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Can Interacting With Computers Help People Choose Better Scenarios?

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IQ SCENE Workshop

March 26, 2014

Humans Are Avid Scenario Builders

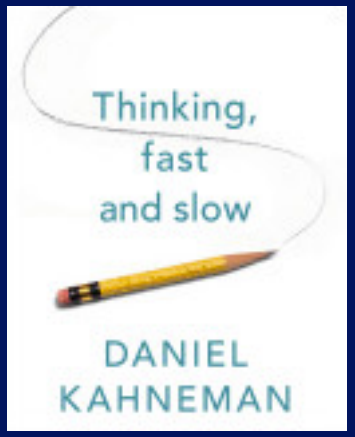
The ability to create and share scenarios represents a key difference between humans and other animals

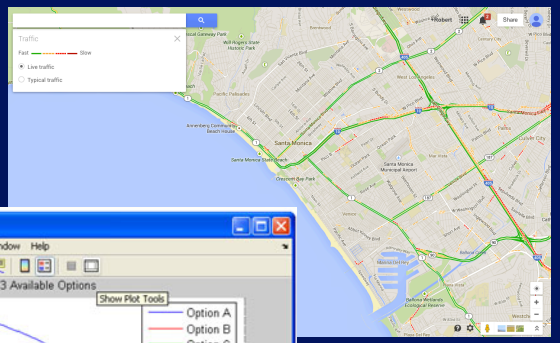
We:

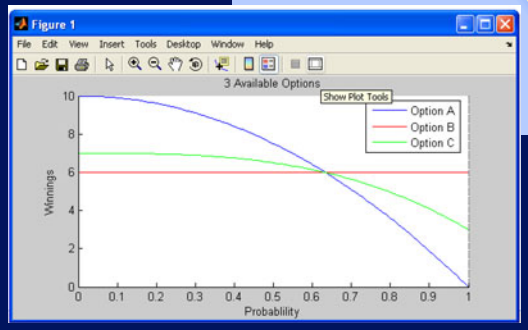
- *Tell stories*
- *Picture future situations*
- *Imagine each other's experiences*
- *Contemplate potential explanations*
- *Plan how to teach*
- *Reflect on moral dilemmas*

Decision Aids Can Help People Overcome Biases in Decision Making

Human decision making has well-understood biases







Many decision aids now available to help

But few decision aids address tasks as complex as choosing scenarios.

Can new methods make such aids possible?

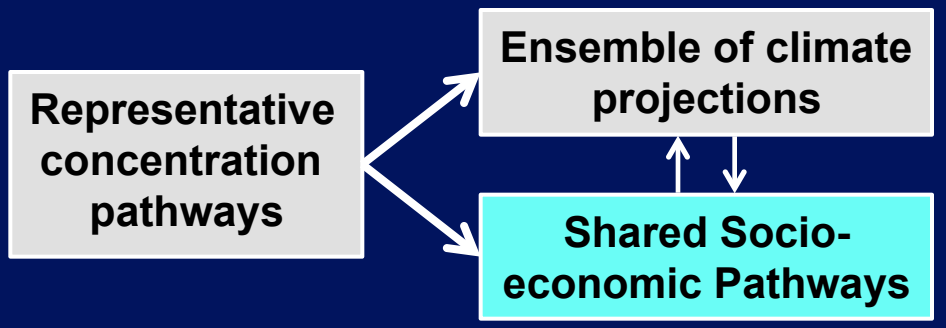
Outline

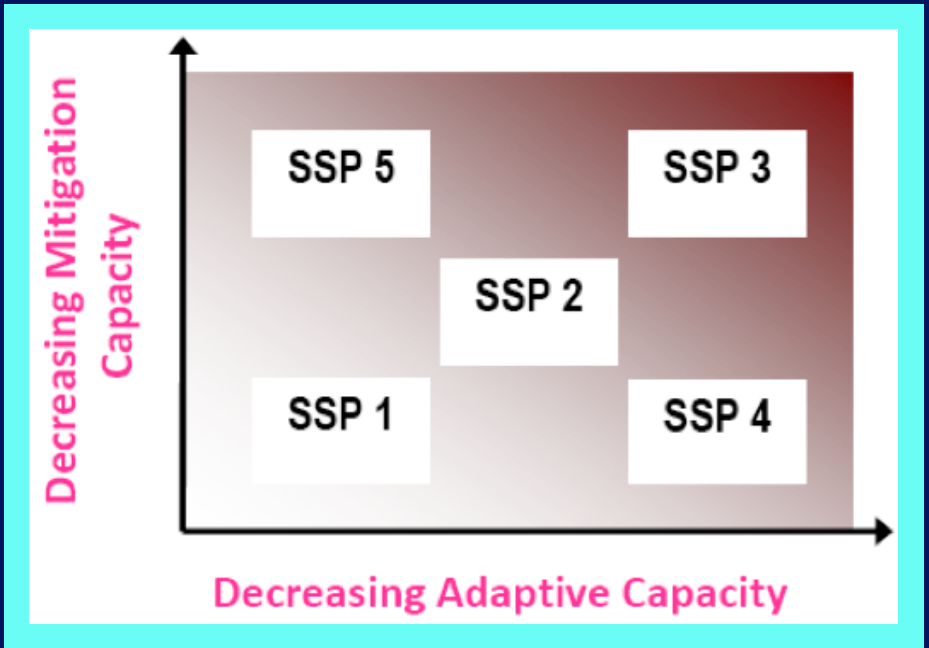
- **Qualitative scenarios processes**
  - **What they do well and poorly**
- **Decision aids to help with choosing scenarios**
- **Context and vision**

Scenario Building Can Prove a Complex Process

New IPCC scenario process

- Begins with four alternative pathways for atmospheric greenhouse gas concentrations
- Generates climate projections from these concentrations
- Develops socio-economic scenarios consistent with these concentrations and climates
- Organizes these SSP's with scenario matrix architectures, narratives, and modeling





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Climatic Change special issue on SSP's (2013)

New IPCC Scenario Process Builds on "Story and Simulation" Approach to Scenario Development

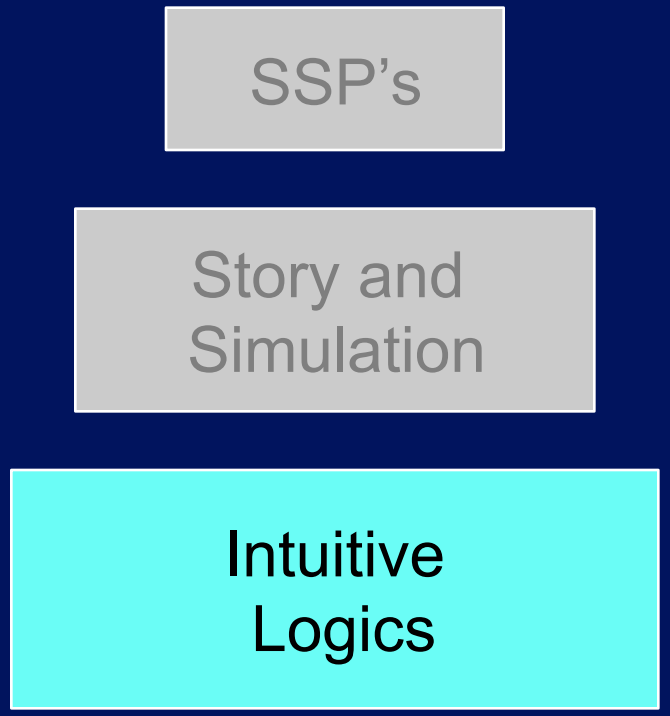
SSP's

Story and Simulation

In story and simulation:

