Why Structured Decision Making?

Predicting the future

"…decision-making is a forward-looking process…And if decision making is the attempt to achieve a desired future, then any such attempt must include, implicitly or explicitly, a vision of what that future will look like."

Sarewitz et al 2000. Prediction: Science, Decision-Making, and the Future of Nature. Island Press

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What makes decisions hard?

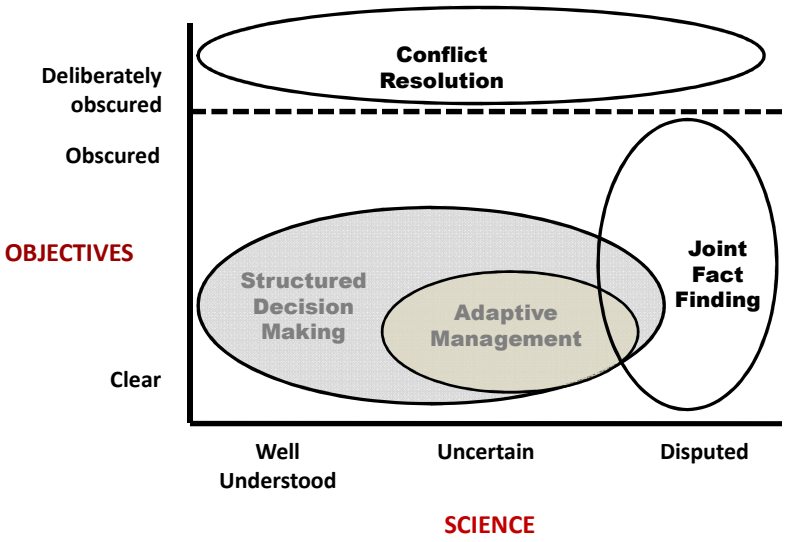
Structured Decision Making

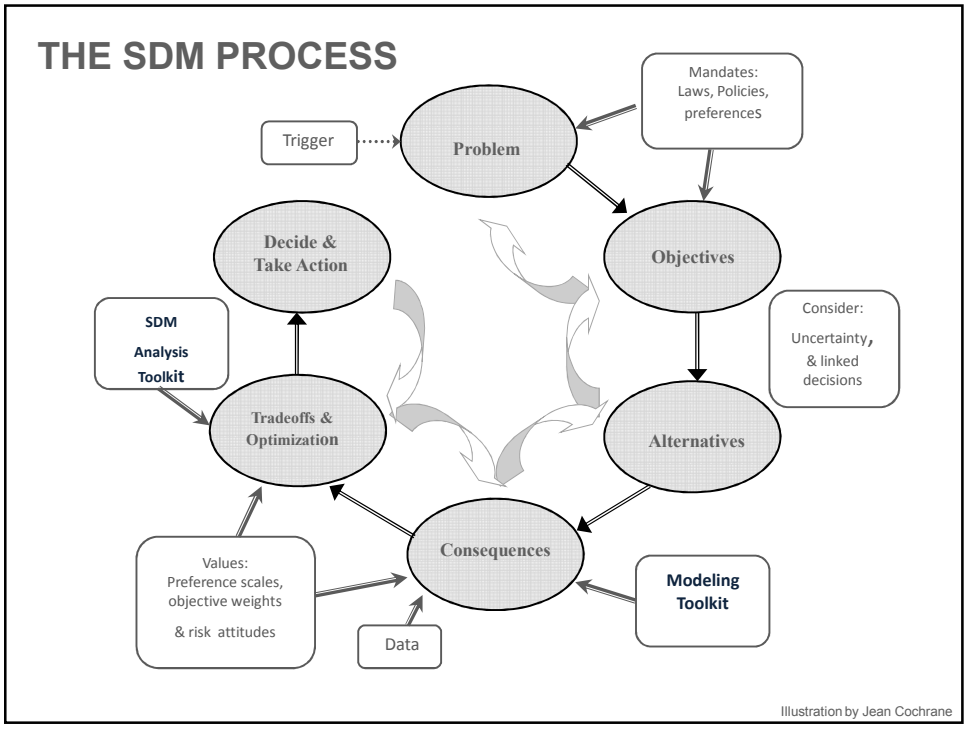
1. Helps identify where the impediments to a decision are, which allows us to focus our efforts on the right parts of the problem
   - Provides tools for dealing with those impediments

Structured Decision Making

2. Integrates
   - Management objectives
   - Alternative management actions
   - Predictive models of system response

When is SDM appropriate?





