Introduction to Structured Decision Making

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Choosing a Mortgage

- Your bank offers you two possible 30-yr fixed rate mortgages: 5¼ %, or 4¼ % with 2 points. Which do you choose?

Financial Example

- Problem: Choose a mortgage
- Objectives: Maximize proceeds less costs
- Actions: Choice between two 30-yr fixed rate mortgages
- Consequences: Use financial formulas (model) to calculate costs and proceeds at time of sale
- Trade-offs: Directly compare consequences (only 1 objective here)

Spreadsheet

OK, that was easy

- Why?
  - Simple set of actions
  - Single, clear objective
  - System dynamics known with certainty
  - Choice of best action transparent
- But what if
  - One of the choices is a 1-yr ARM? Or, in fact, there is a bewildering array of choices from many lenders?
  - You don't know how long you'll be in the house?
  - You have other objectives or constraints (e.g., monthly payments needs to be less than $1000)?

What makes decisions hard?

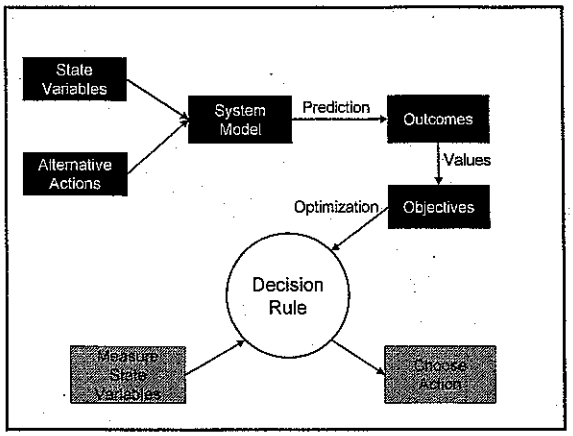
- Sometimes you don't know all the possible actions
- The objectives may be complex or contradictory, or in dispute
- The system dynamics may be poorly known
- Even knowing all the other components, the solution (optimization) may be difficult to figure out

Structured Decision Making

- Is a formal method for analyzing a decision, by breaking it into components
- Helps identify where the impediments to a decision are, to focus effort on the right piece
- Provides a wide array of analytical tools for dealing with particular impediments

Structured Decision Making

- Integrate
  - Management objectives
  - Alternative management actions
  - Predictive models of system response
- To identify optimal actions
  - Optimal control theory provides methods



Objectives

- Explicit statement allows focused discussion, negotiation, and evaluation
- Should capture implied trade-offs
- The objective drives everything else
- Ultimately, a societal question

Potential Actions

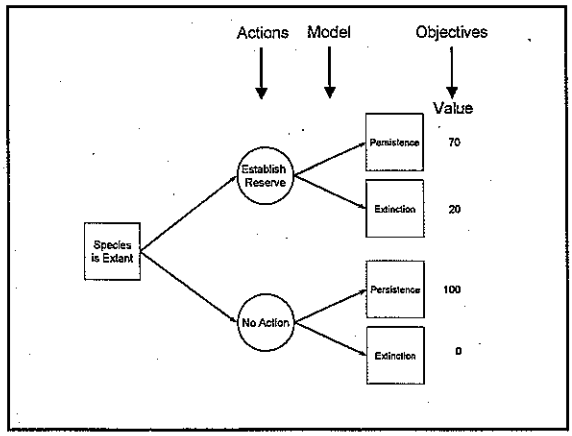
- Considerations
  - Political
  - Technological
  - Scientific
  - Economic
- Development of alternatives requires creative integration of these

System Model

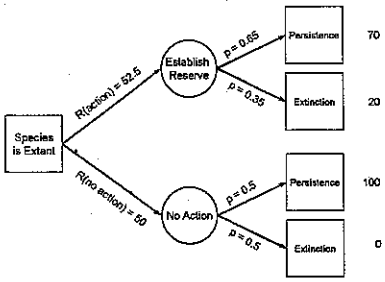
- Represents the state of knowledge
  - But, detail should be specified by context
- Is used for prediction
- Predictions may be distributions, over which expectations may be taken
- Should capture the scientific uncertainty about how the system responds

Decision Trees

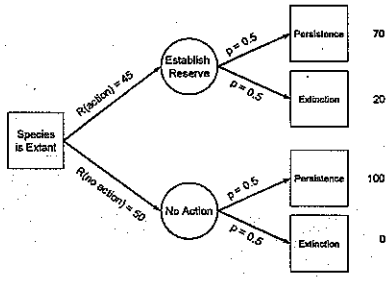
The classic technique, but only one of many



