Ch 17: Projection and Decision Support

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Decision support

- Decision support is, at its heart, a forecasting problem.
- Decision making is ultimately not a technical question, but a question of values. Factual information resolves trade-offs.
- A *consequence table* (Gregory et al. 2012) summarizes how different alternatives perform for different performance measures.

Definitions

Forecasting – future prediction and projection.

Prediction – "probabilistic statement that something will happen in the future based on what is known today" (MacCracken 2001).

Projection – "probabilistic statement that it is possible that something will happen in the future" (MacCracken 2001) conditioned on boundary condition scenarios (Dietze 2017, p222).

Consequence table

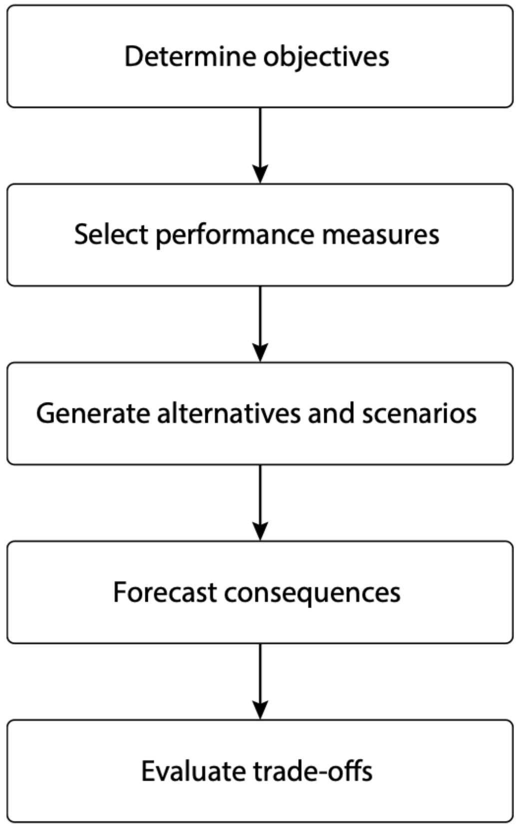

FIGURE 17.1. Decision support flowchart.

Consequence table showing initial objectives and alternatives developed by the consultative committee

Objective	Attribute	Direction	Status Quo	Preservation	Commercial	Terminal Benefits	Spread the Pain 1	Spread the Pain 2	Max Rebuilding	Spread the Pain 3	Sports Compromise
Conservation	% meeting Rec Plan Objective 1	H	73%	76%	82%	80%	72%	80%	84%	79%	81%
Conservation	% meeting Rec Plan Objective 2	H	32%	33%	33%	34%	31%	35%	34%	33%	34%
Conservation	No of returns in 2010	H	6.3	7.8	12.5	8.7	6.5	8.6	13.2	8.0	8.9
Conservation	No of returns in 2016-2019 (ave)	H	16.9	24.3	47.7	31.1	16.8	30.1	53.8	28.7	35.7
Conservation	Probability of extinction	L	2.4%	1.1%	0.0%	0.3%	3.4%	0.2%	0.0%	0.4%	0.2%
Conservation	% Enhanced fish 2010	L	27%	21%	56%	34%	26%	35%	52%	37%	46%
Conservation	% Enhanced ave fish 2016-2019	L	33%	29%	45%	41%	32%	42%	41%	45%	46%
Costs	Total Costs	L	$ 171	$ 309	$ 588	$ 488	$ 171	$ 523	$ 588	$ 328	$ 500
Catch	Total Downstream	H	1,925	304	6,601	3,391	3,391	4,642	1,925	4,618	4,642
Catch	Total Upstream	H	637	2,884	504	2,365	2,365	2,335	3,054	2,131	2,335
Catch	Total First Nations	H	777	739	769	796	796	768	797	768	768
Jobs	Total FTEs	H	1.60	2.80	4.10	3.70	1.60	3.30	4.10	2.50	4.10

Using Structured Decision Making to Help Implement a Precautionary Approach to Endangered Species Management **Risk Analysis, Volume: 29, Issue: 4, Pages: 518-532, First published: 18 March 2009, DOI: (10.1111/j.1539-6924.2008.01182.x)**

Using Structured Decision Making to Help Implement a Precautionary Approach to Endangered Species Management

