INFORMING CLIMATE CHANGE POLICY DECISIONS UNDER UNCERTAINTY

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DECISION RESEARCH

My perspective on this important topic?

- Based on experience as a researcher and consultant, to government & industry, on making smarter decisions.
- It's critical that US agencies and industry follow a defensible decision-making process for CC choices. Why?
  - Whenever uncertainty exists we can't control decision *outcomes*, so our best opportunity to "do things right" is to employ an appropriate and defensible *process* for making choices.
  - This emphasis on process is particularly important when the outcomes in question are significant, expensive, controversial, subject to media coverage and review, or of interest to widely diverse stakeholders – all applicable to CC.
  - Better risk-management decision processes are likely to save time, resources, and avoid regret – all important to public policy choices.

Mix of reasons for seeking to reduce adverse impacts of CC

- Government – national energy security, economic benefits, jobs, policy options
- Industry – profits, revenues to government, innovation, uncertainty in outcome estimates
- Environmental groups – endangered species, renewable energy, sustainability, biodiversity
- Citizens – mix of the above along with fear, disbelief, insignificance, intermittent attention & concern

These different interests stem from diverse concerns, hopes and expectations

- Economic benefits: jobs, revenues
- National emphasis: energy security, politics
- Environmental risks: ecosystems, adaptation
- Social consequences: well-being, communities
- Process concerns: consultation & participation, resilience
- Sustainability: long-run vs. short-run considerations
- Politics: state & national implications
- International: trade, reputation, partners

A first consideration: Understanding the CC policy context

- What is the choice being addressed?
- Who is the decision maker(s)?
- Who are the lead participants / stakeholders? Are some participants more powerful than others?
- What are key elements of the problem structure?
  - What are the key objectives?
  - What are the leading performance measures?
  - What is the time frame for a decision?
  - What are the major constraints: Poor information? Lack of high-quality data? Political maneuvering? Lack of funding? Institutional rigidity? Lack of trust in management?
  - Is there one choice to make or is there a sequence of choices, over time or over geographic areas?

Energy policy is "too complex" for a more casual or less structured approach

Decision-aiding methods are "a formalization of common sense for decision problems which are too complex for informal use of common sense."

– Ralph Keeney

How decisions are made – in addition to *What* decisions -- is also critical

Judgmental research emphasizes that it's difficult for people to:

- Make tradeoffs across objectives
  - Anchor on one objective
  - Anchor on one alternative
- Incorporate probabilities
- Overcome overconfidence: we place far too much faith in our own experience & knowledge
- Recognize the role of external factors (Low probability outcomes can occur!)
- Recognize the role of luck in what typically is referred to as "good" or "bad" decision making
- Integrate more intuitive (S1) and more controlled (S2) modes of decision making
- Integrate choices across risks and benefits

A second consideration: Uncertainty

- Estimates of the expected outcomes of management actions – how effective will actions be?
- Future fossil fuel production levels – offshore oil output? role of fracking? future natural gas production levels?
- Level of agreement regarding future temperature & precipitation changes
- Adaptation capabilities -- communities, individuals
- Market and demand growth --: status of US & Asian economies; status of energy D-side conservation efforts
- Institutional and political responses
- Technological responses

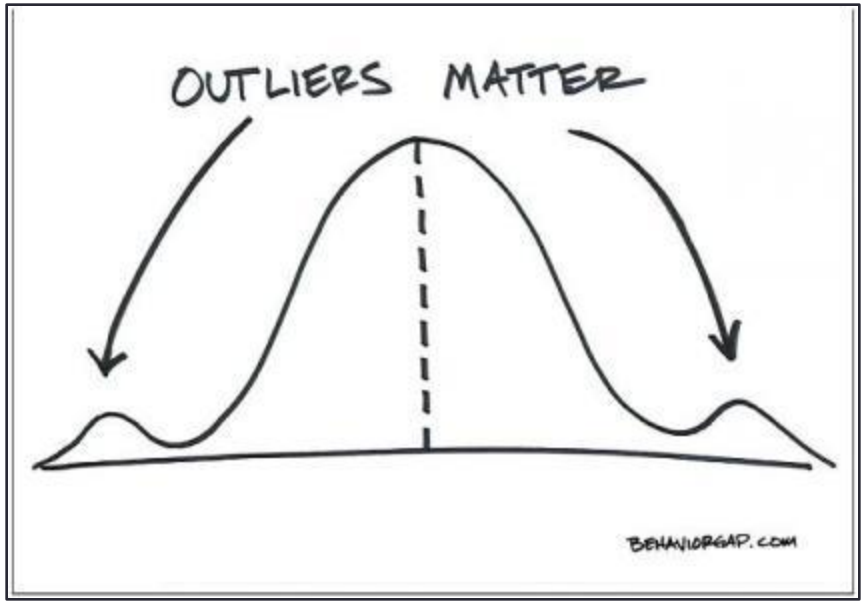
Bringing CC uncertainty into multi-stakeholder deliberative contexts

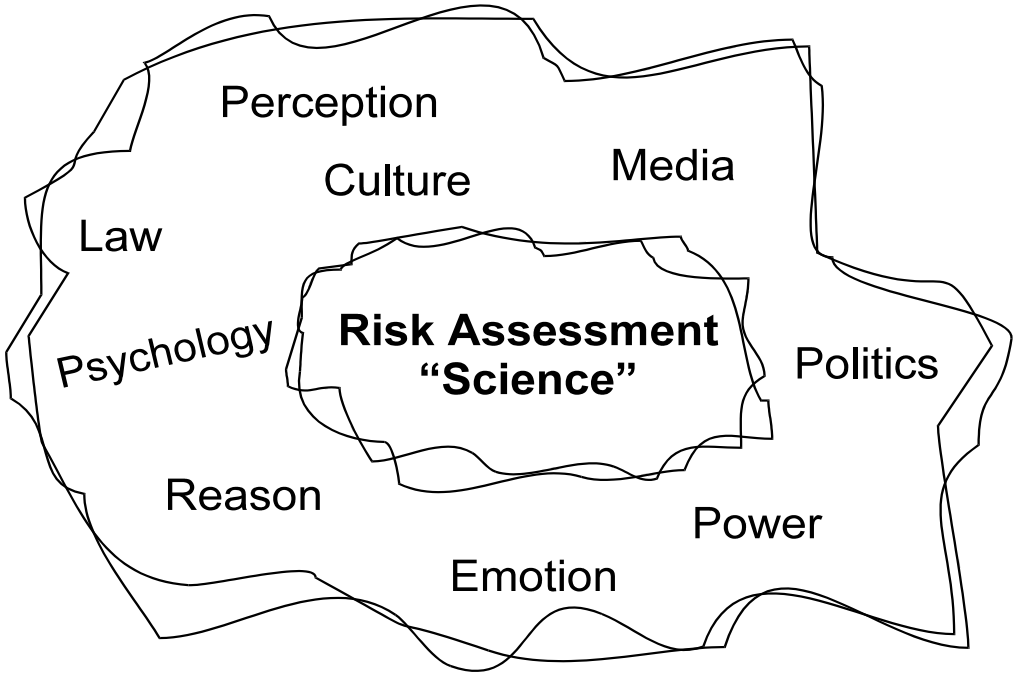
Usual focus: good scientific analysis. Necessary, of course, but often misinforms because:

- Leads to presumption that we know more about future effects than we do (seduction of numbers)
- Emphasizes complex studies and models rather than how well people understand them
- Marginalizes non-science stakeholders, who may be in line for many of the effects
- Discourages dialogue and understanding, leading to a loss of trust and – often – difficulties in implementing plans

Expert Predictions of Uncertainty Often Display Overconfidence and Provide a Poor Guide to Decisions

- Uncertainties may look well-characterized when they're not.
- Averages from past events may poorly characterize the future.
- Responses to extreme events are hard to predict ex ante.
- The "fat tails" associated with extreme events are important when designing responses.
- Explore robust decisions by examining vulnerabilities and worst-case scenarios.





How to think about all this? Decisions that involve risk are complex, and involve intuition and emotions as well as "science" -- many interests, many stakeholders, tough choices.

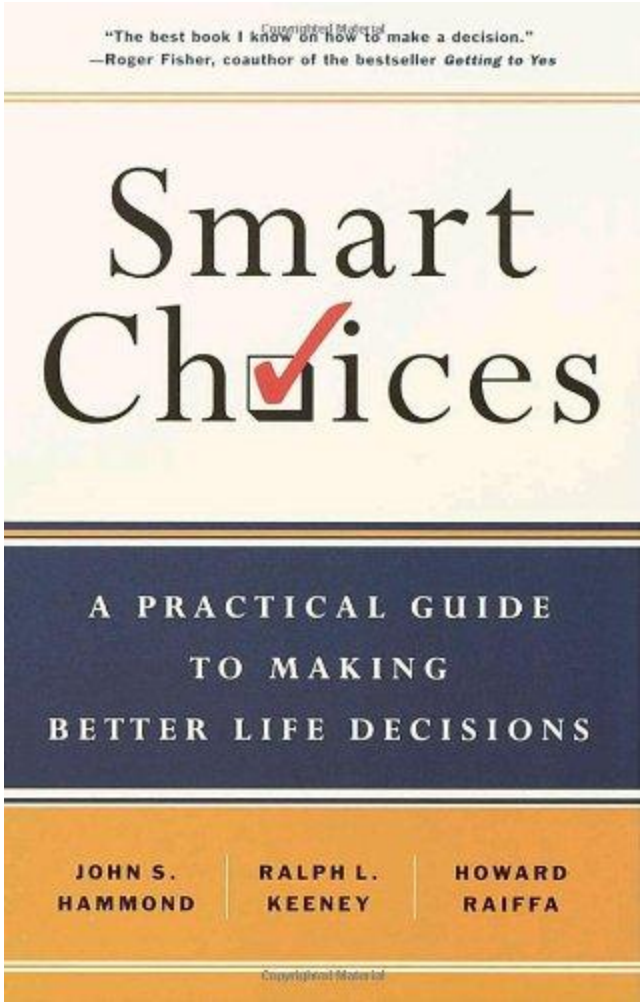
(slide provided by Paul Slovic)