Management improves persistence

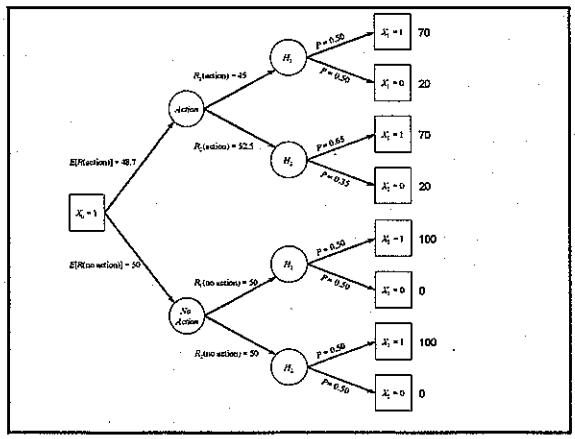


Management has no effect

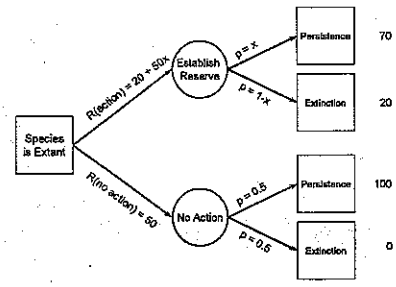


Structural Uncertainty

- Include uncertainty in the state transitions associated with each management action
- Which of the previous models is "right": conservation increases P(persistence) or not?
- Now focus on model-averaged mean utility, with equal weights for each model



Deriving Decision Rules



Rule: Take action if x > 0.6

Multiple Objective Problems

Impoundment Repair

Expected Return	Actions			
Objectives	Status quo	Minor repair	Major repair	Re-build
Cost ($M)	0	5	12	20
Environmental Benefit (0-10)	1	3	10	10
Disturbance (0-10)	0	1	7	10
Silt runoff (k ft³)	3	1	5	5
Water Retention (MG)	41	42	40	41

Impoundment Repair

Expected Return	Actions			Dominated Alternative
Objectives	Status quo	Minor repair	Major repair	Re-build
Cost ($M)	0	5	12	20
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Irrelevant Objective

Impoundment Repair

Expected Return	Actions			
Objectives	Status quo	Minor repair	Major repair	Re-build
Cost ($M)	0 + 1 = 1	5	12 + 2 = 14	20
Environmental Benefit (0-10)	1	3	10	10
Disturbance (0-10)	0	1	7	10
Silt runoff (k ft³)	3 – 2 = 1	1	5 – 4 = 1	5
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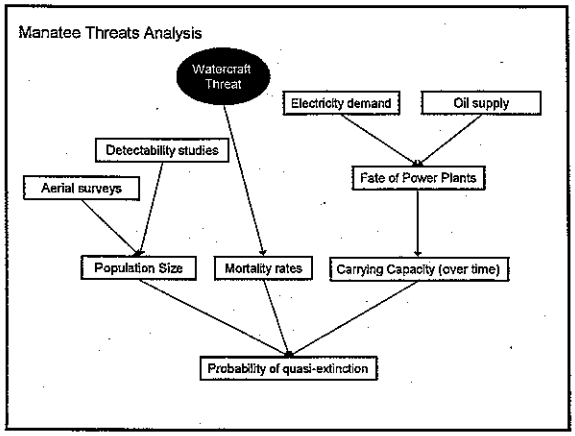
Even Swap

Multiple Objective Decision Analysis

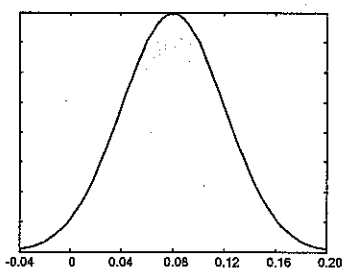
- In this way, complex sets of objectives can be reduced
- There are a variety of approaches to finding a solution based on the remaining objectives
  - We can explore some of these later if necessary

Uncertainty

Influence diagrams and Bayes Nets



Articulate Uncertainty



Understanding Uncertainty

- Risk assessment
  - The analytical side
  - How does uncertainty propagate through our predictions?
- Risk management
  - The policy side
  - What is the decision-maker's attitude toward uncertainty?

Objectives under Uncertainty

- The decision maker's attitude toward uncertainty is actually part of the objective function
- Thus, there is considerable nuance to specifying objectives
- A few brief comments from a vast subject:
  - Formal approaches: expected utility, VOI, robustness
  - Informal approaches: sensitivity analysis
  - Iterative development