Qualitative storylines help to parameterize quantitative models

Story and Simulation Builds on Intuitive Logics Approach



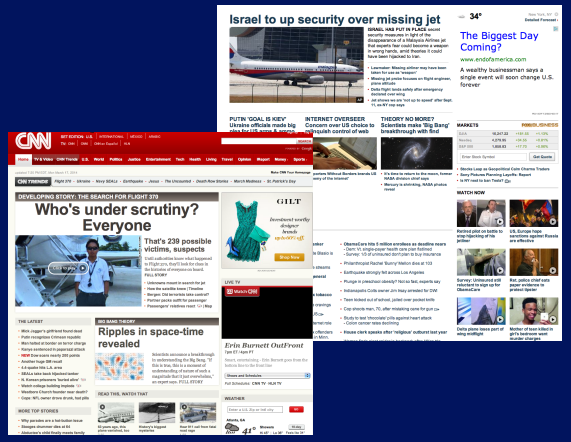
Intuitive logics includes:

- Specifying the decision scenarios aim to inform
- Identifying a small number of key driving forces
- Crafting storylines that explain the scenario logics

Scenarios Address Cognitive Barriers That Complicate Effective Decisions Under Uncertainty

Over-confidence

Uncertainty absorption



Strategic use of uncertainty

Schoemaker (1993)

Scenarios Employ Various Cognitive Mechanisms to Overcome These Barriers

- Presenting futures as "possibilities," not predictions, is less threatening to those holding different worldviews
- Scenarios facilitate learning -- providing a framework for scanning, updating, and understanding the future as it unfolds
- Narratives can engage and influence people's views

Scenarios can change decision makers' assumptions about how the world works, compelling them to reorganize their mental models of reality

Pierre Wack

Schoemaker (1993)

But Scenario Processes Can Prove Ineffective

Ambiguity and Bias

Illusion of Communication

Relevance and Context

Surprise

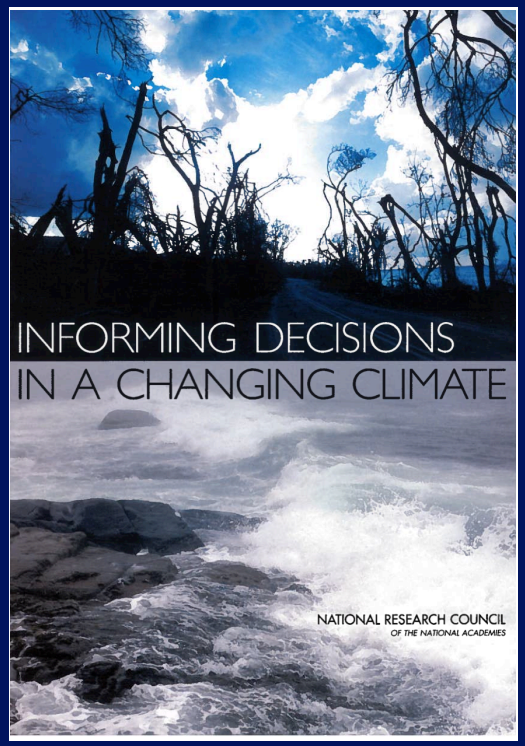
Outline

- Qualitative scenarios processes
  - What they do well and poorly
- Decision aids to help with choosing scenarios
- Context and vision

Decision Support Concept Helps Organize Insights from Cognitive and Organizational Literatures Relevant to Crafting Good Decision Aids

Decision support:

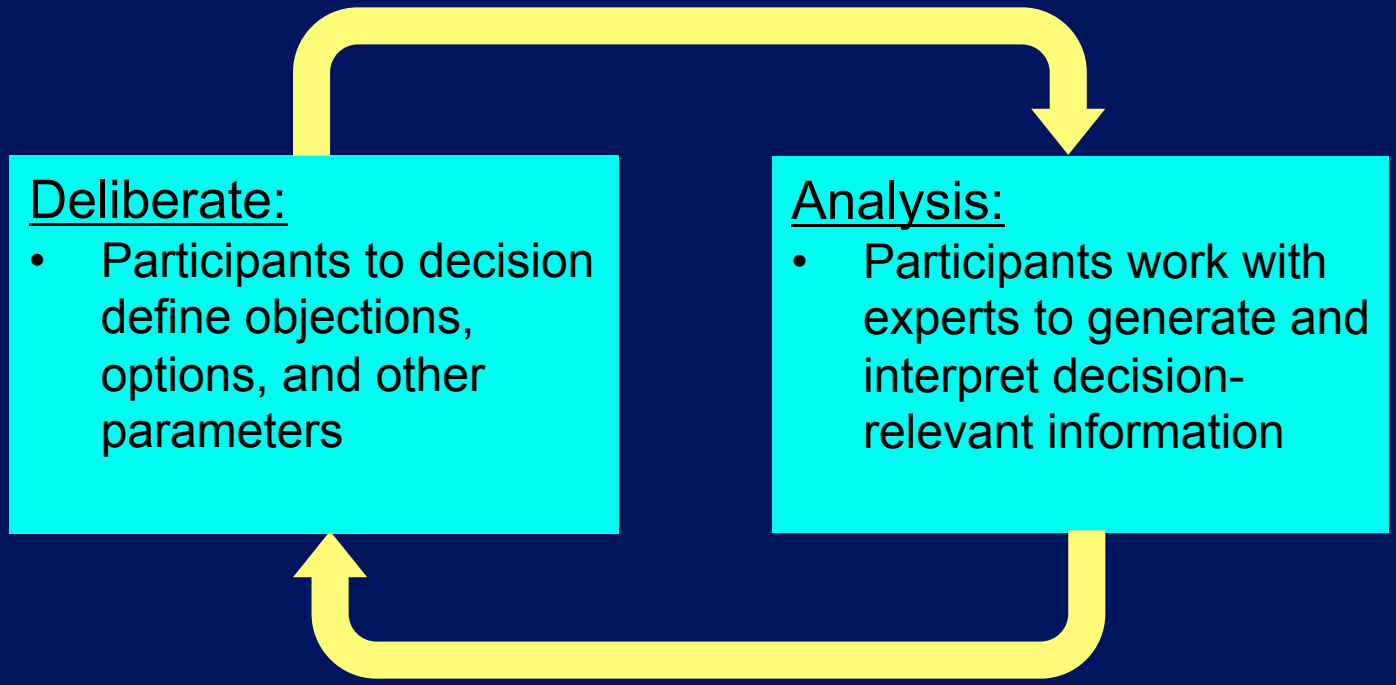
- Represents organized efforts to produce, disseminate, and facilitate the use of data and information to improve decisions
- Includes as key elements:
  - Recognition that decision processes are at least as important as decision products
  - Co-production of knowledge between users and producers
  - Institutional stability
  - Design for learning



NRC (2009)

Decision Support Employs Analysis Embedded in Iterative Process of Stakeholder Engagement

Process of *deliberation with analysis*:



NRC (2009) p. 78

Why is It Hard to Develop Decision Aids to Facilitate Scenario Selection?