Problem

- Develop a plan of actions to manage the vegetation in Coconino National Forest

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Objectives

- Fundamental
  - Maintain healthy populations of native vertebrates and invertebrates in understory of Ponderosa Pine forest
- Means
  - Maintain open canopy pine stand with appropriate understory vegetation

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Actions

- Alternative actions
  - Prescribed understory fire
  - Mechanical thinning of understory
- Timing
  - How frequently?
  - Under what conditions?

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Consequences

- Predict by 'modeling'
  - How basal area and vegetation composition change as a function of time and treatment
  - How native animal communities change as a function of habitat conditions
- These models might be mental, conceptual, or quantitative
  - But they should explicitly link actions to objectives

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Trade-offs or Optimal Solution

- Find by integrating
  - Objectives
  - Actions
  - Models
- Identify the action (and its timing) that best achieves the objectives
- For example, thinning whenever the basal area exceeds 85 ft^2/ac

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Benefits of SDM

- Decision processes that are
  - Deliberative, thorough, robust to uncertainty
    - More likely to achieve objectives
  - Transparent, explicit, able to be documented, replicable
    - More likely to be accepted by others

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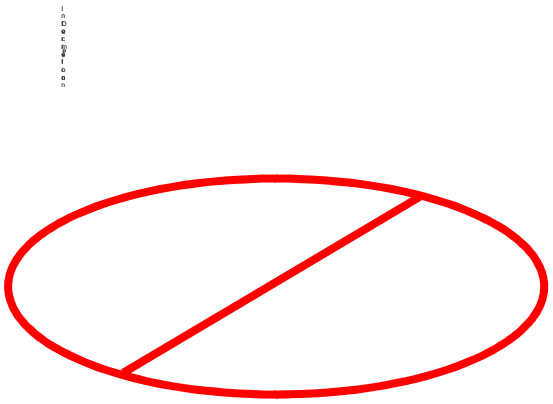

Problem Statement

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3. Develop a decision statement

- **Trigger**: why this decision? Why now?
- **Action**: What is the decision?
- **Constraints**: legal, financial, political? Are they real or perceived?
- **Decision Maker(s)**
- **Frequency and timing**: Periodicity of the decision. Are there linked decision?
- **Scope:** how broad or complicated is the decision?

Determining Objectives

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"If you don't know where you're going,
Any road will get you there." --Lewis Carroll

Objectives are what you really care about

Recipe for Good Objectives

1. Articulate concerns and wishes
2. Convert concerns to objectives
3. Structure objectives
4. Create measurable attributes for each objective
5. Repeat as needed

Step 1. Articulate goals & concerns

Think about:

- Why is it hard to make this decision?
- What's wrong with the current situation?
- What do you want to avoid?
- What are you ultimately trying to achieve?

Ask "why"

Step 2. Convert concerns into objectives

State objective as an
object and a *preferred direction of movement*

Concern	Potential Objective
It's hard to catch bluegills any more	Increase bluegill population
Many loons die ingesting lead tackle	Minimize lead in tackle
Ballast water brings invasive species	Minimize ballast dumping
Certain stakeholders feel excluded	Increase communication
I won't have enough money for this	Reduce cost

Step 3. Structure Objectives

Types of objectives

- **Fundamental**: the basic reason for caring about the decision (essential)
- **Means:** influence the achievement of fundamental objectives (not necessarily essential)
- **Process:** concerns *how the decision is made* rather than *what* decision is made

Getting to Fundamental Objectives

Ask "Why?"

