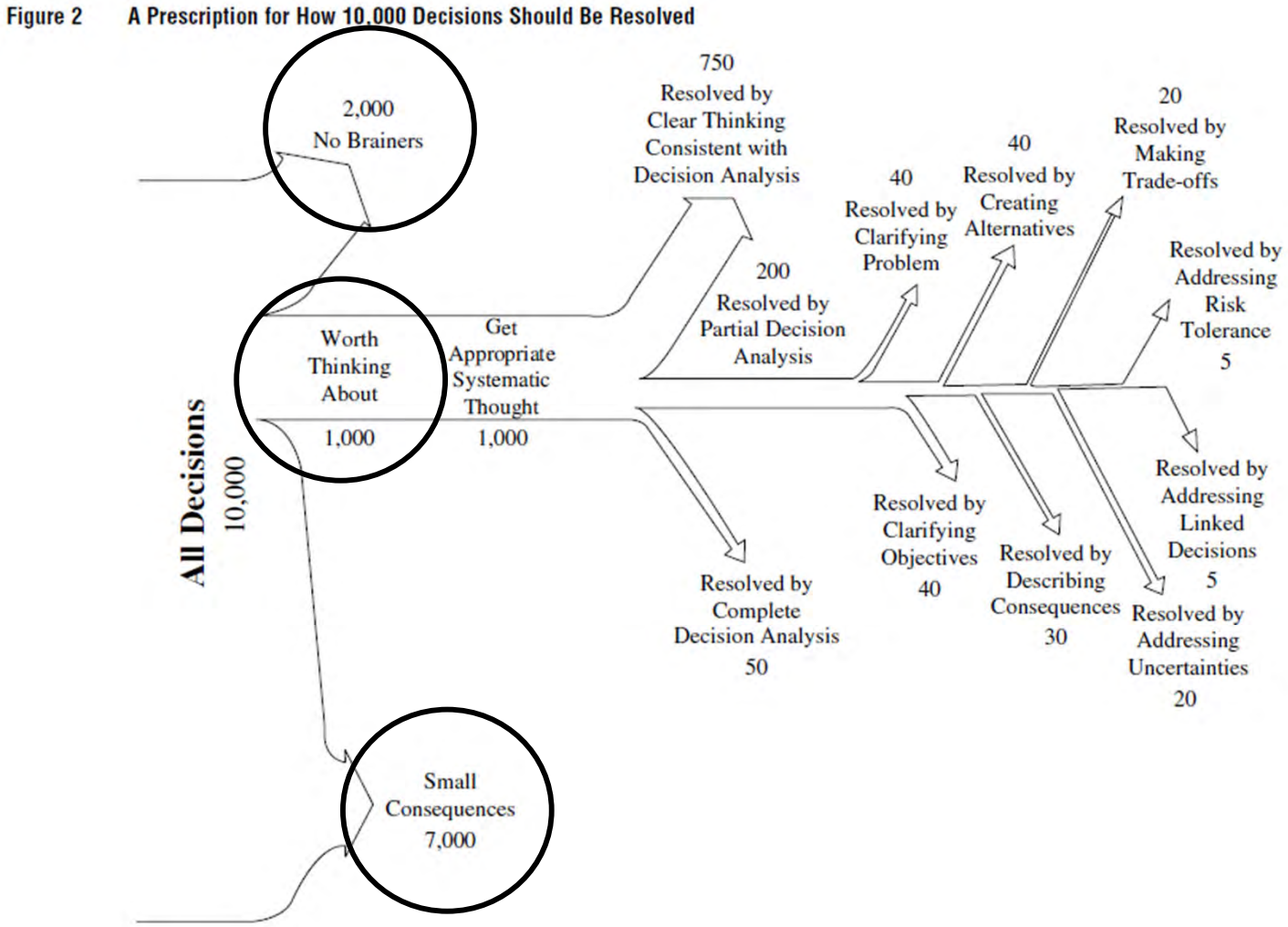
- Do
- Learn

What is Structured Decision Making?

- Decision analysis is “a formalization of common sense for decision problems which are too complex for informal use of common sense.”

  - Ralph Keeney

Decisions Worth Thinking About



Keeney 2004. Making better decision makers. Decision Analysis 1:193-204.