Informed CC choices require an overall strategy & clear decision context

- Values information is often partial & conflicting
- Factual information is often conflicting or ambiguous
  - Government, industry, and interest-group reports present contradictory or vague information
  - Internet perspectives and media summaries are available to everyone, but can both inform and misinform
  - Talks by government or industry staff often emphasize a single point of view, making it hard to form a complete picture
- So how might a comprehensive CC reduction strategy be developed, one that incorporates the views of citizens and could help to inform choices by decision makers?
- Thankfully, not starting from scratch: lots of work over the last 50 years in JDM: "judgment & decision making"

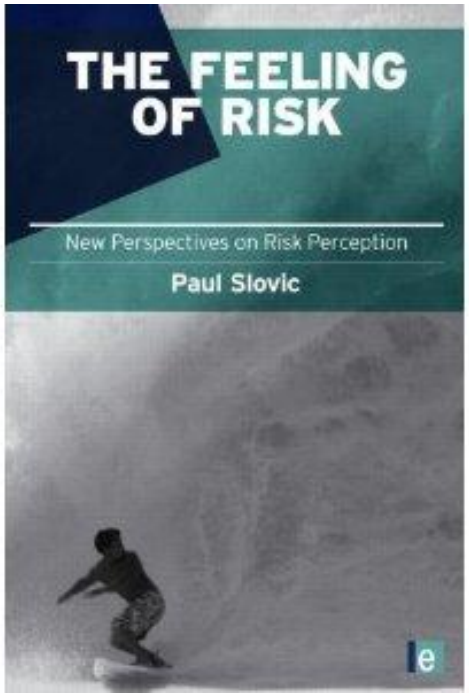
Adopting a defensible decision-making process

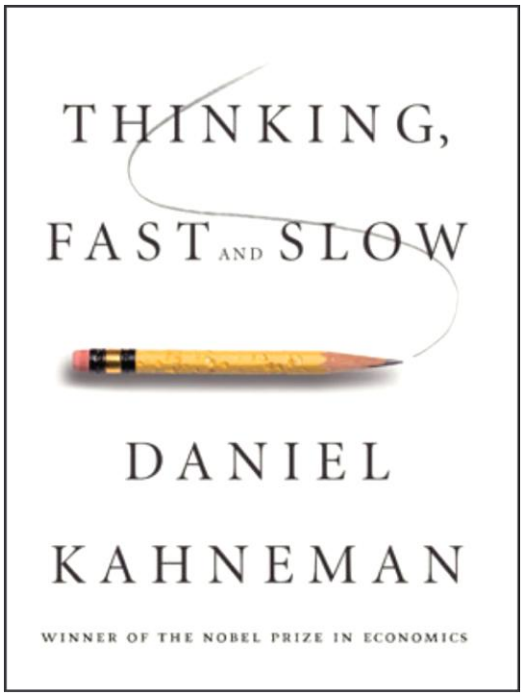
Hammond, J. S., Keeney, R. L., & Raiffa, H. (1999). *Smart choices: A practical guide to making better decisions. Cambridge, MA: Harvard Business School Press.*

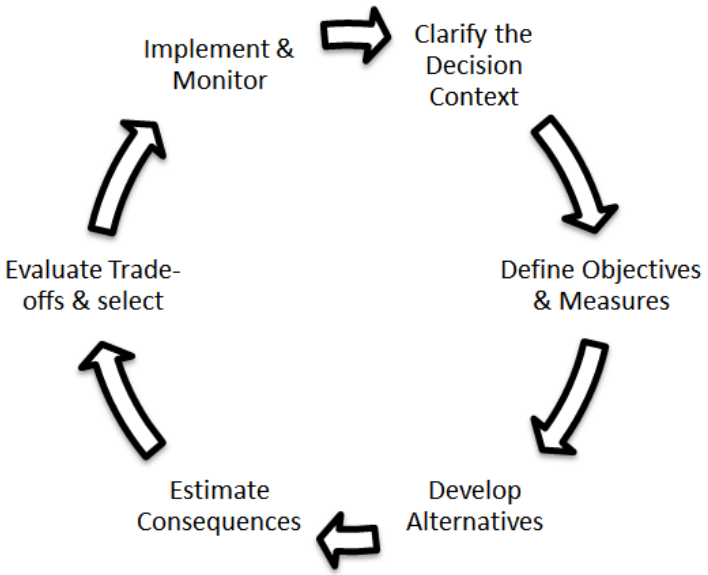


Understanding and integrating information – about values and perceptions as well as facts -- as part of a decision-making process

- **Slovic, P. (Ed.). (2010). *The feeling of risk: New perspectives on risk perception*. London, UK: Earthscan.**
- **Kahneman, D. (2011). *Thinking, fast and slow.* New York: Farrar, Straus and Giroux.**



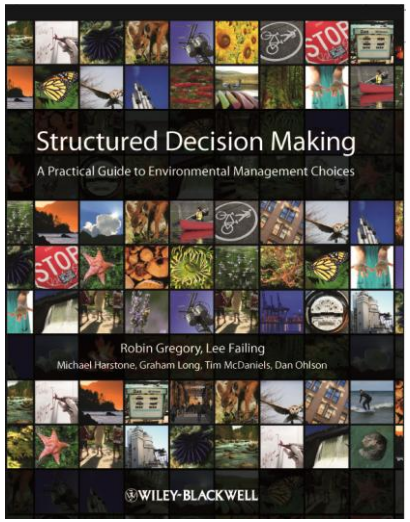




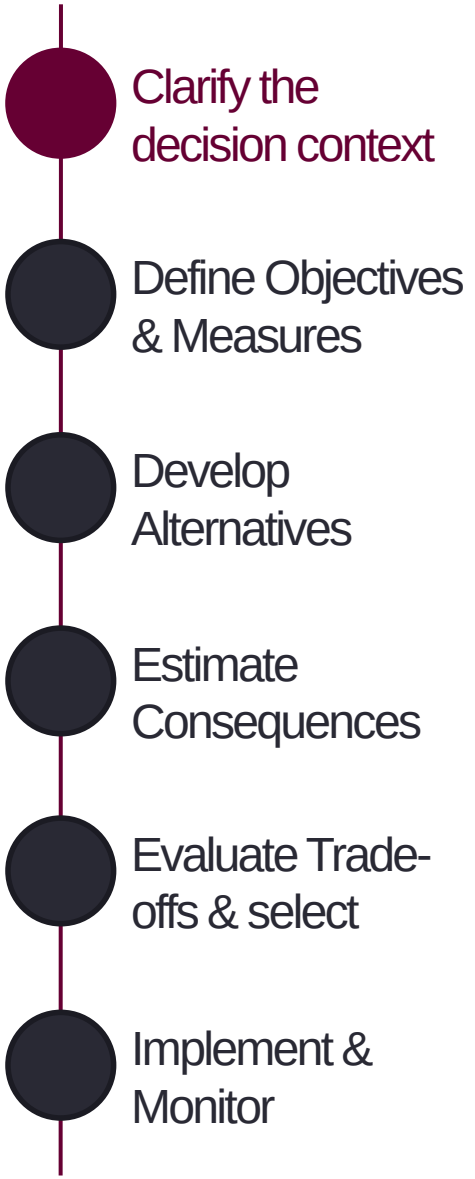
Structured Decision Making

A step-by-step approach to generating and evaluating policy strategies marked by

- Multiple interests
- Multiple participants
- Conflicting information
- Uncertainty



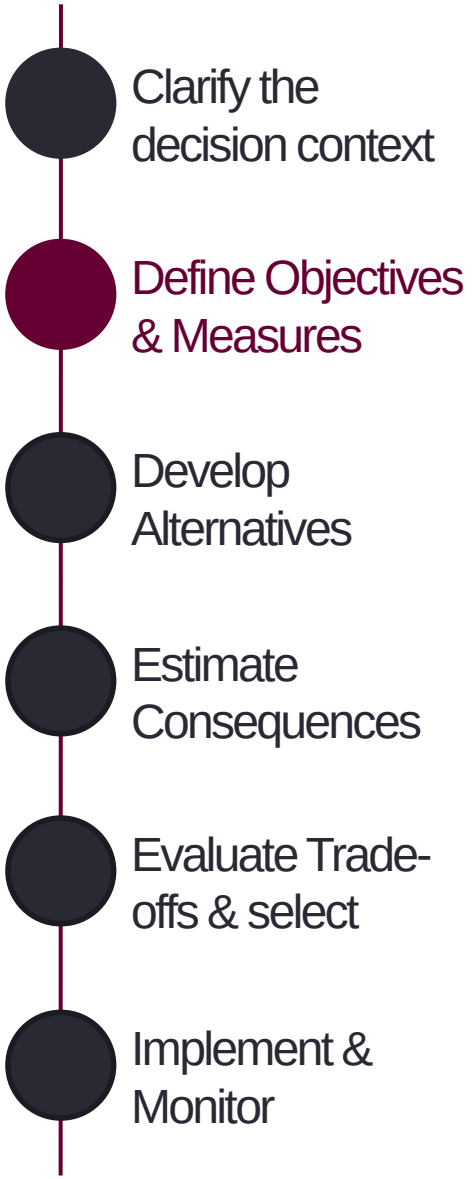
Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T., &Ohlson, D. (2012). *Structured decision making: A practical guide to environmental management choices.* Chichester, West Sussex, UK: Wiley-Blackwell.