Most decision aids support a choice task, that is, choosing among a menu of options

But scenario selection is a decision structuring task, that is, defining the scope of the problem, the goals, and options under consideration

In particular, scenarios should help users engage with multiple ways of seeing the world

So What Scenarios Do We Choose?

On the occasion of the 1893 World Columbian Exposition 74 experts wrote essays predicting what the US would look like in 1993

- *Most were wrong*
- *Some were strangely close to truth*
- *All reflect the differing passions, fears, and dreams of their authors*

Walter (1992)

What Are Criteria for Good Scenarios?

	Individual scenarios	Set of scenarios
Salient (Relevant)	X	X
Credible (Plausible)	X	
Legitimate (Representative)		X

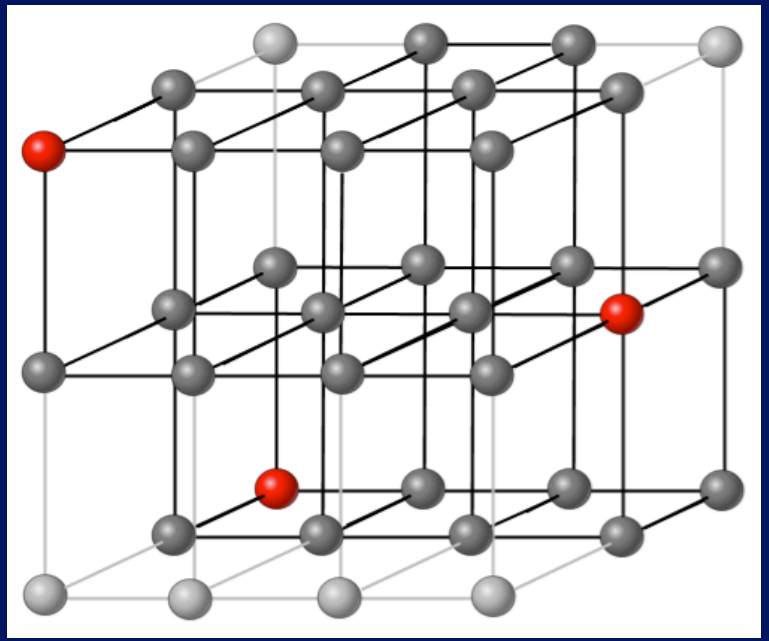
From Carlsen

Carlsen Offers Methods to Suggest Scenario Diversity

	Individual scenarios	Set of scenarios
Salient (Relevant)	X	X
Credible (Plausible)	X	
Legitimate (Representative)		**X**

Seek a small number of maximally diverse scenarios:

- Define measures of diversity
- Run optimization algorithms to suggest diverse scenario sets



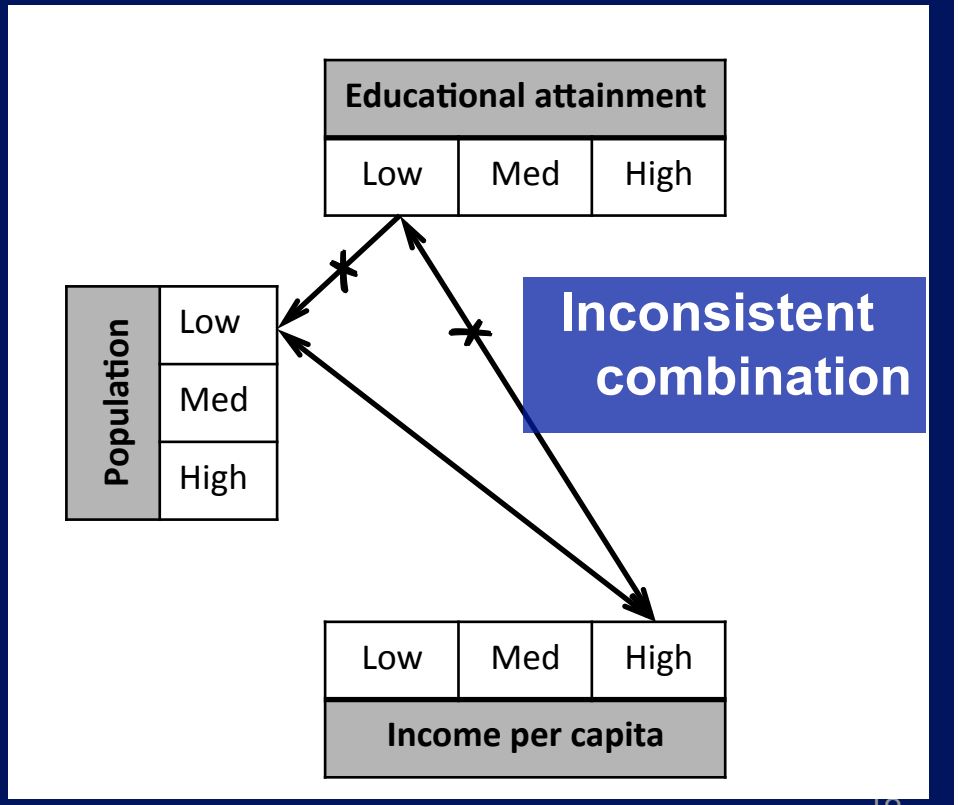
From Carlsen

Schweizer Offers CIB Methods for Scenario Consistency

	Individual scenarios	Set of scenarios
Salient (Relevant)	X	X
Credible (Plausible)	**X**	
Legitimate (Representative)		X

Use Cross Impact Balance (CIB) methods to evaluate scenario consistency

- List factors that contribute to storylines
- Assess direct influence for each pair of factors
- Use CIB matrix to quantify resulting scenario consistency



Schweizer and Kriegler (2012)