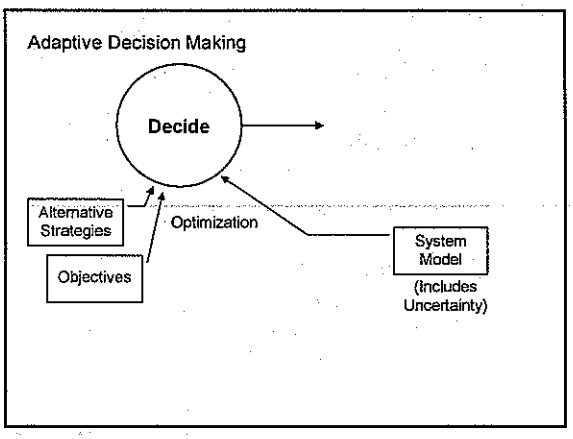
Linked Decisions & Adaptive Management

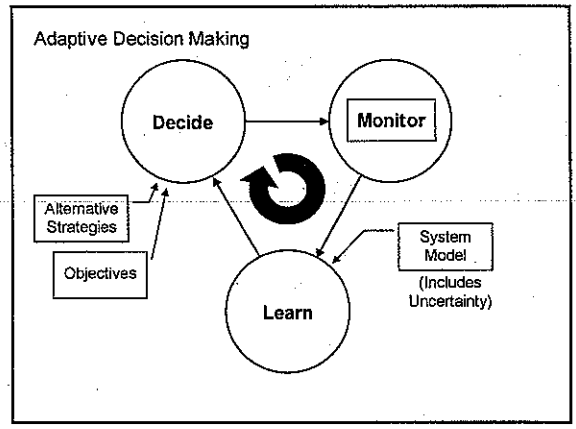
Linked Decisions

- Often, we have a series of dependent decisions to make
  - A decision early on can affect the options available later, as well as the state of the system at a later time
- Analyzing such decisions separately can lead to suboptimal decisions

ARM: Motivation

- All management decisions are made without perfect knowledge
- This uncertainty is what makes decisions difficult
- Any management decision can potentially provide the chance to learn
- Iterated decisions can be adaptive





Some Concluding Comments

Constructed Preferences

- In many important and complex decisions, preferences may not be fully formed
- Elicitation and decision analysis processes may be the means by which decision-makers' preferences become fully formed
- The constructed preferences can be influenced by the methods of development

"Soft" Approaches

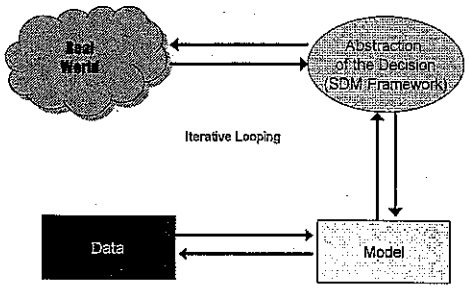
- May be more qualitative in nature
- But nevertheless use the same approach for analysis:
  - Enumerate actions
  - Articulate objectives
  - Predict consequences of actions in terms of objectives
  - Examine trade-offs
  - Perform sensitivity analysis to understand effects of uncertainty

"A formal application of common sense for situations too complex for the informal use of common sense."
R. Keeney

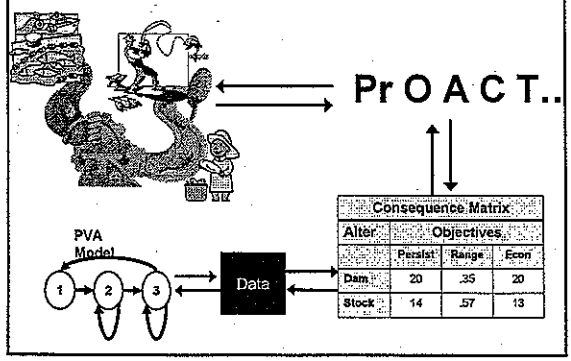
Our Goal

- Use the concepts of structured decision making to develop first prototype frameworks for the applied problems you've brought
- A framework includes the elements of a structured decision, spelled out enough so that you can see how they fit together
  - It's the consultants' job to bring in the theory of SDM as needed for your work
  - Different groups may emphasize different elements and different approaches, but the core ideas should be recognizable in all
- It's likely that future work will be needed to flesh out the details
  - Part of your task will be to specify what the next steps are

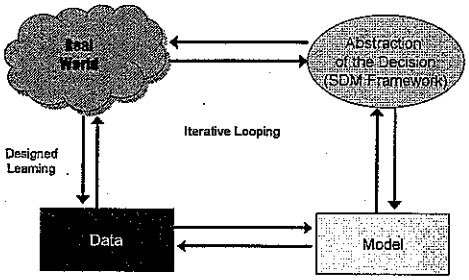
Structured Decision Making



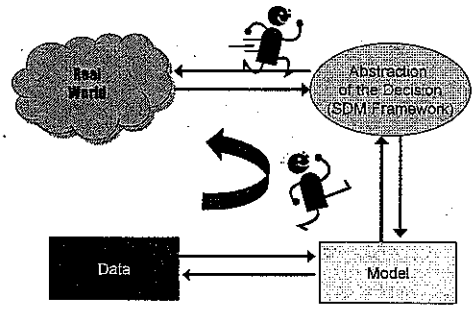
Atlantic Salmon Recovery SDM



Adaptive Management



RAPID PROTOTYPING



Rapid Prototyping

- Get around the track as fast as you can the first time
  - Include all the elements of a structured decision, but keep them very simple (find the skeleton)
  - Focus on the key elements
  - Use placeholders and guesses to keep going
- See how it works
  - Check back to Real World – is this abstraction working?
  - Discover what needs to be improved

Rapid Prototyping

- You learn about and improve your framework by trying it
  - Build iteratively
  - Increase complexity thoughtfully *(if at all)*
- Low risk – high return approach
  - It doesn't matter if you're wrong the first time, you can start over with little loss
  - Don't invest more than you need to
  - Understand what you are doing