1. Define the Issue or Problem

What should a CC *strategy* address? Depends on how the problem is defined …

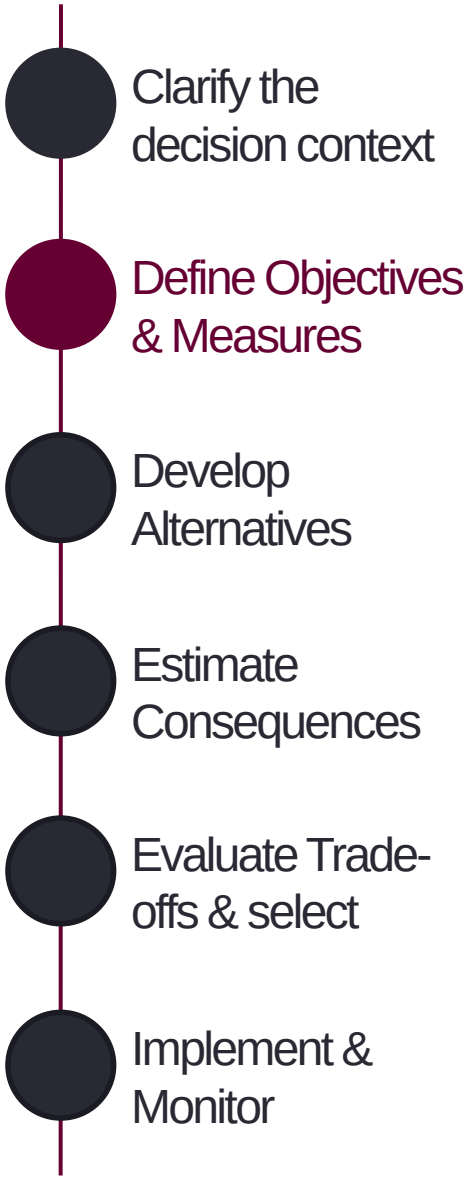
- Who is involved (stakeholders)?
- What concerns are included? -- social, economic, environmental & health -- benefits, costs, and risks
- What options are possible?
- What are goals of decision makers?
  - reduce emissions?
  - get better information?
  - encourage adaptation?



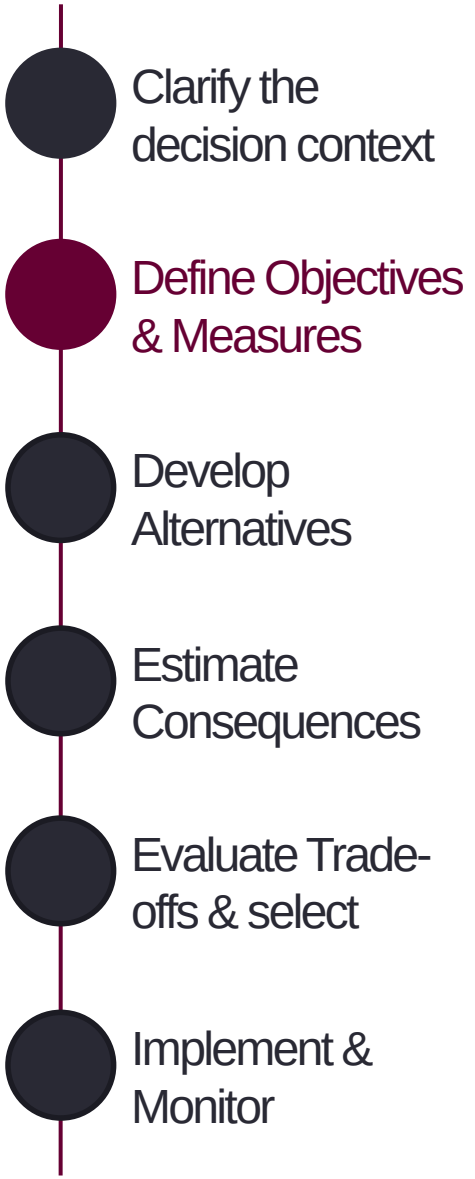
2. Establish Critical Objectives

- Economic
- Environmental
- Health
- Social
- Cultural
- Political

But all of these can be defined in different ways – what matters, in this context, for selecting a preferred alternative?



- Identify direction: more or less?
  (*higher* economic Bs vs. *lower* health risks)
- Establish *performance measures* to clarify progress in meeting objectives
  - **Be precise**: Vague terms will be misunderstood.
  - **Be measureable**: can high-quality information be obtained?
  - **Be honest**: confidence in estimates of future performance?
  - **Be clear**: use terms that are easily understood.
  - **Be comprehensive**: cover the important considerations.
    - Keeney & Gregory, 2005: Selecting attributes to measure the achievement of objectives. Operations Research 53: 1-11.



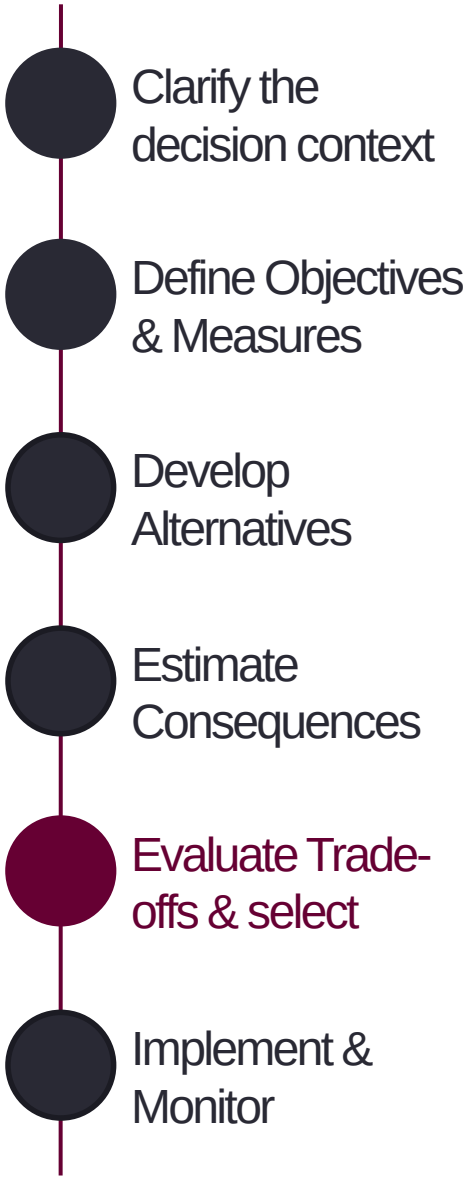
- Economic benefits
  - Short- or long-term (define)?
  - Role of externalities?
  - Net or gross benefits?
  - Employment: type of jobs, location, skill requirements, rates of pay?
- National security
  - Use only US energy sources?
  - Use only US-owned companies?
  - Reduce % imports (to 50%? 5%?)

3. Develop Initial Strategy

- Identify various alternatives
  - Max. short-run economic returns
  - Min. long-run worst case
  - Max. protection of environment
  - Min. adverse health effects
  - Max. returns under uncertainty (robust options)
  - Max. political support
- Discuss, then mix-and-match (moderate s-t economic returns + moderate environmental protection + ???) and refine

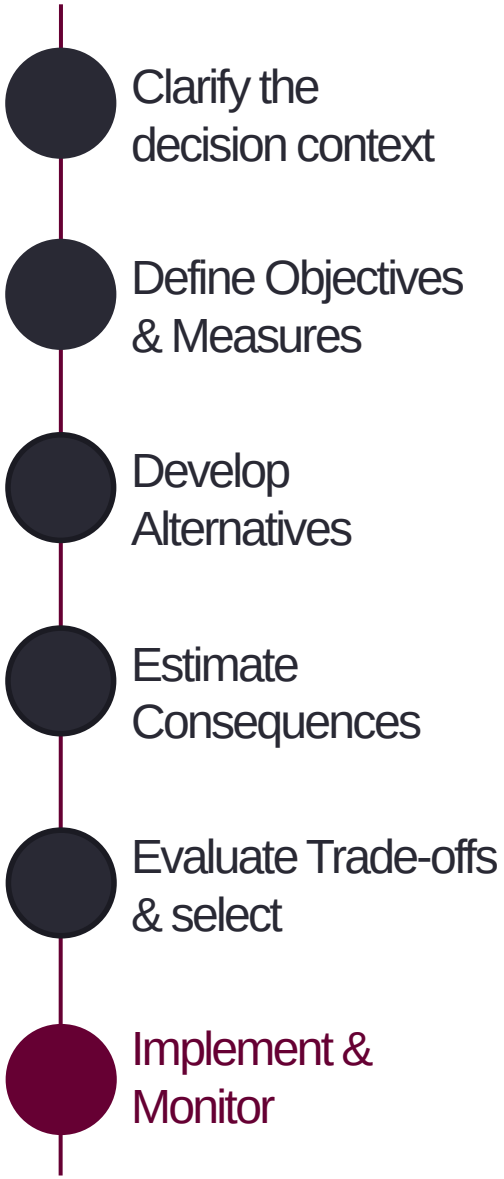
4. Identify and Discuss Consequences and Outcomes

- How will actions affect the identified objectives & performance measures?
- What about factors outside our control? – political, economic, environmental, social.
- How should information be presented? (reports, videos, talks, etc) and by whom?
- How should uncertainty be treated and communicated?