Schweizer Offers CIB Methods for Scenario Consistency

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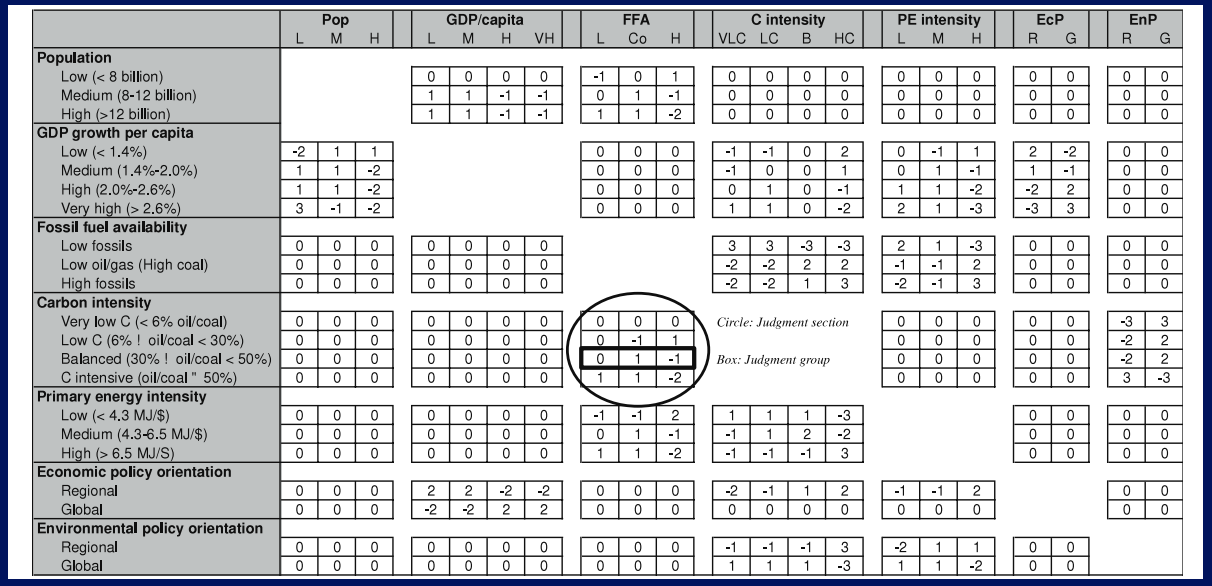
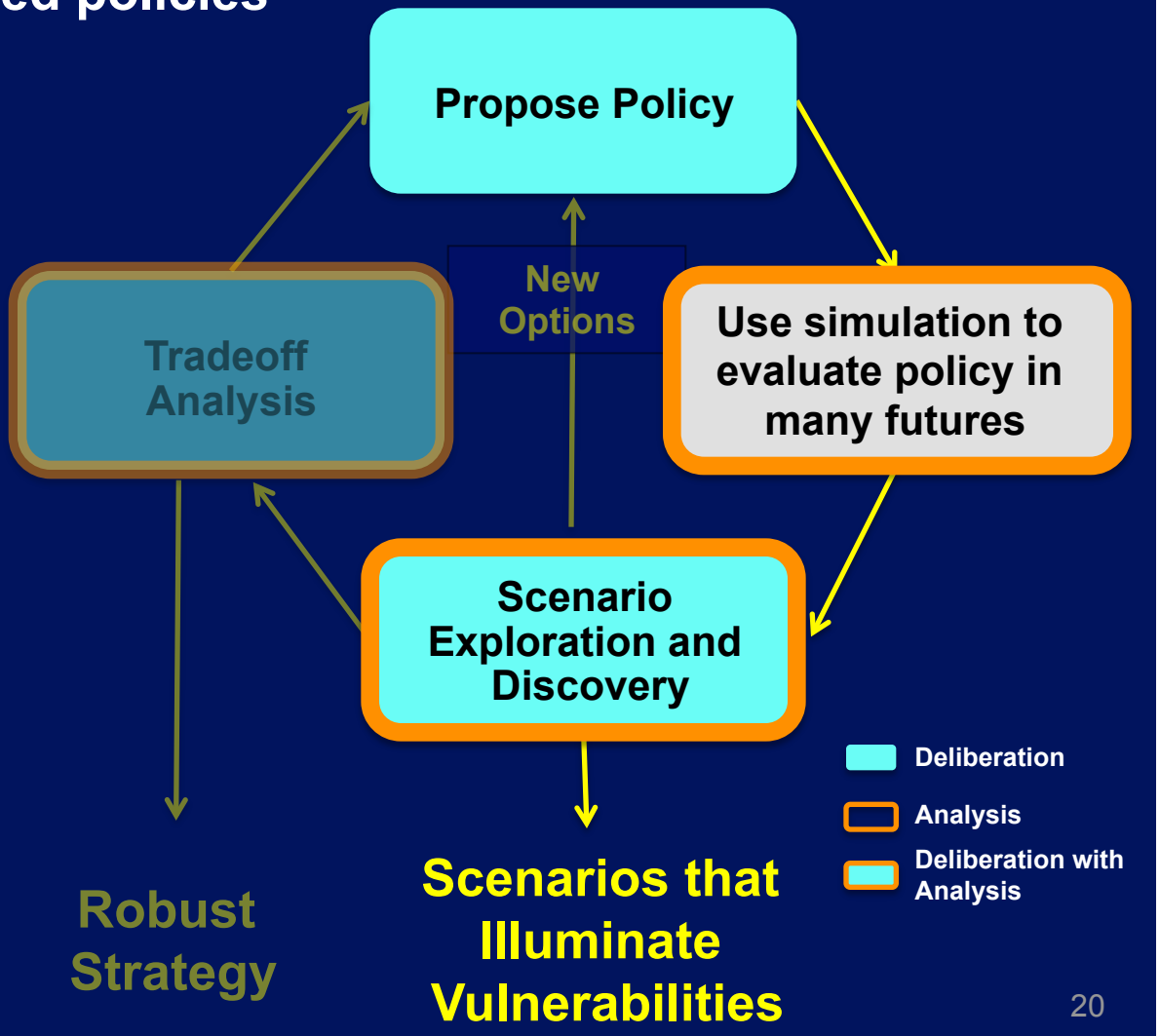