Robin Gregory, Graham Long

Abstract

Endangered species protection is a significant risk management concern throughout North America. An extensive conceptual literature emphasizes the role to be played by precautionary approaches. Risk managers, typically working in concert with concerned stakeholders, frequently cite the concept as key to their efforts to prevent extinctions. Little has been done, however, to evaluate the multidimensional impacts of precautionary frameworks or to assist in the examination of competing precautionary risk management options as part of an applied risk management decision framework. In this article we describe how decision-aiding techniques can assist in the creation and analysis of alternative precautionary strategies, using the example of a multistakeholder committee charged with protection of endangered Cultus Lake salmon on the Canadian west coast. Although managers were required to adopt a precautionary approach, little attention had been given to how quantitative analyses could be used to help define the concept or to how a precautionary approach might be implemented in the face of difficult economic, social, and biological tradeoffs. We briefly review key steps in a structured decision-making (SDM) process and discuss how this approach was implemented to help bound the management problem, define objectives and performance measures, develop management alternatives, and evaluate their consequences. We highlight the role of strategy tables, employed to help participants identify, alternative management options. We close by noting areas of agreement and disagreement among participants and discuss the implications of decision-focused processes for other precautionary resource management efforts.

Objectives and performance measures

- Objectives describe the desired direction of change, but do not prescribe targets.
- Performance measures should not unnecessarily be monetarized.

Scenarios

- Boundary condition = driver = scenario (treated as synonyms in Dietz 2017).
- Representative "what-if" statements.
- Not meant to be random samples from a set of plausible futures

  => Do not average, evaluate individually
- Scenario can have different definitions in the literature. A scenario meets the definition of an "alternative" in decision support.
- Can be used to evaluate rare low probability events with large impacts: "failures of imagination", "unknown unknowns".

Definitions - alternatives

- Robust alternatives perform adequately over a wide range of uncertainties
- Brittle alternatives are optimal but sensitive to deviations
- Adaptive alternatives learn as they go, refining approaches as additional data is collected and uncertainties are reduced over time

Alternatives and scenario development

- Scenarios are not to be random samples.
- Any decision is only as good as the set of alternatives considered.
- Once the bookends are established, consider a wide range of alternatives including minority viewpoints.

Alternatives and scenario development

The development of scenarios is subject to cognitive bias

- Anchoring: value assigned to alternatives is relative to an initial impression (often the status quo)

  FIX => Use bookends to focus on the range

- Representative bias: stereotyping
- Availability bias: giving more weight to recent examples
- Sunk cost bias: protecting and justifying earlier choices
- Groupthink: premature convergence to one viewpoint without sufficient analysis

Alternative and scenario development

- Time, money, manpower and computation are practical limitations.
- 4-12 alternatives to be discussed by stakeholders, narrowed down to 3-4 to be presented to decision maker (Schwartz 2005)
- "Paradox of choice": when there are too many choices it is difficult to keep track of the differences between them.
- Alternatives need to:
  - have neutral names, i.e. not "pro-business"
  - be complete, comparable and internally consistent. Also mutually exclusive.
  - enough detail to drive projections

Consequences and uncertainties

- This is the forecasting/modelling component.
- Linguistic uncertainties associated with vagueness, ambiguity, under-specificity (unwanted generality), context dependence, indeterminacy (change in meaning over time) should be minimized.
- Epistemic uncertainties are those associated with knowledge and were the focus of much of the *Ecological Forecasting* book.
- Further data collection should focus on aspects that affect the decision.

Careful thought should be given to how uncertainties are reported

- The full PDF, or many summary statistics, are likely unhelpful
- Most end-users that have not been trained in statistics will interpret all values in a confidence interval as equally likely
- 1 in 20 is easier to understand, but perceived as higher risk than 5%
- Most people cannot visualize the difference between 1 in 1 million and 1 in 1 billion
  - It can be helpful to report relative to a baseline

Risk tolerance

- Risk tolerance is how gains and losses are perceived
- A 10% loss is perceived, on average, to be twice as bad a 10% increase (Berger 1985; Kahneman 2013)
- Downside reporting and exceedance probability can help as risk perception (and consequences) are asymmetric (losses are worse than gains).
- Downside reporting is reporting relative to a worst plausible case.