5. Balance interests – Tough trade-offs across values

- Different importance weights placed on objectives will result in different preferred options
- How to resolve? Differences in values & risk tolerances will remain – but need respectful, honest dialogue (no bullying or fudging of data)
- Engage in a deliberative process, informing each others' choices
- Examine reasons for support or opposition



6. Implement and monitor

- Learn over time
  - New factual information – reduce uncertainties, explore new alternatives
  - New values information – informs dialogue as individual and societal values are constructed over time
- Generate new options
  - New technological possibilities – changes what is possible, but are plans sufficiently flexible?
  - New political possibilities/partners

Success requires integrating cognition & emotion in CC policy deliberatives

- Goal: to provide a forum where participants can make informed choices, which requires expanding the envelope of meaningful participation so that:
  - **Options are understood**, which means that their representation is complete and comprehensible. Recognize the constructive nature of preferences; use tools such as influence diagrams – level the playing field for including knowledge of different types.
  - **Options are evaluated**, which requires cognitively compatible elicitation methods (sensitive to the problem presentation and using multiple metrics), cognitively tractable methods (quantiative and qualitative measures), and emotional stabilizing methods (finding helpful ways to elicit emotion-laden concerns).
  - **Outputs are informative** – decisions or recommendations?

Framework for Analysis: System 1 & System 2 Behaviors

(Source: H . Kunreuther)

System 1 operates automatically and quickly with little or no effort

- Individuals use simple associations including emotional reactions
- Highlight importance of recent past experience
- Basis for systematic judgmental biases and simplified decision rules

System 2 allocates attention to effortful and intentional mental activities

- Individuals undertake trade-offs implicit in benefit-cost analysis
- Recognizes relevant interconnectedness and need for coordination
- Focuses on long-term strategies for coping with extreme events

Example: integrating risks and benefits (part of every CC or energy-use decision)

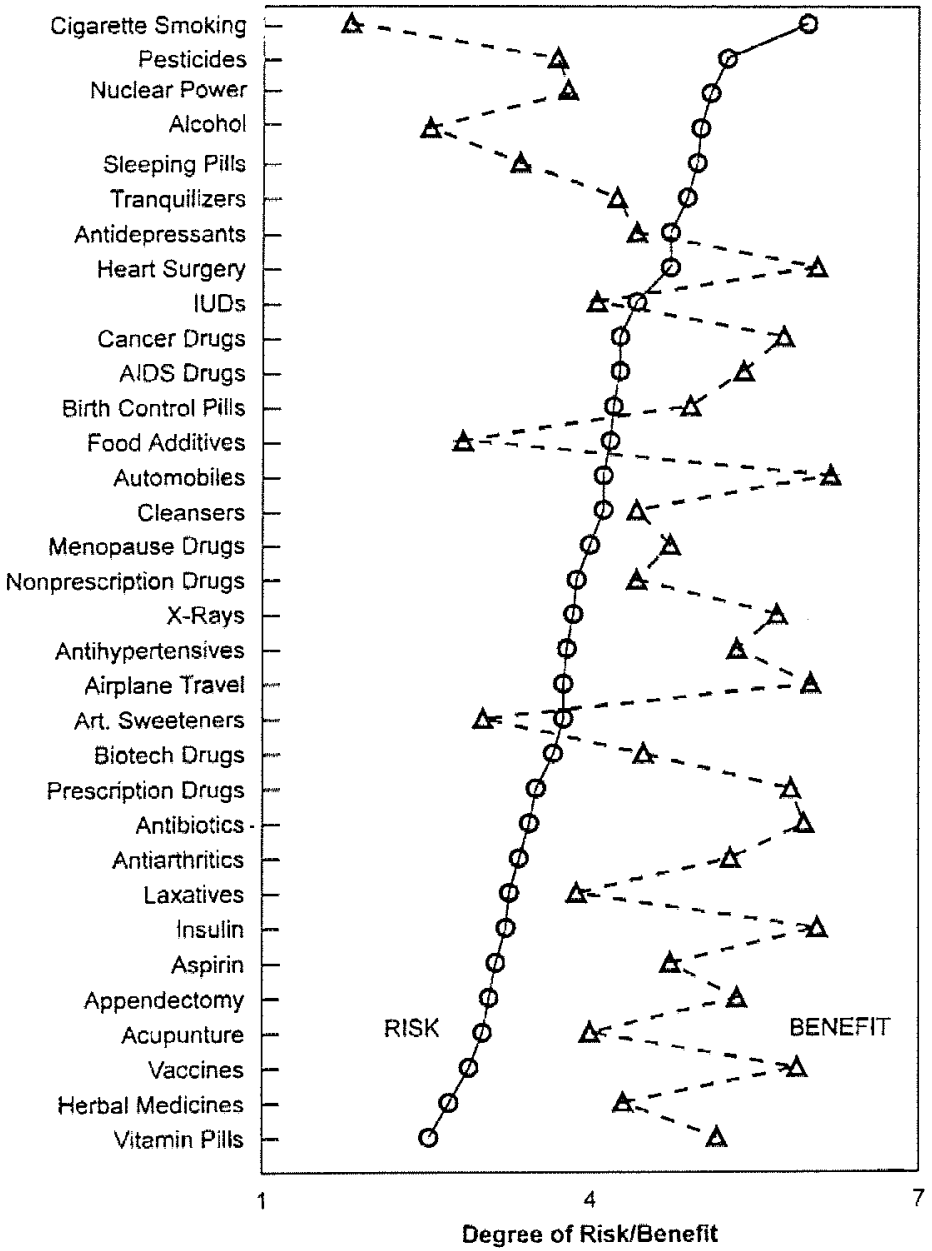
Usual presumption: provide people with information about relevant benefits and costs of an action and they can make informed decisions (cost-benefit analysis)

Research shows: improbably high correlation between estimated levels of benefits and risk. If people are favourably disposed toward a technology, they rate it as offering large benefits and imposing little risk. If people dislike a technology, they think of its disadvantages and not its benefits. So there are no tough trade-offs to make!

So moral is: if you want people to support a proposal, don't question its risks but talk about its benefits. Or provide detailed information about risks and benefits diminish.

Perceived risk and benefit ratings

Alhakami, A. S., & Slovic, P. (1994). A psychological study of the inverse relationship between perceived risk and perceived benefit. *Risk Analysis, 14, 1085-1096.*



Incorporating Uncertainty in CC Policies

- Bottom line: Experts need to provide clear assessments of what they do and do not know to end users:
  - Uncertainty in estimates of outcomes
  - Degree of confidence in assessments
- Failures in communicating uncertainty:
  - If uncertainty is ignored or understated, end users will be overconfident.
  - If uncertainty is overstated, end users may ignore or underweight information.

Information on outcomes of policies is often very low quality and/or controversial

- Solution? Field studies may take too long, be too expensive, or not be possible. Options?
  - Look to other, similar contexts
    - But how “similar” are they? Will findings be accepted?
  - Trust to hope or intuition
    - For complex problems, intuition and hope may mislead or obscure –and dialogue will likely be frozen.
  - Elicit judgments from experts (accepted protocols?)
    - First issue: what is the question to answer?
    - Second issue: who are the relevant experts?
    - Third issue: will they be listened to?
    - Fourth issue: how to elicit and aggregate judgments?

Expert Judgment (EJ) elicitations

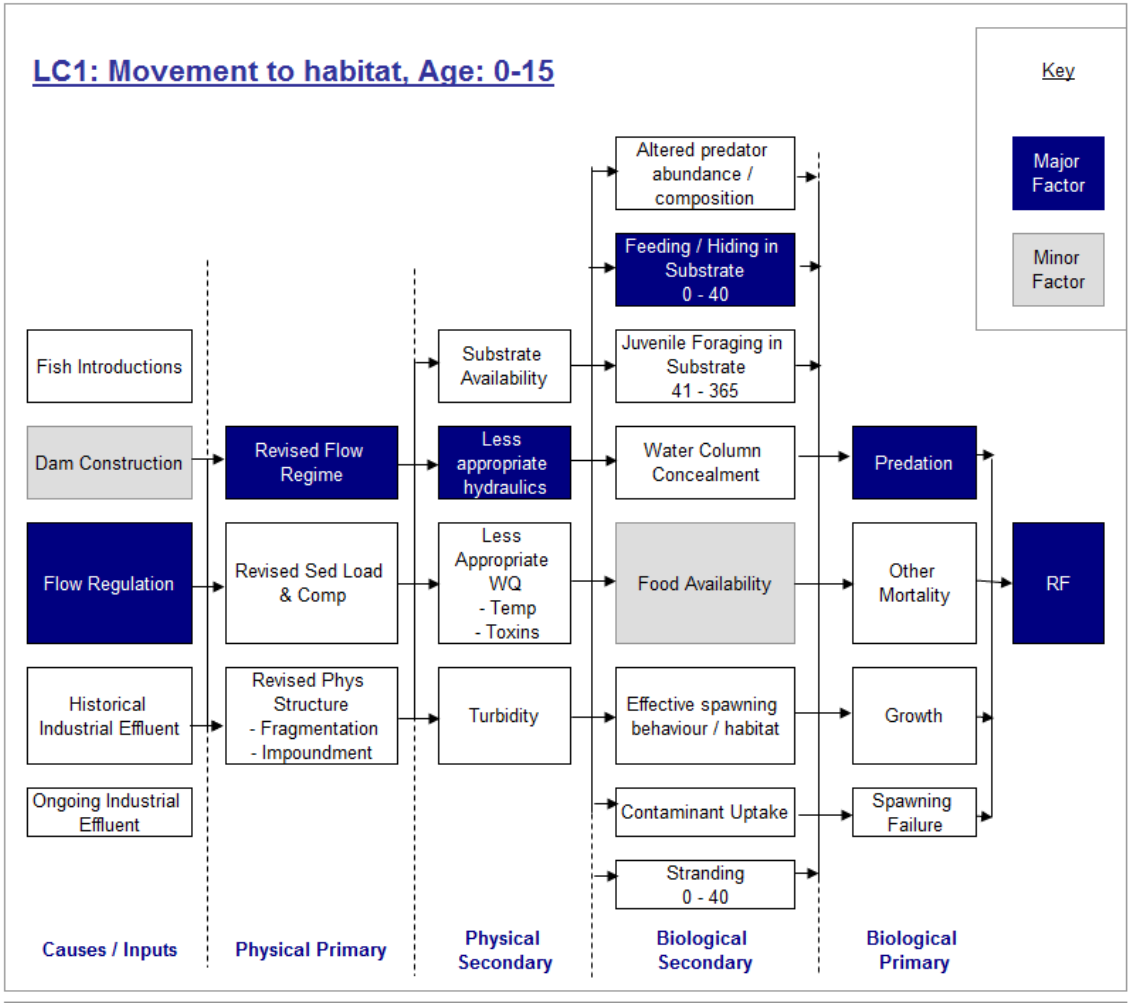
- If working only with experts (e.g. technical committees), many EJ techniques available:
  - Expose fundamental assumptions regarding how a problem is thought about (mental models)
  - Encourage experts to reach agreement
  - Facilitate learning and incorporation of knowledge from different sources
- However, make sure about the knowledge level of the "experts."
- And expect that expert elicitations with experts will often be regarded with skepticism:
  - Undercutting science by merely stating "opinions"
  - Creating dissention by demonstrating disagreements
  - Initiating contest: who is right and who is wrong?