	Pop			GDP/capita				FFA			C intensity				PE intensity			EcP		EnP	
	L	M	H	L	M	H	VH	L	Co	H	VLC	LC	B	HC	L	M	H	R	G	R	G
Population																					
Low (< 8 billion)				0	0	0	0	-1	0	1	0	0	0	0	0	0	0	0	0	0	0
Medium (8-12 billion)				1	1	-1	-1	0	1	-1	0	0	0	0	0	0	0	0	0	0	0
High (>12 billion)				1	1	-1	-1	1	1	-2	0	0	0	0	0	0	0	0	0	0	0
GDP growth per capita																					
Low (< 1.4%)	-2	1	1					0	0	0	-1	-1	0	2	0	-1	1	2	-2	0	0
Medium (1.4%-2.0%)	1	1	-2					0	0	0	-1	0	0	1	0	1	-1	1	-1	0	0
High (2.0%-2.6%)	1	1	-2					0	0	0	0	1	0	-1	1	1	-2	-2	2	0	0
Very high (> 2.6%)	3	-1	-2					0	0	0	1	1	0	-2	2	1	-3	-3	3	0	0
Fossil fuel availability																					
Low fossils	0	0	0	0	0	0	0				3	3	-3	-3	2	1	-3	0	0	0	0
Low oil/gas (High coal)	0	0	0	0	0	0	0				-2	-2	2	2	-1	-1	2	0	0	0	0
High fossils	0	0	0	0	0	0	0				-2	-2	1	3	-2	-1	3	0	0	0	0
Carbon intensity																					
Very low C (< 6% oil/coal)	0	0	0	0	0	0	0	0	0	0	*Circle: Judgment section*				0	0	0	0	0	-3	3
Low C (6% ! oil/coal < 30%)	0	0	0	0	0	0	0	0	-1	1					0	0	0	0	0	-2	2
Balanced (30% ! oil/coal < 50%)	0	0	0	0	0	0	0	0	1	-1	*Box: Judgment group*				0	0	0	0	0	-2	2
C intensive (oil/coal " 50%)	0	0	0	0	0	0	0	1	1	-2					0	0	0	0	0	3	-3
Primary energy intensity																					
Low (< 4.3 MJ/$)	0	0	0	0	0	0	0	-1	-1	2	1	1	1	-3				0	0	0	0
Medium (4.3-6.5 MJ/$)	0	0	0	0	0	0	0	0	1	-1	-1	1	2	-2				0	0	0	0
High (> 6.5 MJ/S)	0	0	0	0	0	0	0	1	1	-2	-1	-1	-1	3				0	0	0	0
Economic policy orientation																					
Regional	0	0	0	2	2	-2	-2	0	0	0	-2	-1	1	2	-1	-1	2			0	0
Global	0	0	0	-2	-2	2	2	0	0	0	0	0	0	0	0	0	0			0	0
Environmental policy orientation																					
Regional	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	3	-2	1	1	0	0		
Global	0	0	0	0	0	0	0	0	0	0	1	1	1	-3	1	1	-2	0	0		

Schweizer and Kriegler (2012)

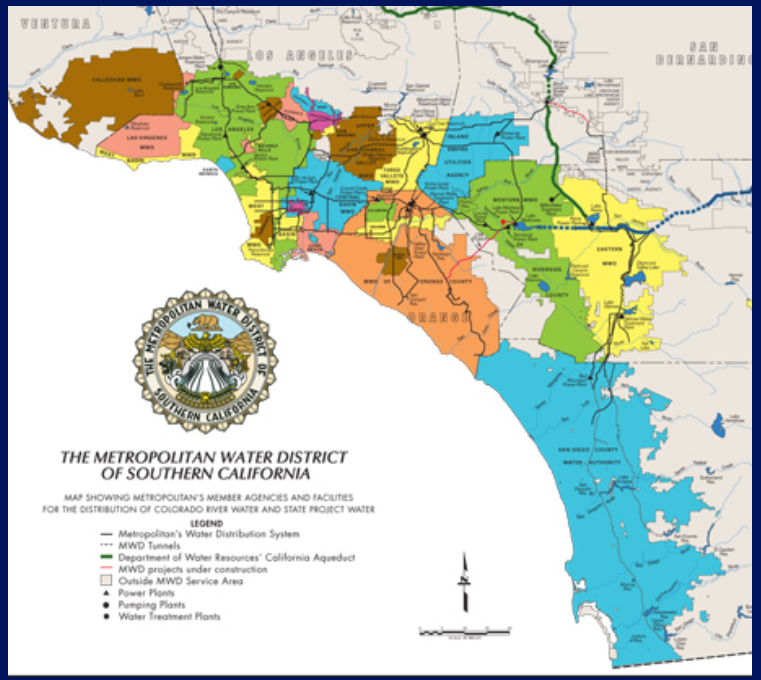
Scenario Discovery Uses Scenarios To Stress Test Proposed Policies

- Concept envisions scenarios as illuminating the vulnerabilities of proposed policies
  - Implements concept with cluster analysis on large databases of simulation results
  - Scenarios *emerge* from analysis, rather than provide inputs to it



Approach Helping Metropolitan Water District of Southern California Implement Adaptive Management Plan

- **Metropolitan's 2010 Integrated Resources Plan describes 25 year investment and policy plan**
  - **Explicitly calls for 10% buffer and adaptive management to address uncertainty**
- **Now run IRP planning models to explore system reliability over 1000's of cases with assumptions regarding:**
  - **Climate, economics/land use, ground water policy, and others**



- **Run cluster analysis to summarize cases where IRP fails to meet reliability goals**
- **Use these scenarios to suggest early warning signs that the Metropolitan Board might monitor**

Consider Plan's Performance in Thousands of Plausible Futures

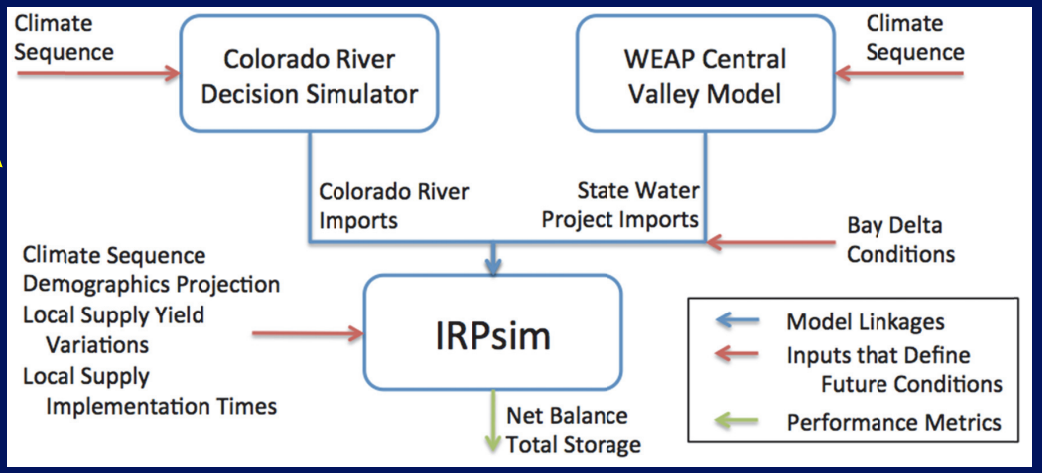
Plan

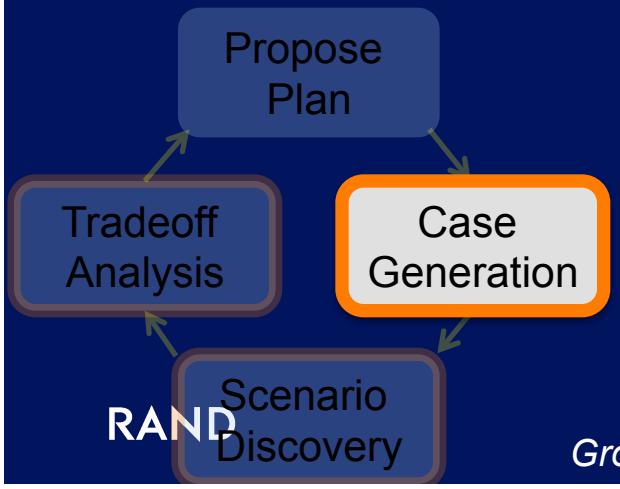
Integrated Resource Plan

Run 3,744 cases to explore many combinations of uncertain factors:

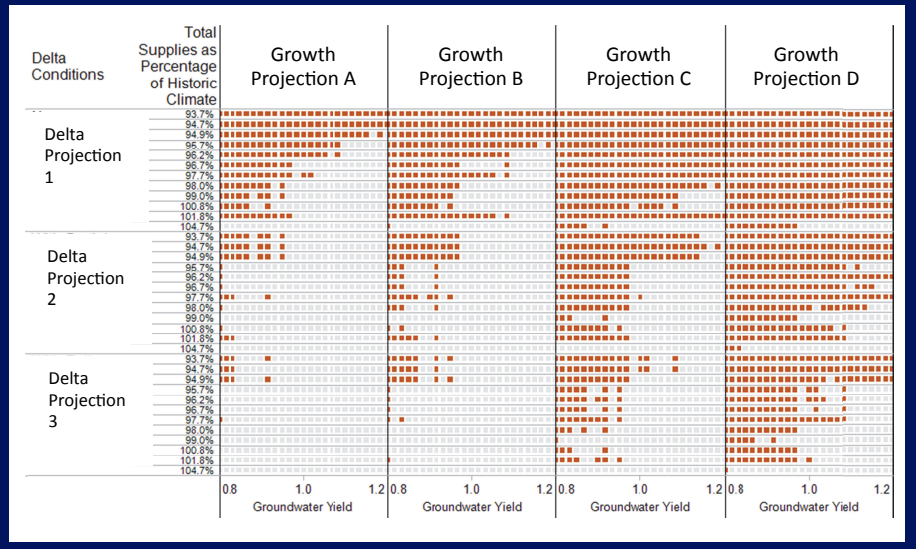
- Climate change
- Regional patterns of development, demand for water
- Yields from local resources
- Timeliness of IRP project implementation

Model & Uncertainties





Database of Results



Groves et. al. (submitted)

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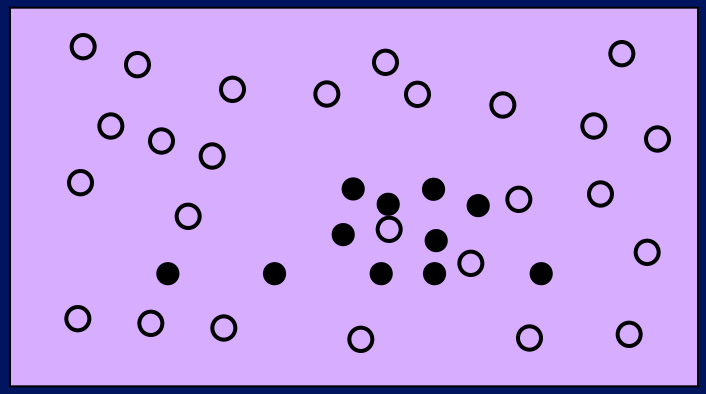
Scenario Discovery Provides an Approach for Computer-Assisted Scenario Development

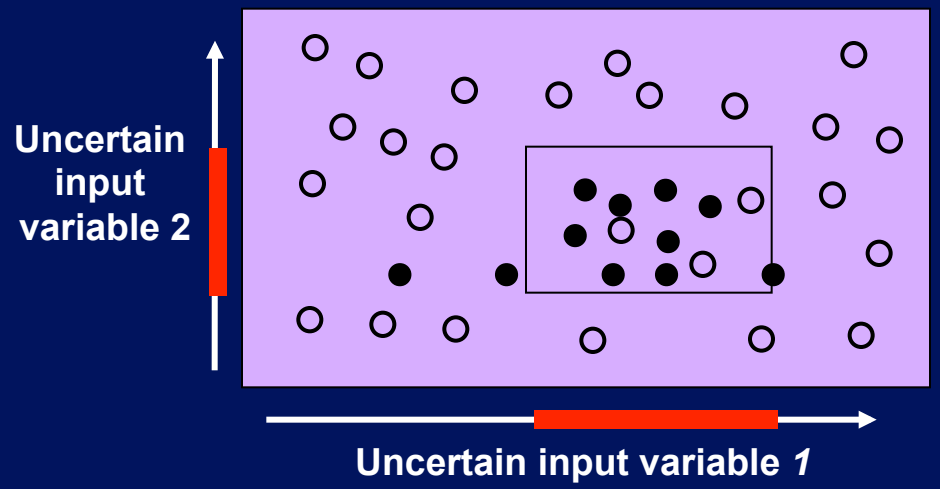
1.Indicate policy-relevant cases in database of simulation results



Bryant and Lempert (2010)

Scenario Discovery Provides an Approach for Computer-Assisted Scenario Development

1. *Indicate policy-relevant cases in database of simulation results*
2. *Statistical analysis finds low-dimensional clusters with high density of these cases*



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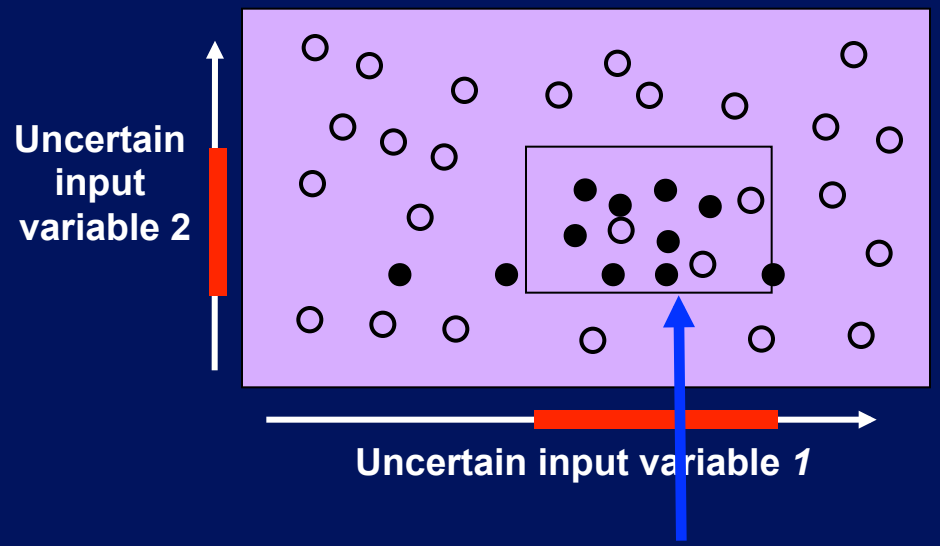