WITI – Why Is That Important?

When your answer is:
- *"Just because (it is an essential area of concern)"*
- *"It's the law"*
- *"This is important"*
- *"Inherent value"*

You have reached a fundamental objective.

Fundamental and Means Objectives are Decision-Specific

Fundamental objectives are the broadest objectives for that decision.

	Fundamental	Means
Context 1:	Increase loon populations	Minimize lead in tackle
Context 2:	Conserve NE biodiversity	Increase loon populations

Step 4. Create Measurable Attributes

Attributes provide the evaluation criteria for how well your alternatives serve your objectives.

Attribute = Performance Measure = Criteria

An attribute includes:

*Content (what you'll measure)

*Preferred direction of the measured content

*The aspiration:

-- maximize (or minimize)

-- a threshold

-- a particular level of change

Example:

Objective: Establish a reproducing plant population

Measurable attribute: 3-year mean flowering stems/m^2

Preferred direction: Increase

Aspiration: Maximize

Three types of attributes

1. Natural attributes

- Objective can be directly measured

2. Constructed attributes

- Sliding or relative scale
- Requires interpretation

3. Proxy attributes

- Natural attribute that is highly correlated with the objective, but does not directly measure it

Natural attribute examples

Minimize number of employee sick days
→ # of sick days

Maintain reproductive success → # of fledglings

Constructed attribute example

Wetland development impacts scale:

0 No loss of riparian areas and ≥ 300 acres estuary restored
1 No loss of riparian areas and < 300 acres estuary restore
2 No loss of riparian areas and no loss of estuary
3 Loss of < 300 acres riparian area and < 300 acres of estuary
4 Loss of < 300 acres riparian area and ≥ 300 acres of estuary
5 Loss of ≥ 300 acres riparian area and ≥ 300 acres of estuary

Proxy attribute examples

Minimize student boredom → # of yawns

Maintain genetic diversity →
% of natural range preserved

I want to get a new pet. What kind should I get?

Objectives	Measurement Criteria	Desired direction
Minimize total cost	**$/year**	Low
Maximize friendliness	**Scale (1=low, 5=high)**	High
Maximize pet-sitters	**# possible pet-sitters**	High
Minimize required care	**Hours per week**	Low

- Objective: Maintain biodiversity
- Objective: A fish management strategy that's robust across a range of climate scenarios
- Objective: Identify and protect resilient habitat

Write at least one possible attribute (content, direction, aspiration) for each objective

Develop Alternatives

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I want to get a new pet. What kind should I get?

Objectives	Measurement Criteria	Desired direction				
Minimize total cost	**$/year**	Low				
Maximize friendliness	**Scale (1=low, 5=high)**	High				
Maximize pet-sitters	**# possible pet-sitters**	High				
Minimize required care	**Hours per week**	Low				

Good alternatives require…

- *Imagination*
  - Don't consider only 'practical' alternatives
  - Think outside the box
- *Creativity*
  - Expand range of possibilities
  - Identify assumptions and challenge constraints

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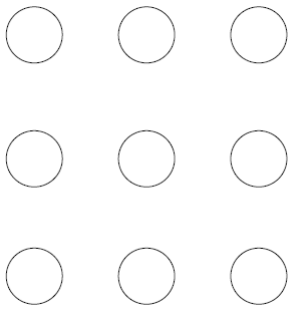
Creativity & Imagination Exercise

Without lifting your pencil from the page, draw 4 or fewer straight lines that connect all 9 circles



Source: *Conceptual Blockbusting: A Guide to Better Ideas*, James L. Adams

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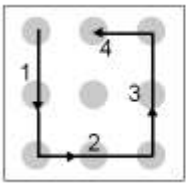
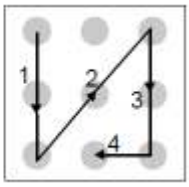
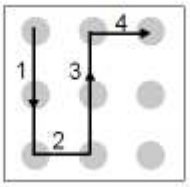
Did anyone try these?