Example: Recovery planning for Endangered Upper Columbia River White Sturgeon

- Used DA / EJ methods to clarify uncertainty, through development of “science court”
  - Expose differences across technical experts
  - Explore reasons for these differences
  - Consensus position or agreement to disagree?
  - Use influence diagrams to clarify “hypothesis pathways”
  - Explore degree of confidence that experts hold in their assessments

    - Source: Gregory, Failing, Harstone, Long, McDaneils&Ohlson (2012). Structured Decision Making: A Practical Guide to Environmental Management Choices. Wiley-Blackwell.

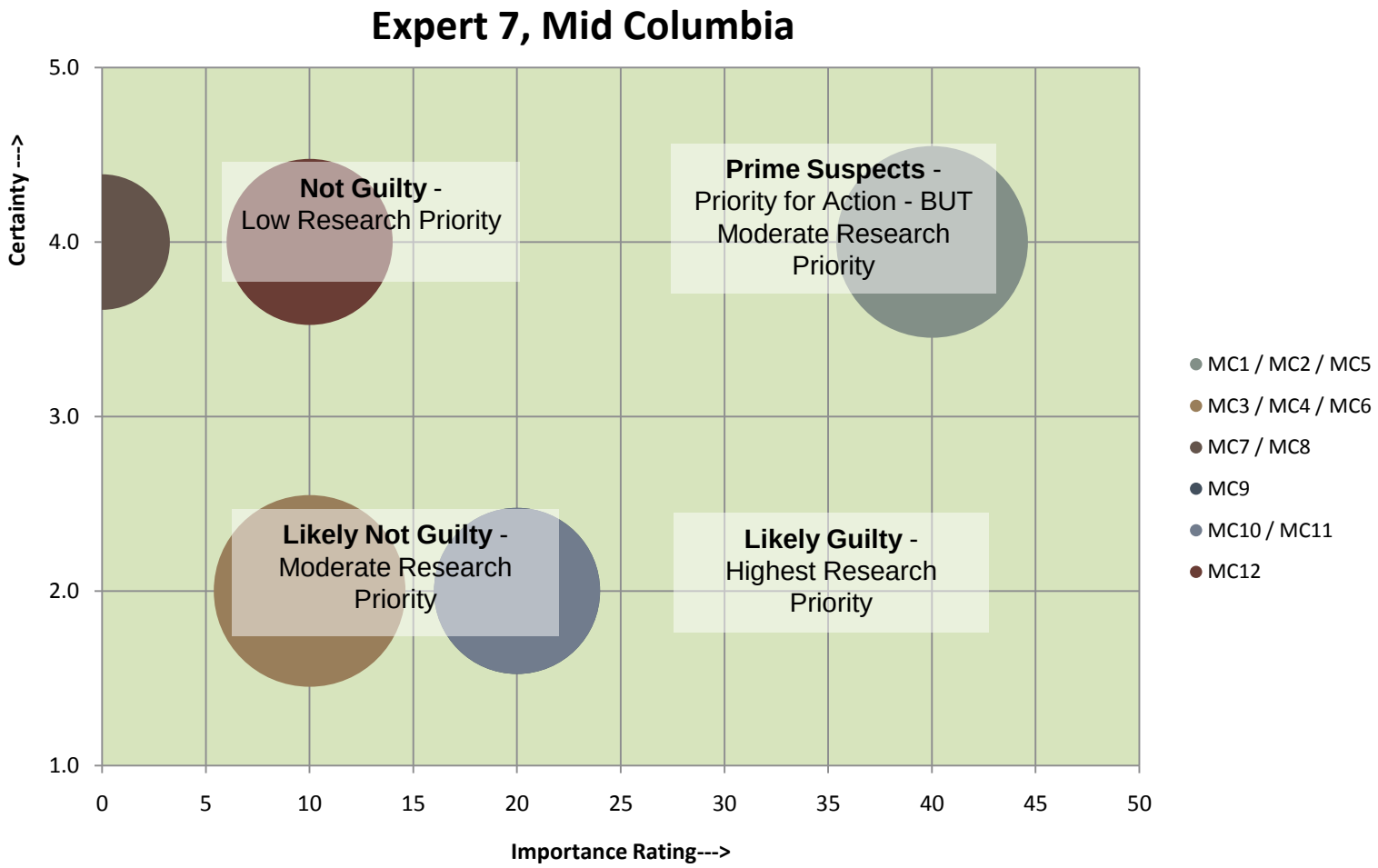
UPPER COLUMBIA WHITE STURGEON



UPPER COLUMBIA WHITE STURGEON

Q1	Q2	Q3
What % of ongoing RF is attributed to this H, based on current knowledge?	**How certain are you in your assessment for Q1?**	**How likely is it that further research could 'confirm' that this H accounts for <u>at least</u> 20% of ongoing RF?**
Distribute 100% points	5 = I expect I could be wrong by up to ±10% points	1 = Very unlikely (<20% chance)
	4 = I expect I could be wrong by up to ±20% points	2= Unlikely (20-40% chance)
	3 = I expect I could be wrong by up to ±30% points	3= As likely as not (40-60% chance)
	2 = I expect I could be wrong by up to ±40% points	4 = Likely (60-80% chance)
	1 = I expect I could be wrong by more than ±40% points	5 = Very likely (>80% probability)