3. *Clusters represent scenarios and driving forces of interest to decision makers*

Bryant and Lempert (2010)

Scenario Discovery Provides an Approach for Computer-Assisted Scenario Development

Approach provides measures of merit for scenario quality

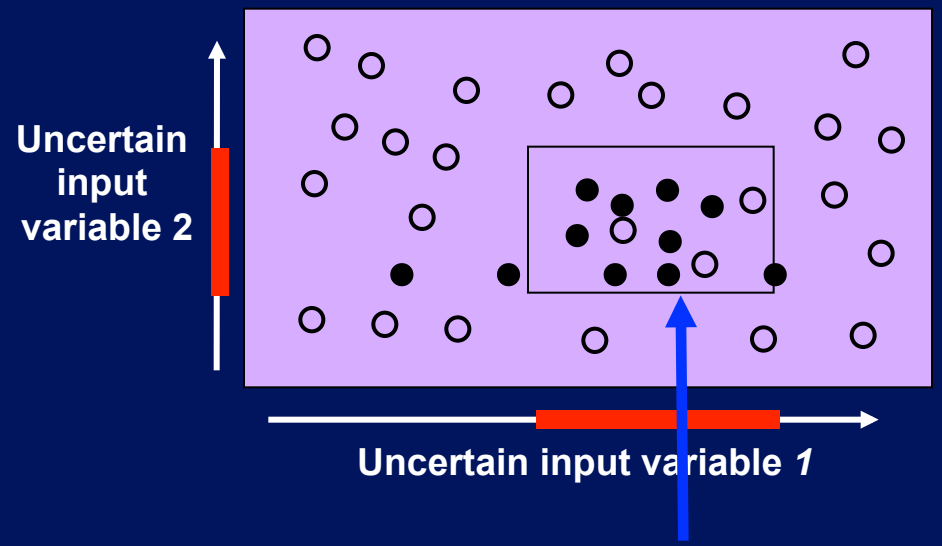
Density:
- How many cases inside the scenario are *policy-relevant?* (e.g. 75%)

Coverage:
- How many of all the *policy-relevant* cases do the scenarios include? (e.g. 82%)

Interpretability:
- Is the number of scenarios and driving forces sufficiently small to understand? (e.g. 1 scenario with two driving forces)

1. Indicate policy-relevant cases in database of simulation results

2. Statistical analysis finds low-dimensional clusters with high density of these cases



3. Clusters represent scenarios and driving forces of interest to decision makers

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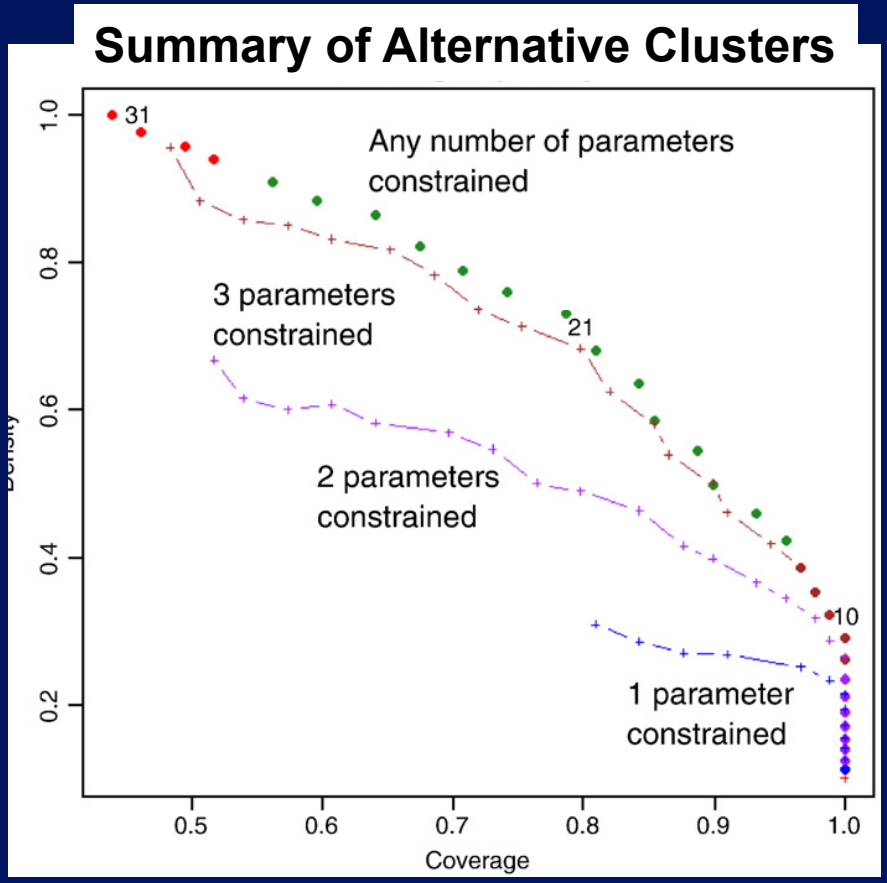
Bryant and Lempert (2010)