If you had trouble, WHY?

You defined the scope of the problem narrowly and were not creative in alternative solutions (didn't think outside the box)

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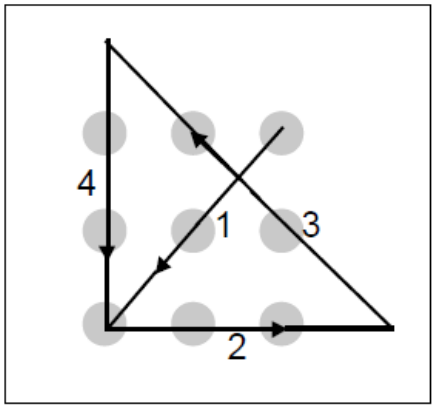
Preconceived limitation?



Perceptual Block

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Develop alternatives

(only after you've laid out your problem and objectives!)

- Focus on your values and fundamental objectives first
- You can never choose an alternative you haven't considered
- No matter how many alternatives you have, the alternative that you choose can be no better than the best of the bunch

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Assess Consequences

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Consequence tables

- Geeky but very useful
- Puts a lot of information in a concise and orderly format
- Easy to compare alternatives, objective by objective
- Initial framework for assessing tradeoffs

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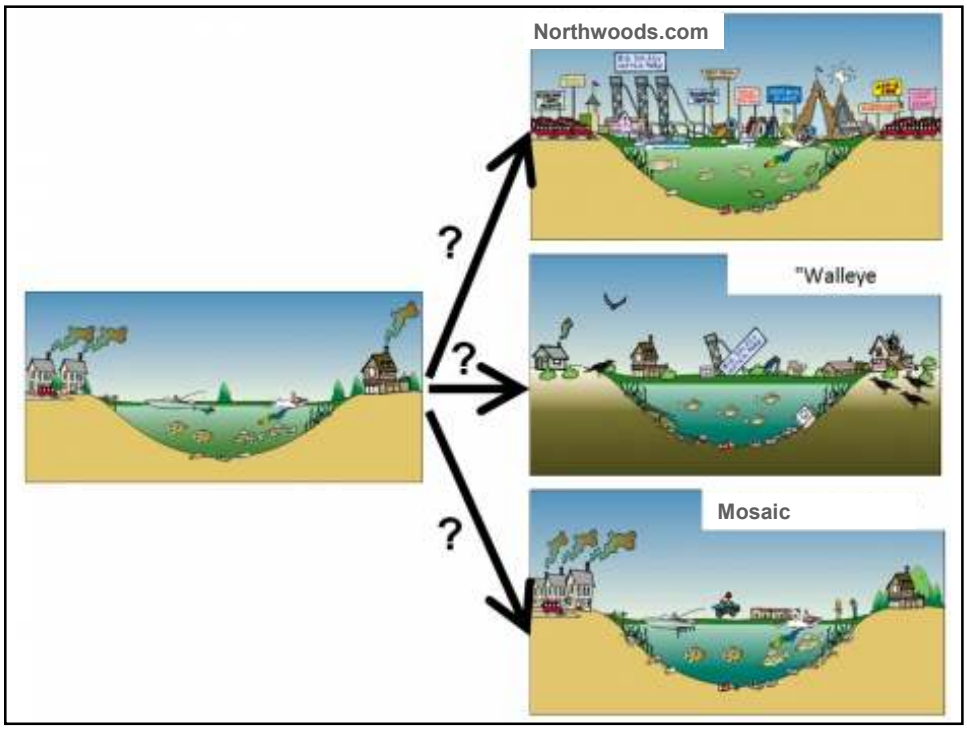
I want to get a new pet. What kind should I get?