UPPER COLUMBIA WHITE STURGEON



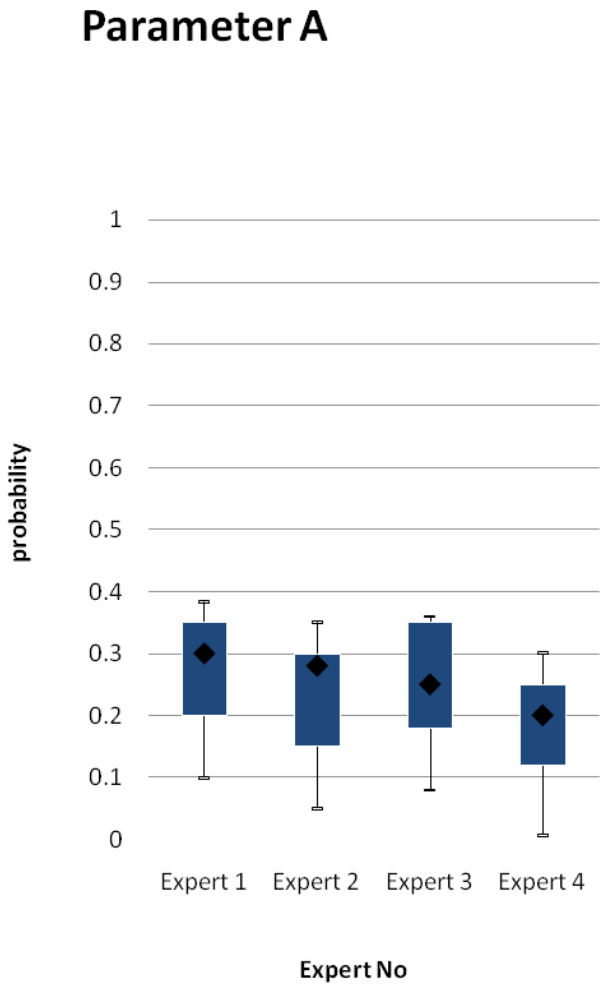
Uncertainty Communication

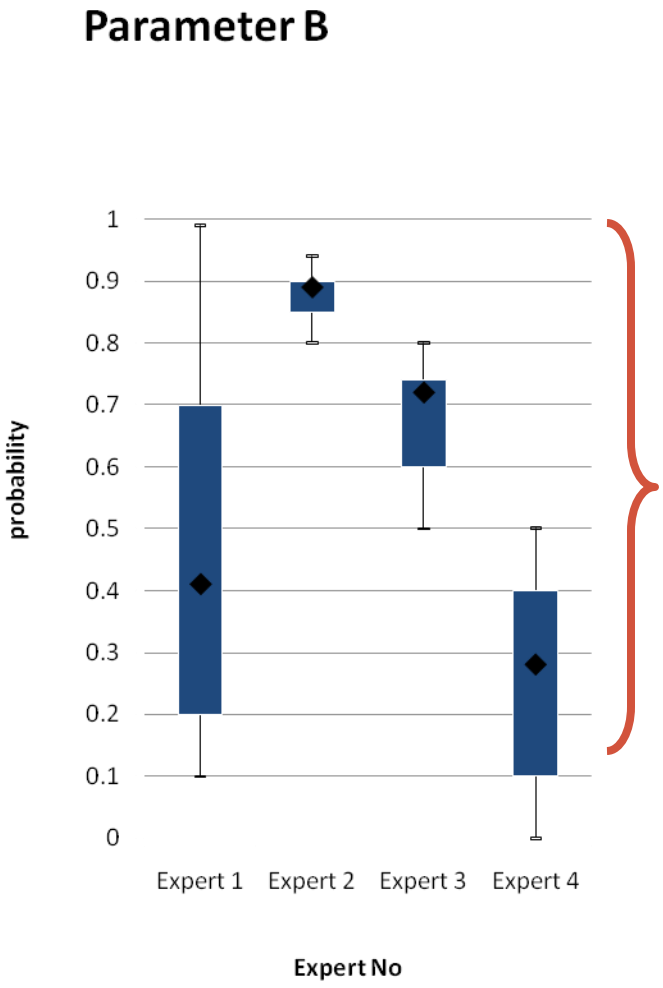
- Effective communication should facilitate:
  - Thorough deliberation about the risks and benefits of different options.
  - Informed, value-consistent choices.
- Important balance between completeness and understandability.
  - Not overly complicated, yet sufficiently detailed to be useful for decision making.
  - Present uncertainty to the level of detail that is useful for the decision context.

Expressions of Uncertainty

- Binary questions
  - Will this action reduce emissions?
  - Will this increase in temperature cause more than 1/3 meter sea level rise at location X?
- Expressions
  - Verbal probabilities
  - Numerical probabilities: frequencies, percentages
  - Simple ranges (low-high), three point ranges (low-best estimate-high), 5-point summaries (low-25%-median-75%-high)
  - Box-whisker diagrams; full probability distributions
  - Other approaches for communicating strength of belief (e.g., belief functions)

Expert judgment elicitations with experts: two problems





Wide range of judgements…

– priority for research?

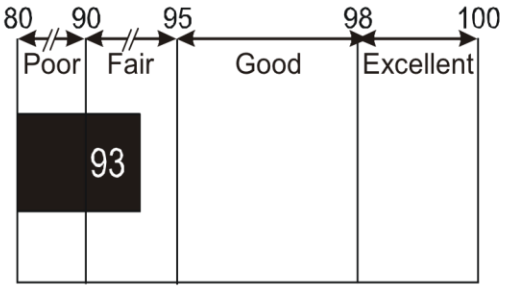
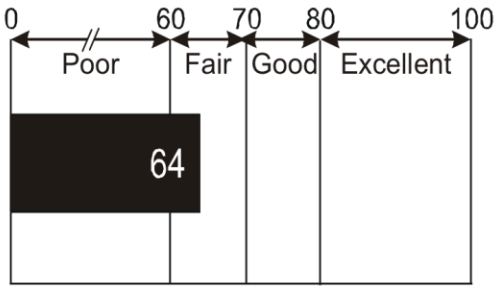
- improved info on stakeholder risk tolerance?

Seek to increase understanding of uncertainty through evaluative structures

- What is an evaluative structure? Any information element that helps decision makers evaluate the goodness or badness of information (gist representation, Reyna et al.).
- Advantages of evaluative structures
  1) Can help laypeople evaluate the meaning of numerical uncertainty expressions.
  2) Can highlight particular aspects of uncertainty that are important for the decision context.
- Examples
  - Color codes to indicate high versus low uncertainty in weather forecasts (e.g., hurricane trajectory)
  - Evaluative labels such as stars or checkmarks (Peters, Dieckmann, et al., 2009)
  - Verbal labels to characterize degree of uncertainty

Evaluative labels

- Evaluative labels have been shown to facilitate the use of unfamiliar numerical information (Peters, Dieckmann, et al. 2009).

Hospital	Survival — Percent (%) of pneumonia patients who survive while being treated	Percent of heart attack patients given recommended treatment (ACE Inhibitor)	Percent of hospital patients who rated their care as very good or excellent
A			

Research Context – NSF / DRMS award to Decision Research (Gregory, Dieckmann& Peters)

- Motivated by the challenges of presenting uncertainty in real-world contexts where end users need to integrate several sources of information to make a decision.
- Focus on:
  - Presenting uncertainty about risks, costs & benefits to decision makers facing regulatory choice.
  - Presenting uncertainty about the consequences of proposed actions in environmental risk management.
- Mix of experiments and case-study tests

Experiment participants: experts and laypersons

- Lay subjects (N=367) were randomly drawn from a web panel.
  - Mean age was 40.35 years (range 19-76) and was 65.1% female.
- Expert Risk managers from US Fish and Wildlife service (N=67).
  - Mean age was 45.48 years and was 38.8% female.
- Experts older, more educated, and more numerate.

Study 1

- Research Questions:
  - 1: How well can people draw meaning from uncertainty (comprehension)?
  - 2: How sensitive are laypeople and experts to evaluative labels in terms of choices.

- Manipulated uncertainty format:
  - Numerical range only
  - Evaluative label only
  - Combined condition

Use of Consequence table to compare policy alternatives in light of uncertainty

	Option 1	Option 2	Option 3
Best estimate of bird population	5,000	5,000	5,000
Confidence in best estimate of bird population	4,500–5,500 High	3,500–8,000 Medium	250–10,000 Low
Cost savings ($ per household per year)	$150	$400	$575
New employment	7	7	7

Guidelines for building uncertainty communications

- No representations that will work in all contexts.
- When both numerical ranges and evaluative labels are provided, experts tend to rely on numerical range and laypersons on evaluative labels.
- Effort and difficulty of making choices also vary: labels hard for experts, numbers for laypersons.
- Responses by experts and laypeople are most different when presented with numerical range information only (focus on width of range as measure of uncertainty vs. ends of range?)
- (Source: Gregory, Dieckmann, Peters et al.; Risk Analysis, in press.)

Guidelines: Multiple Presentations to aid in understanding uncertainty

- Multiple presentations of uncertainty
  - Common recommendation so people can use what is best for them.
  - Be aware that different groups may focus on different representations and come to different conclusions.
    - Experts versus laypeople
    - Higher versus lower numerate
  - Need to consider the communication context and whether a focus on different formats could lead to different conclusions by different individuals / groups.

General Guidelines for building uncertainty into management policies

- Important that goal of communication is clear
  1) What tasks are end users going to perform? Information presentation should make these tasks as easy as possible.
  2) Be clear about the aspects of uncertainty that you want to make most salient.
  3) Prioritize information in terms of importance.
  4) Think about how the communication might go wrong as well as how it might go right.
  5) Test the proposed approach empirically.

Example: Climate Change as Contributor to Forest Policy -- the Mountain Pine Beetle

- Problem: Management options for improving forest policies following death of trees due to pest infestation
- Study focus: Explore the feasibility of judgmental approaches to identifying robust alternatives in a specific climate adaptation decision context: how to manage forest land after pine beetle infestation
- Working definition of robust:. Options reasonably likely to achieve objectives, over a range of uncertainties”
- Three climate uncertainty scenarios, low to high
- Participants: 14 regional forest mgt. specialists
- Timing: one half-day workshop
    - (Source: McDaniels, Mills, Gregory &Ohlson. Risk Analysis, in press.)