Decisions Worth Thinking About

- Decisions worth thinking about:
  - have meaningful consequences
  - are not “no brainers”

- What makes decisions hard?
  - The objectives are contradictory or complex
  - The alternatives are unknown
  - We have significant uncertainty about outcomes
  - Even knowing everything else, the best alternative is difficult to identify

The Six Kinds of Decisions

- In Runge et al. (2020), we argue that there are six fundamental kinds of decision problems
- Recognizing these decision types is useful for understanding how to structure the decisions and what tools to use to solve them
- The decision types are characterized by what makes the decision difficult:
  - Simple optimization problems
  - Multiple-objective problems
  - Risk problems
  - Information problems
  - Portfolio problems
  - Dynamic problems

Decision Classes

Classes

- Simple optimization problems
- Multiple-objective problems
- Risk problems
- Information problems
- Portfolio problems
- Dynamic problems

Each class of decision

- Has a specific challenge or impediment
- Has analytical tools to help

Class 1: Simple Optimization Problems

Description

- Issue of prediction lies at the heart of all decisions, but sometimes it's the main issue.
- The search for the solution is by inspection

Challenge

- "It's tough to make predictions, especially about the future"

Tools

- Data analysis and model building
- Linear programming (and others)

Your Decisions (Simple Optimization Problems)

- Choosing a hatchery water temperature to maximize steelhead viability
  - Some water temperatures will be too warm and reduce health, while some will be too cool and reduce growth

- This class, which is the simplest, is also the most rare

Class 2: Multiple-Objective Problems

Description

- Decisions with competing objectives

Challenge

- Science: forecast outcomes on all objectives
- Values: how to deal with trade-offs

Tools

- Multi-criteria decision analysis
- Multi-objective programming

Your Decisions (Multiple-Objective Problems)

- How should sea lion depredation on steelhead be addressed?
- Multiple objectives might include:
  - Comply with MMPA
  - Minimize public unhappiness
  - Minimize steelhead mortality
  - Minimize costs

- How should steelhead catch-and-release seasons be regulated?
- Multiple objectives might include:
  - Improve public experience
  - Increase compliance with regulations
  - Minimize negative effects on the population
  - Allow for broodstock collection

Class 3: Risk Problems

Description

- Decisions in the face of uncertainty when you do not have any other choice

Challenge

- Science: characterize the uncertainty
- Values: understand risk tolerance

Tools

- Decision trees, risk analysis, utility theory

Your Decisions (Risk Problems)

- Should a small population be listed under the ESA?
- Listing decisions are typically focused on understanding risk to the population in the face of uncertainty and making a decision in accord with the estimated risk

Class 4: Information Problems

Description

- Decisions about whether to gather more information

Challenge

- How much could the outcome be improved if uncertainty could be resolved prior to committing to action?

Tools

- Expected value of information

Your Decisions (Information Problems)

- How much should be spent on monitoring at dams?
- In a management setting, monitoring data should help us make better decisions – determining whether additional monitoring data will be helpful can be undertaken using *expected value of sample information*

Class 5: Portfolio Problems

Description

- Searching among a huge number of alternatives
- Resource allocation, portfolio selection, “prioritization” problems

Challenge

- Describing all alternatives
- Predicting outcomes in automated manner
- Smartly searching for the optimal solution

Tools

- Linear programming and other constrained optimization methods
- Solutions for “knapsack” problems

Your Decisions (Portfolio Problems)

- How should habitat restoration funding be allocated across multiple populations and stream reaches?
- We can build lots of different portfolios that involve differential investment in different spawning areas – sorting out which of these is optimal is the challenge

Class 6: Dynamic Problems

Description

- Decisions linked across time
- Adaptive management is a special case

Challenge

- Find the optimal solution that balances short-term costs and long-term benefits

Tools

- Dynamic programming and related methods

Your Decisions (Dynamic Problems)

- How should hatchery broodstock collections and releases be managed over time?
- The collections and releases we undertake this year will affect the population next year, and so on over time – I need to anticipate these dynamics in solving the problem

- Both adaptive management and management strategy evaluation fall into this class

Decision Problem Types

- Real problems are hybrids of these classes
  - The sea lion depredation management problem involves multiple objectives, but also risk due to uncertainty

How to get Started

Rapid Prototyping

- Start simple
- Sketch the decision structure
- Add complexity as needed
- Gain insight and revise
- Continue to revise as needed until a decision is reached

On high-stakes and difficult problems, bring in expertise

- Cooperative Research Units in Oregon, Washington, Idaho, and Montana have deep expertise in this area
- There is top-notch expertise in British Columbia (e.g., Compass Resource Management, Tara Martin at UBC)

How to get Started

Grow your own expertise

Resources

- University courses
- Short courses (e.g., through Cooperative Research Units, professional societies)
- National Conservation Training Center curriculum
- National Conservation Training Center Decision Analysis Certification Program
- Practice!

A couple of useful references

- Runge MC, SJ Converse, JE Lyons, and DR Smith. 2020. Structured decision making: case studies in natural resource management. Johns Hopkins University Press, Baltimore, USA.
- Hemming V, AE Camaclang, M Adams, M Burgman, K Carbeck, J Carwardine, I Chades, L Chalifour, SJ Converse, LNK Davidson, GE Garrard, R Finn, J Fleri, J Huard, HJ Mayfield, E McDonald-Madden, I Naujokaitis-Lewis, H Possingham, L Rumpff, MC Runge, D Stewart, VJD Tulloch, T Walshe, and TG Martin. 2022. An introduction to decision science for conservation. Conservation Biology: in press.