Objectives	Measurement Criteria	Desired direction	Dog	Cat	Fish	Hamster
Minimize total cost	**$/year**	Low	$300	$250	$20	$50
Maximize friendliness	**Scale (1=low, 5=high)**	High	3 - 5	2- 4	1	2
Maximize pet-sitters	**# possible pet-sitters**	High	3	4	5	4
Minimize required care	**Hours per week**	Low	7	2	1	3

Concerns

Lake is filling with silt

- Boating and ice skating are getting difficult
- We like seeing birds and wildlife on the lake
- Expensive and time consuming to keep treating
- The river at lake outlet is sensitive to silt runoff



Objectives & Attributes

Concerns	Objectives	Attributes
Boating/Skating	Maximize recreation	% Area open to use
Birds/Wildlife	Maximize wildlife values	Scale (1 - 5)
Expense	Minimize costs	$/10 yrs
Silt into River	Maximize filtration	Avg siltation at outlet

Consequences

Objectives	Attributes	Desired level	Alternative Consequences			
			Mech	Chem	Dredge	None
Recreation	% open	Max	**15**	**25**	**50**	**5**
Wildlife	1-5 scale	Max	**4**	**2**	**4-5**	**3**
Costs	$$/10 yr	Min	**10k**	**5k**	**50k**	**0**
Filtration	Avg silt	Min	**0.6**	**2.1**	**4.0**	**0.5**

Tradeoffs and Optimization

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Classes of Analytical Methods

Repeated	No Uncertainty	With Uncertainty
Single	No Uncertainty	With Uncertainty
Single Objective		
Multiple Objectives		

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Before you get into all kinds of fancy tools…

Simplify the problem

Simplify the problem

A. Identify any dominated alternatives:
   - at least one alternative performs the same or better on all objectives

Simplifying an impoundment repair decision
Any dominated alternatives?

Objectives		Alternatives			
		Status quo	Minor repair	Major repair	Re-build
Cost ($M)	min	0	2	12	20
Environmental Benefit (0-10)	Max	1	3	10	10
Disturbance (0-10)	min	0	1	7	10
Silt runoff (k ft3)	min	5	1	3	3
Water Retention (MG)	Max	41	41	41	39

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Simplify the problem

A. Identify any dominated alternatives
B. Identify any irrelevant objectives
   - Performance measures do not vary across alternatives
   - This doesn't mean the objective isn't important to you, just that it doesn't help discern among these alternatives

Simplifying an impoundment repair decision
Any irrelevant alternatives?

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Simplify the problem

A. Identify any dominated alternatives
B. Identify any irrelevant objectives
C. Consider even swaps (merging one objective into another)
   - Express one objective in terms of another
   - Set the first objective to the same value for all alternatives by shifting the differences to the second objective

Convert silt runoff to cost @ $0.5M / Kft3

Objectives		Alternatives			
		Status quo	Minor repair	Major repair	Re-build
Cost ($M)	min	0 + 2 = 2	2	12 + 1 = 13	20
Environmental Benefit (0-10)	Max	1	3	10	10
Disturbance (0-10)	min	0	1	7	10
Silt runoff (k ft3)	min	5-4=1 $2M	1	3-2=1 $1M	3
Water Retention (MG)	Max	41	41	41	39

Another approach to simplifying the problem:
Turn some objectives into constraints

Which ones?

Objectives		Alternatives			
		Status quo	Minor repair	Major repair	Re-build
Cost ($M)	min	0	2	12	20
Environmental Benefit (0-10)	Max	1	3	10	10
Disturbance (0-10)	min	0	1	7	10
Silt runoff (k ft3)	min	5	1	3	3
Water Retention (MG)	Max	41	41	41	39

You can also essentially turn a multiple-objective problem into a single-objective problem by:

- Assigning a weight to each objective
- Converting all the scores to normalized scales, then
- Calculating a summed, weighted score for each alternative

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Before you get into all kinds of fancy tools…

1. Simplify the problem

2. Direct trade-off methods (quantitative)

3. Negotiated solution
   - Examine the trade-offs directly
   - Negotiate a palatable solution from among the "equally-best" solutions