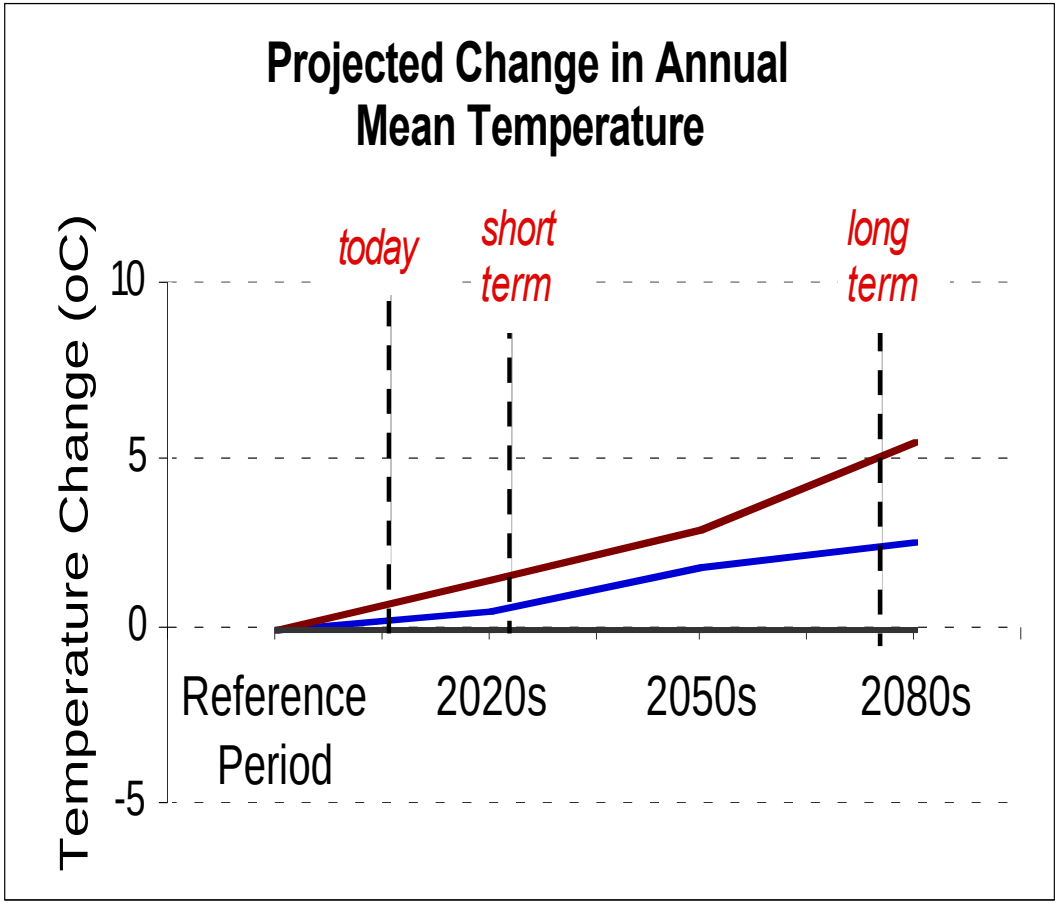
Expected Impacts of Climate Change

Expected Impacts of Climate Change on climatic variables in BC	Predicted Impacts of Climate Change on BC Forests
1 to 4ºC increase in surface air temperature with winter temperatures most affected	Increase in frequency and severity of forest damaging events including forest fires
10 to 20% increase in annual precipitation with less snowfall and more rainfall	Higher than present treeline and northward migration of treeline
Reduced snow depth and an increase in the length of the growing season	Major expansions of grassland and shrublands
Increasing risk of summer drought and decreasing soil moisture	Disappearance of wetlands, shrinking lakes and changing hydrology
More thunderstorm activity	Increase in incidence of insects, disease outbreaks and spread of invasive species
	New assemblages of species occurring in time and space
	Overall loss of biodiversity
	Changes in disturbance regimes and forest productivity
	Forest migration into previously treeless landscapes
	Reduced access for winter logging

Workbook / Workshop

- Elicit expert judgments
- Purposive Sampling
- Pilot test
- Workshop (n=14 after one rejection)
- Workbook:
  - Defines the problem: influence diagram, area maps
  - Clarifies three management objectives
  - Presents climate change scenarios
  - Introduces four management alternatives
  - Evaluates the strategies using judgments

Climate Change Scenarios



Objectives

Category		Objective
Economic	**Short Term (10 - 30 yrs)**	Maximize Overall Net Economic Value (Government, Industry, local employment, etc.)
	Long Term (30 yrs+)	Maximize Overall Net Economic Value (Government, Industry, local employment, etc.)
Social	**Short Term (10 - 30 yrs)**	Maximize Non-timber Values (cultural/spiritual, recreation, aesthetics etc.)
		Minimize Community Fire Risk
	Long Term (30 yrs+)	Maximize Non-timber Values (cultural/spiritual, recreation, aesthetics etc.)
		Minimize Community Fire Risk
Ecological	**Short Term (10 - 30 yrs)**	Maximize Ecosystem Resilience (both terrestrial and aquatic)
	Long Term (30 yrs+)	Maximize Ecosystem Resilience (both terrestrial and aquatic)

Alternatives
Strategy Tables

STRATEGY A

HARVEST

AAC Uplift (5-10 years)	Retention Target	Partition Cut?	Utilization Standards
+ 40%	50%	YES	Decrease
+ 30%	30%	**NO**	**Status Quo**
+ 25%	**20%**		Increase *
+ 15%	10%		
+ 0%	5%		* Off-quota; reduced stumpage

Harvest Profile	Average Annual Harvest Volume	Landscape-Level Residual Structure
	Decrease	Decrease
	Same as recent	**Same as recent**
	Increase	Increase

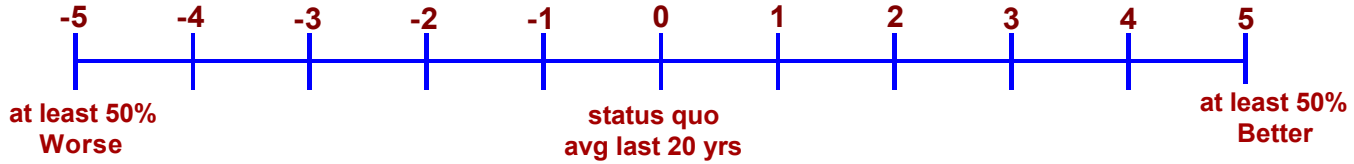
SILVICULTURE

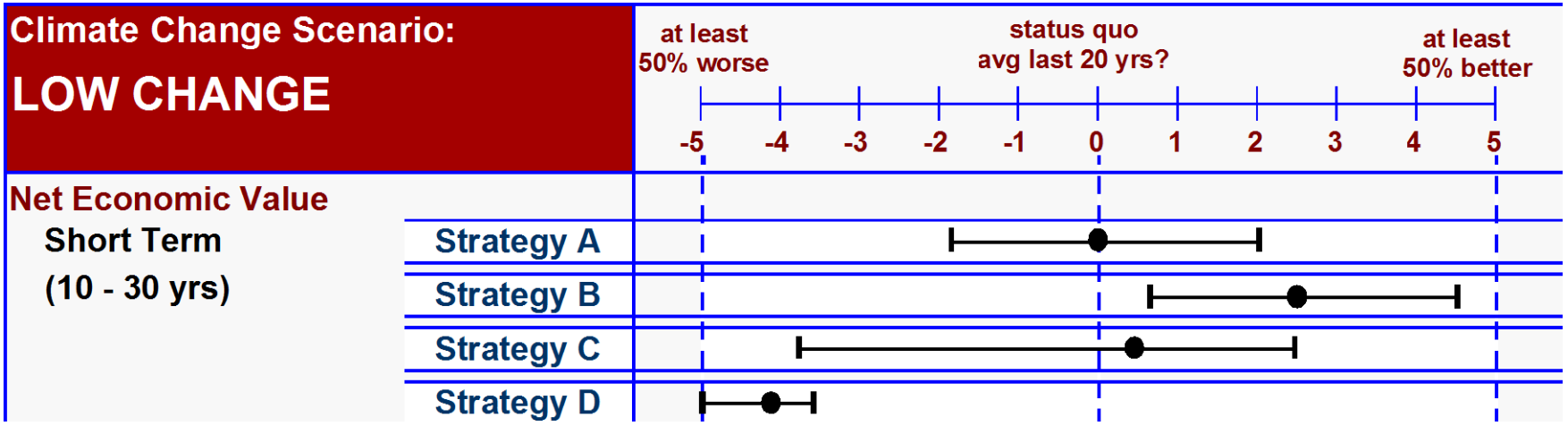
Silviculture	Species	Restoration
Basic	Manage to Pine (> 60%)	None
Enhanced	**Increase other Conifers**	**Plantations Only ($200k)**
	Increase Mixed Wood	Comprehensive ($400k)

FIRE

Fire Management
Aggressive Suppression
Strategic Suppression
Fuels Management (pb)

Judgements

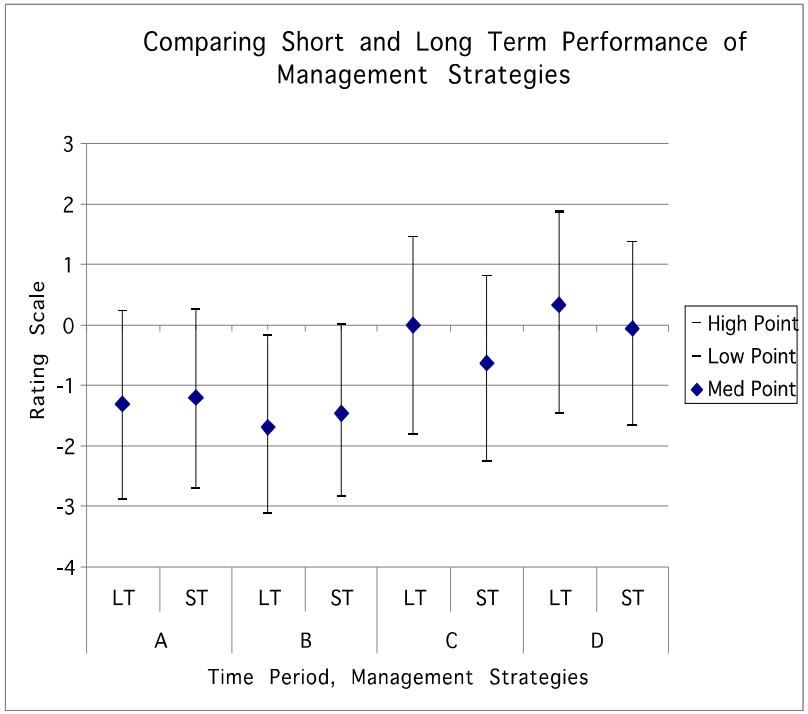

-5
-4
-3
-2
-1
0
1
2
3
4
5
at least 50%
Worse
status quo
avg last 20 yrs
at least 50%
Better