Risk tolerance

- The worse plausible case: “plausible” is defined relative to a pre-defined probability.
- Exceedance probability – probability of exceeding a pre-defined threshold.
- Decision-makers may be less risk averse when decisions are repeated because consequences average out. As a decision becomes more routine, we progressively become more risk neutral.

Precautionary alternatives

- Precautionary alternatives apply the precautionary principle embodied in the United Nations (1993) Rio Declaration on Environment and Development:

  Lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation

- Being precautionary involves trade-offs with other objectives and it may be useful to develop alternatives that explore different levels of precaution

Utility: Value and risk tolerance

Utility is often logarithmic

Economists represent the concepts of value, preference, and risk tolerance as utility

Utility functions are used to compare performance measures:

$$E[U] = \int U(a, y)P(y)\ dy$$

a is an action

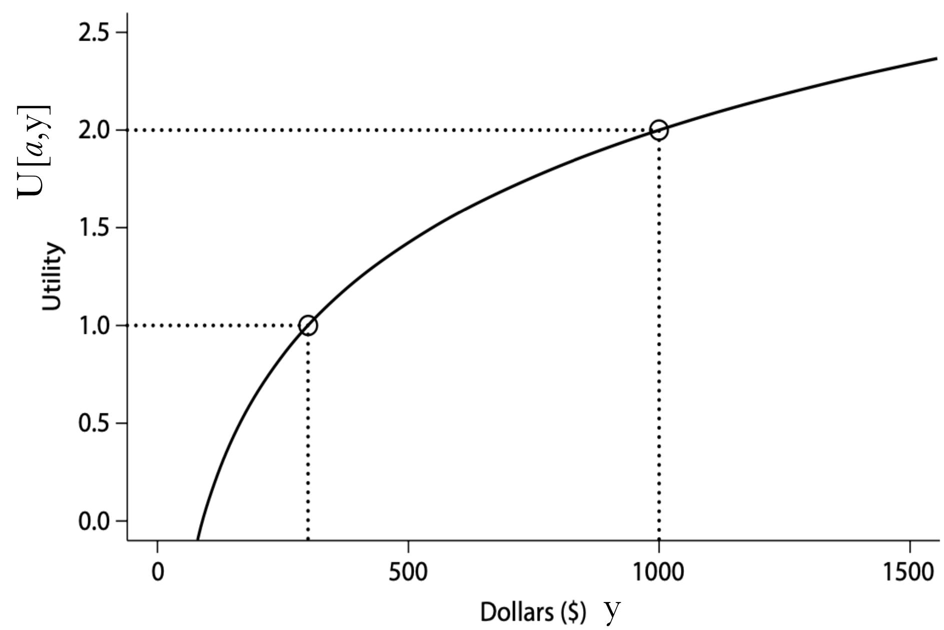

FIGURE 17.2. Example utility function. The meaning of utility is primarily a relative measure so the units can be arbitrary. In this example the reference value of $300 is used as a baseline ($U = 1$) for estimating the utility of $1000.

Trade-offs: “winnowing of alternatives”

1. Deleting bad alternatives and insensitive performance measures
2. Refining our understanding of key tradeoffs
3. Adding new alternatives that address these trade-offs

Objective	Attribute	Direction	Status Quo	Preservation	Commercial	Terminal Benefits	Spread the Pain 1	Spread the Pain 2	Max Rebuilding	Spread the Pain 3	Sports Compromise
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Dominated alternatives

- Dominated alternatives: lose on all measures relative to another alternative.
- "Practically" dominated alternative: there are tradeoffs, but they are judged to be negligible.

Pareto optimization

- Used when there are many alternatives, such that manual consideration isn’t feasible
- Seeks to clarify the trade-off front (termed ‘Pareto Front’)