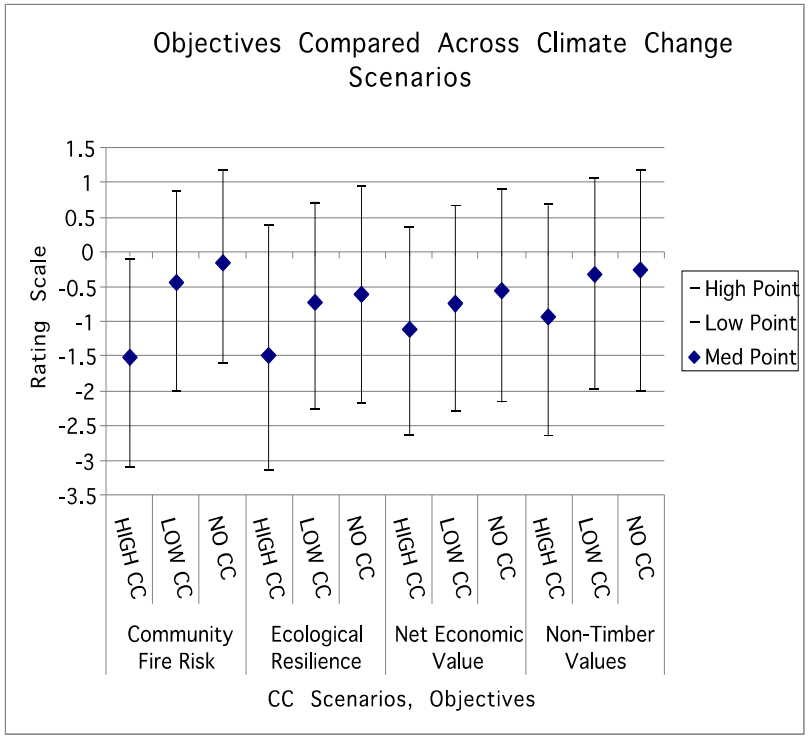

Climate Change Scenario:
LOW CHANGE
at least
50% worse
status quo
avg last 20 yrs?
at least
50% better
-5
-4
-3
-2
-1
0
1
2
3
4
5
Net Economic Value
Short Term
(10 - 30 yrs)
Strategy A
Strategy B
Strategy C
Strategy D

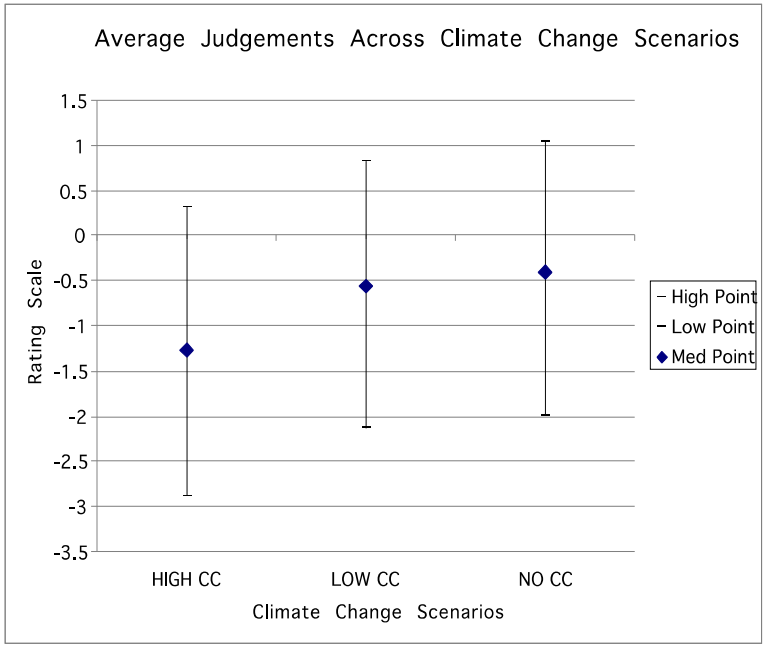
Findings

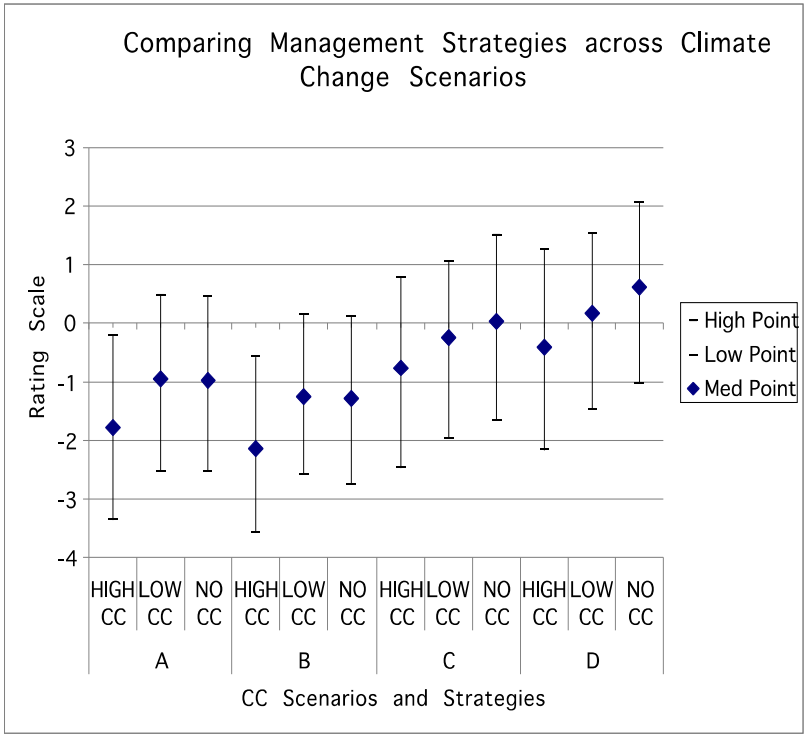
- Two alternatives widely seen as most robust over the climate uncertainty
- The current status quo policy performs worst
- The more robust alts have higher performance in part due to more flexibility and diversity on the ground (like findings of analytical RDM)
- Conclusion by participants: this is an encouraging method that deserves further work, in part because it provides quick insights – helps to focus more detailed decision-aiding efforts

How were judgements affected by time period, objectives and climate change scenarios?

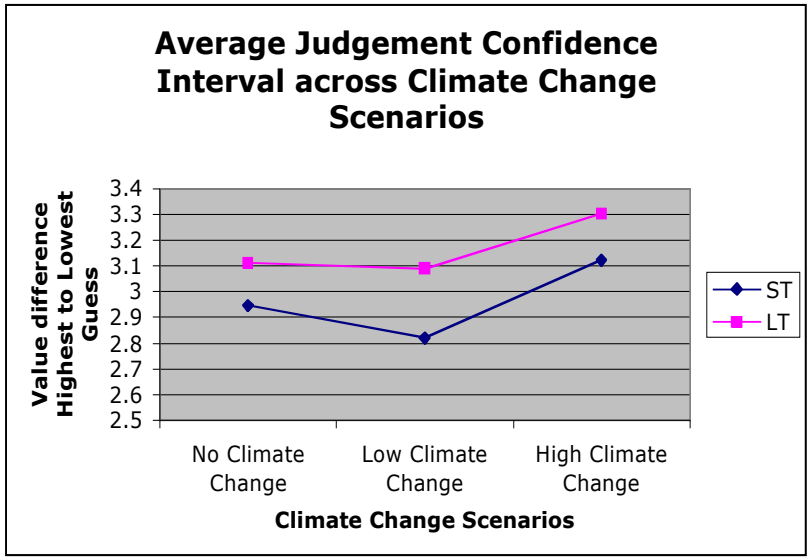


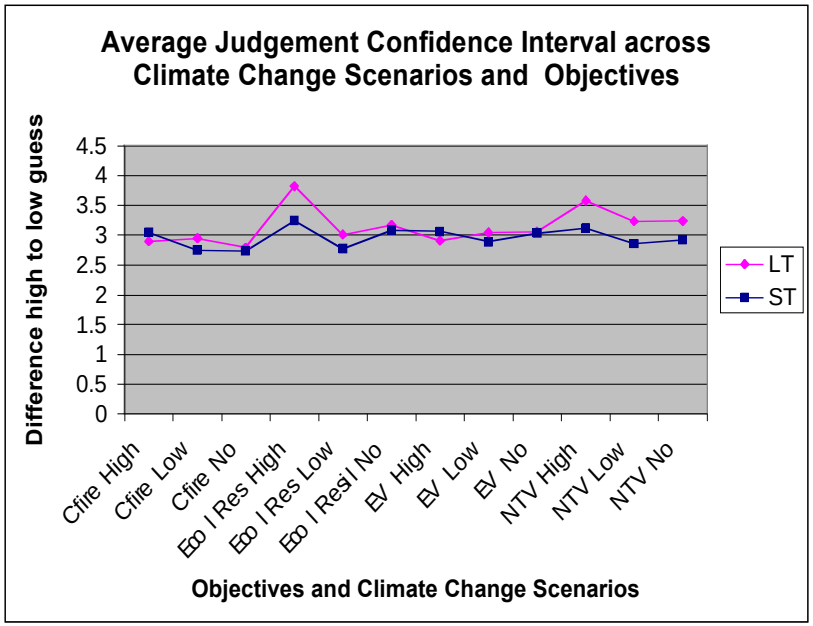



Average Judgements Across Climate Change Scenarios
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
Rating Scale
HIGH CC
LOW CC
NO CC
Climate Change Scenarios
High Point
Low Point
Med Point


Comparing Management Strategies across Climate Change Scenarios
3
2
1
0
-1
-2
-3
-4
Rating Scale
HIGH CC
LOW CC
NO CC
HIGH CC
LOW CC
NO CC
HIGH CC
LOW CC
NO CC
HIGH CC
LOW CC
NO CC
A
B
C
D
CC Scenarios and Strategies
High Point
Low Point
Med Point

Confidence in judgments of uncertainty





Conclusion: Integrating Uncertainty into Evaluations of Policy Choices

- An organized, structured decision-aidingprocess is essential to informed choices
- Immediate and long-term benefits
  - Increases opportunity to work on / resolve the real problems
  - Choices will better reflect citizen& scientific priorities
  - Levels the playing field: improves understanding, incorporates multiple perspectives
  - Transparency -- people will see how their input is used
  - Less controversy, due to adherence to clear mandate
  - Fewer delays when implementing plans
  - Fewer surprises, because uncertainty is recognized explicitly
- What's not to like?

THANK YOU

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DECISION RESEARCH