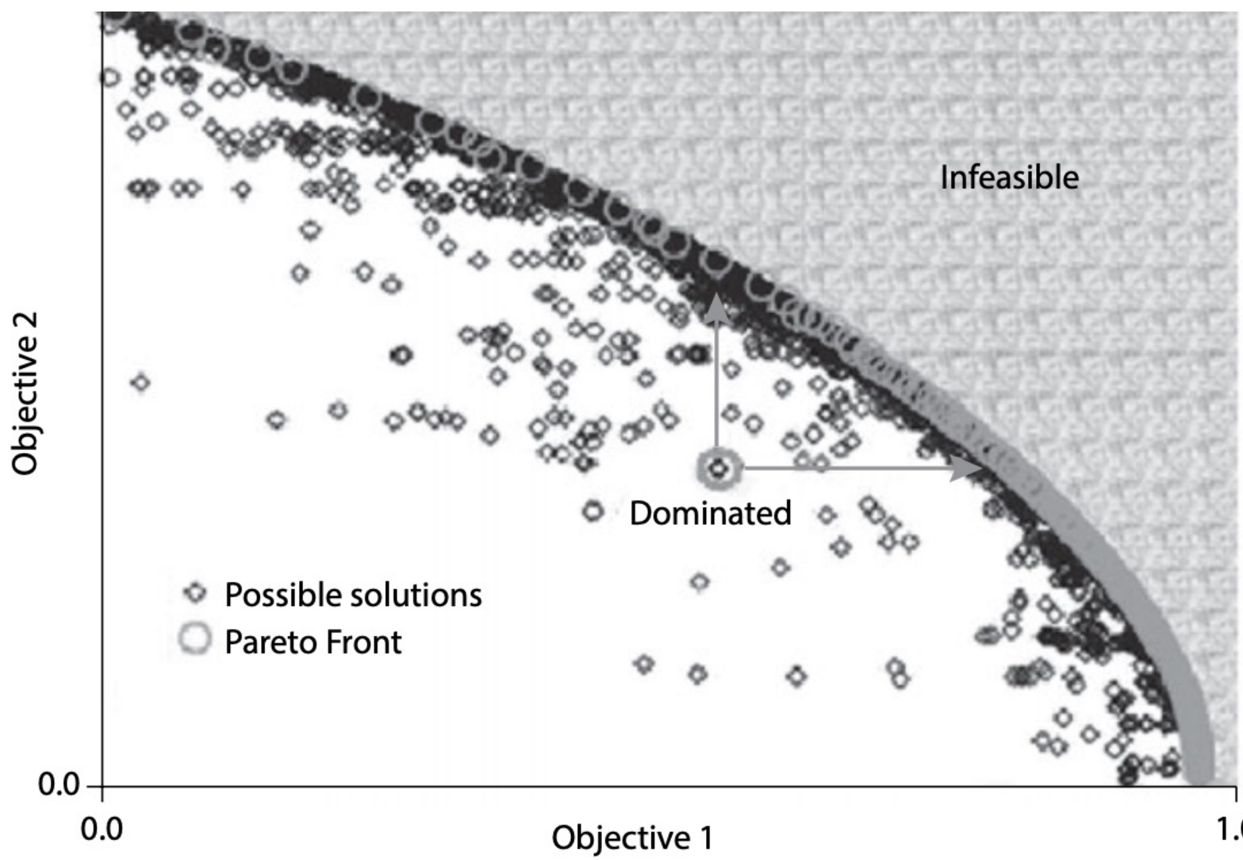
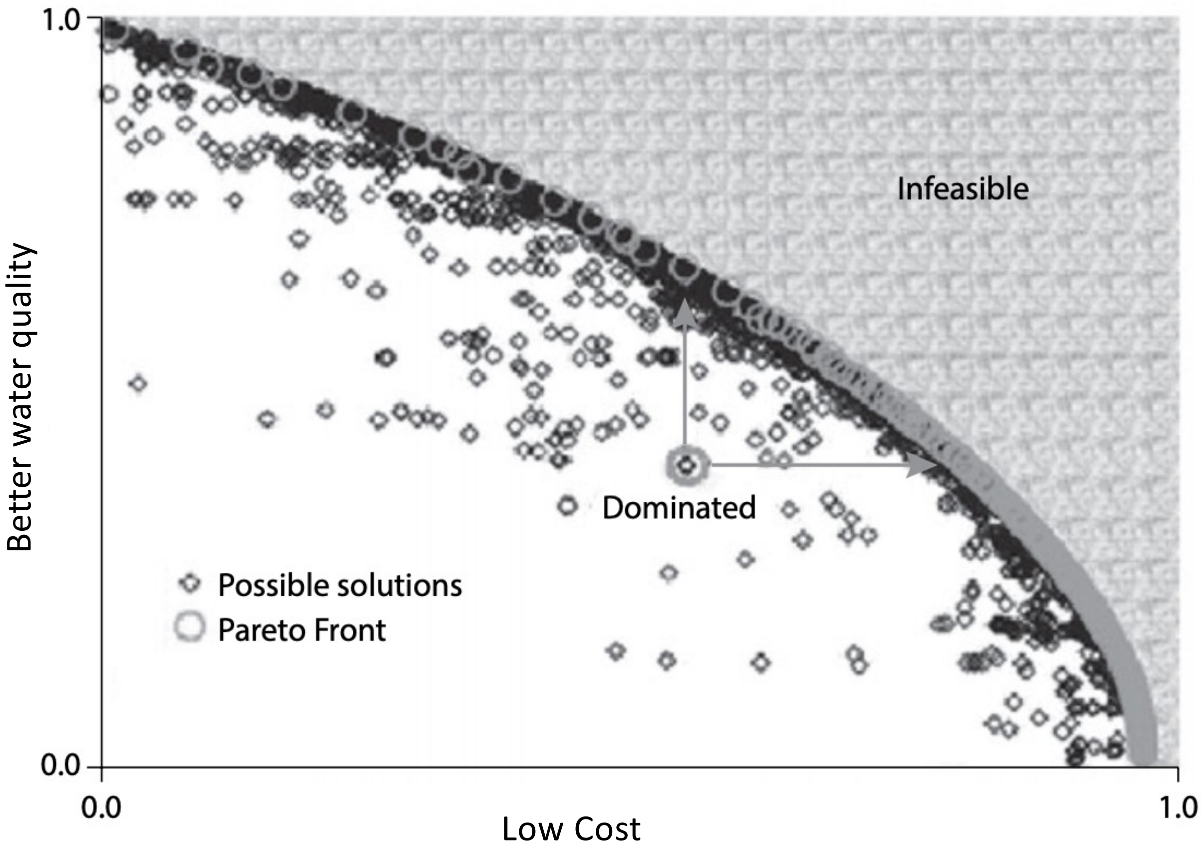


FIGURE 17.3. Pareto optimization aims to optimize multiple objectives simultaneo eliminating alternatives that are dominated (perform worse on all measures), and identify the trade-off surface across objectives (the Pareto Front). Reproduced from gerhut et al. (2010).

Have stakeholders evaluate the consequence table

Which alternatives do they enthusiastically support/are willing to accept/actively oppose?

- Can any alternatives be eliminated due to lack of support?
- Identify ‘no-regret’ actions – features that are common to all alternatives along the Pareto front that can be implemented immediately without disagreement



No-regret action: no disagreement and along Pareto front

Ex. implement volunteer community monitoring program

Swing weighting

1. Imagine an alternative that performs worst on all metrics
2. Consider, if you could improve one objective, which would be it?
   - Label this objective, i=1, and assign p_1 = 100.
3. Iteratively repeat 2, and assign appropriate p_i
4. When all objectives have been considered, calculate

$$w_i = \frac{p_i}{\sum p_i}$$

5. Perform sensitivity analyses to determine if choices are robust to small changes in weights

Critical value analysis

- Considers how much a performance measure would have to change to change the decision.
- Calculates the probability of crossing this threshold.

Provinces ramp up COVID-19 boosters as they try to head off Omicron surge

KELLY GRANT > HEALTH REPORTER
MIKE HAGER >
PUBLISHED DECEMBER 20, 2021

This article was published more than 1 year ago. Some information may no longer be current.

Conclusions

- Better than 50:50 is the only the only threshold for modelling to be useful for decision-making.
- Decision support may end with a narrowed set of alternatives and a clear identification of the trade-offs between them.

Conclusions

- The goal of decision support is not to reach consensus, but to inform decision makers about how different trade-offs are viewed.
- Decision support must consider a wide suite of cognitive biases in how both alternatives and probabilities are generated and presented.
- Precautionary, adaptive, and robust alternatives may guard against risk and uncertainty.

Conclusions

- Within decision support, modelling occurs as estimating the consequences of decisions
- The accurate quantification of uncertainty is essential to guard against decisions that are overconfident or excessively precautionary.
- The only “bad” trade-offs are the ones we make unknowingly, or without fully appreciating their implications.