Interactive Visualizations Link Quantitative Analysis and Human Insight

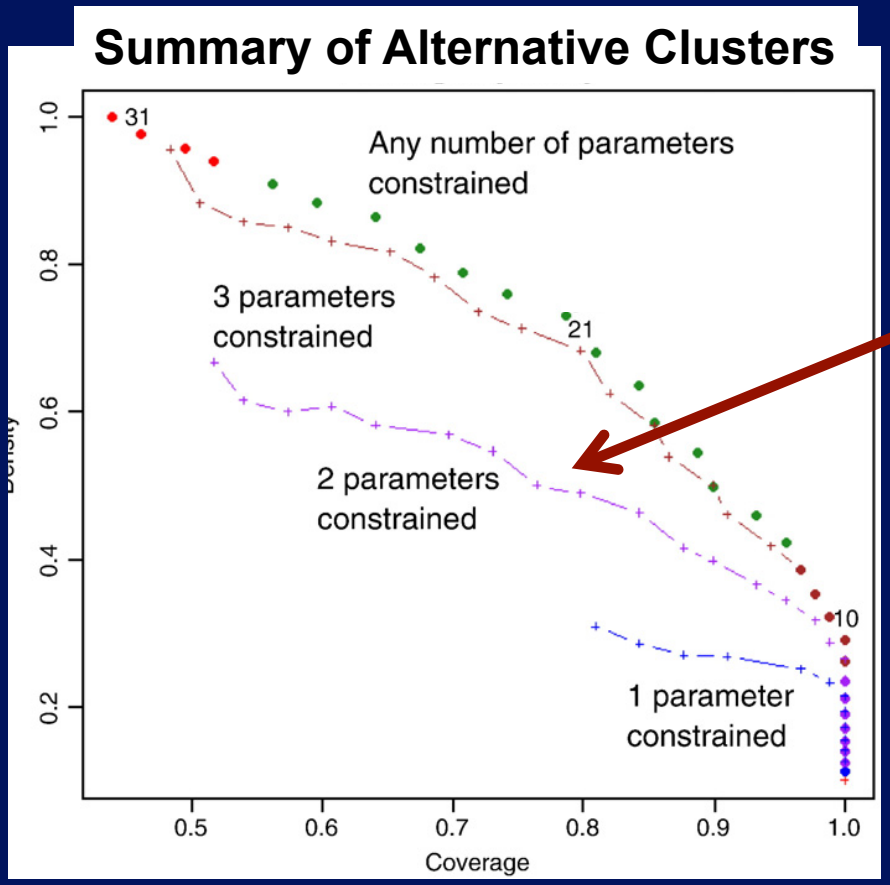


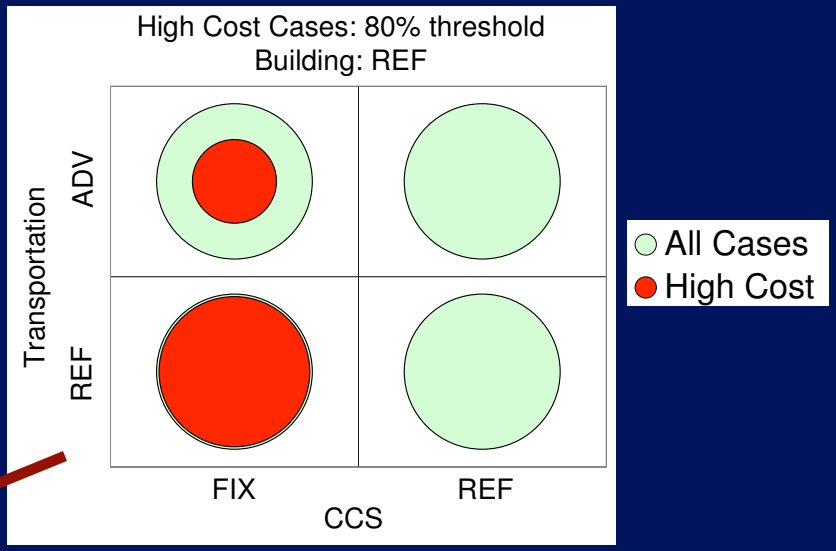
Scenario Discovery algorithms interact with user by reporting many alternative clusters, each with an alternative mix of:

- **Coverage**
- **Density**
- **Interpretability**

Bryant & Lempert (2010)

Interactive Visualizations Link Quantitative Analysis and Human Insight





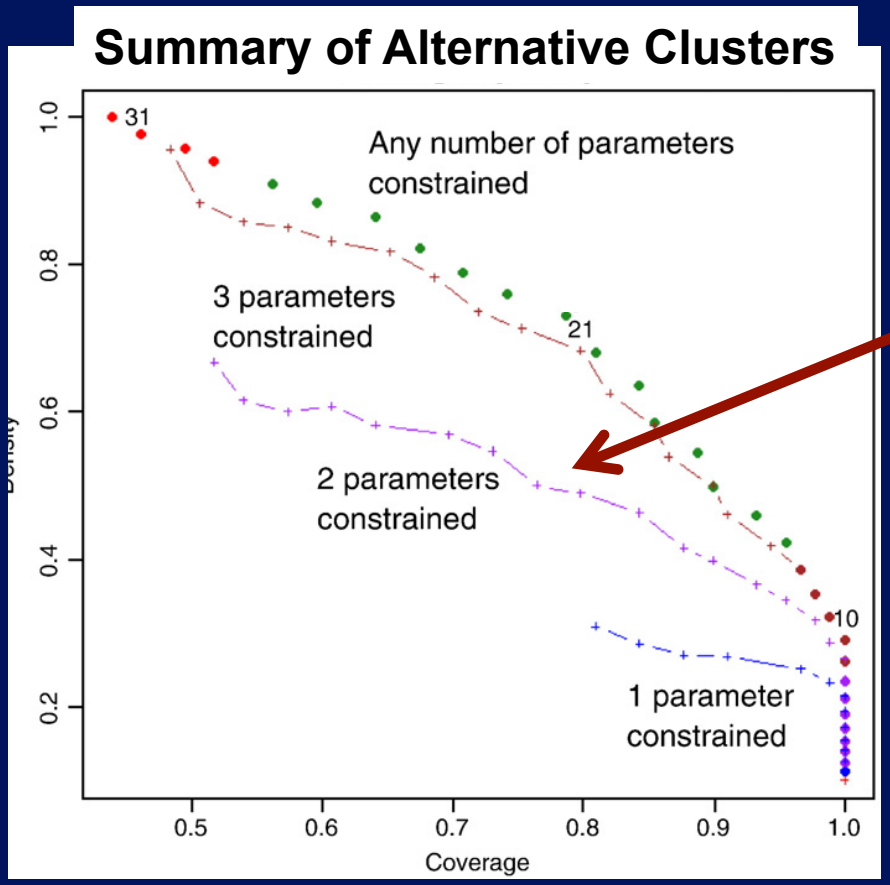
Summary of ~800 GCAM runs

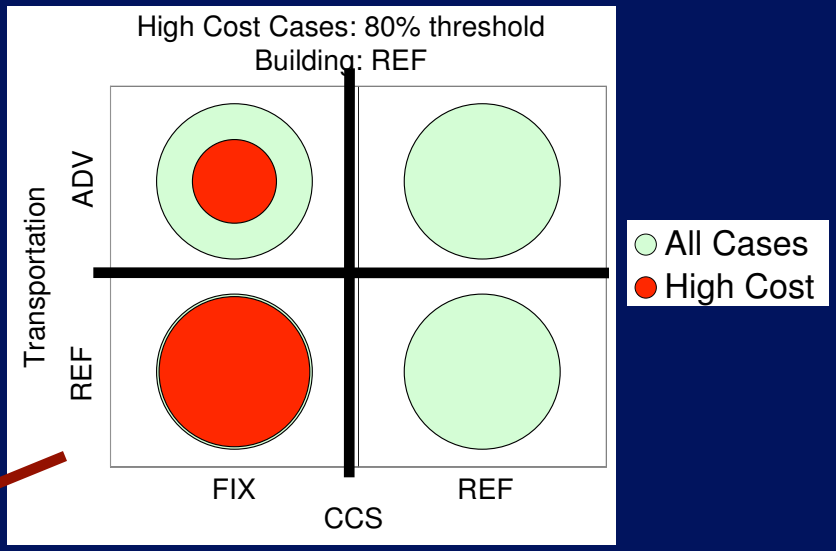
Each clusters described by different combinations of driving forces

Policy makers and analysts can choose best clusters for their decision

McJeon et. al. (2011)

Interactive Visualizations Link Quantitative Analysis and Human Insight





Summary of 800 GCAM runs

Parameters describing clusters represent key driving forces for vulnerable scenarios

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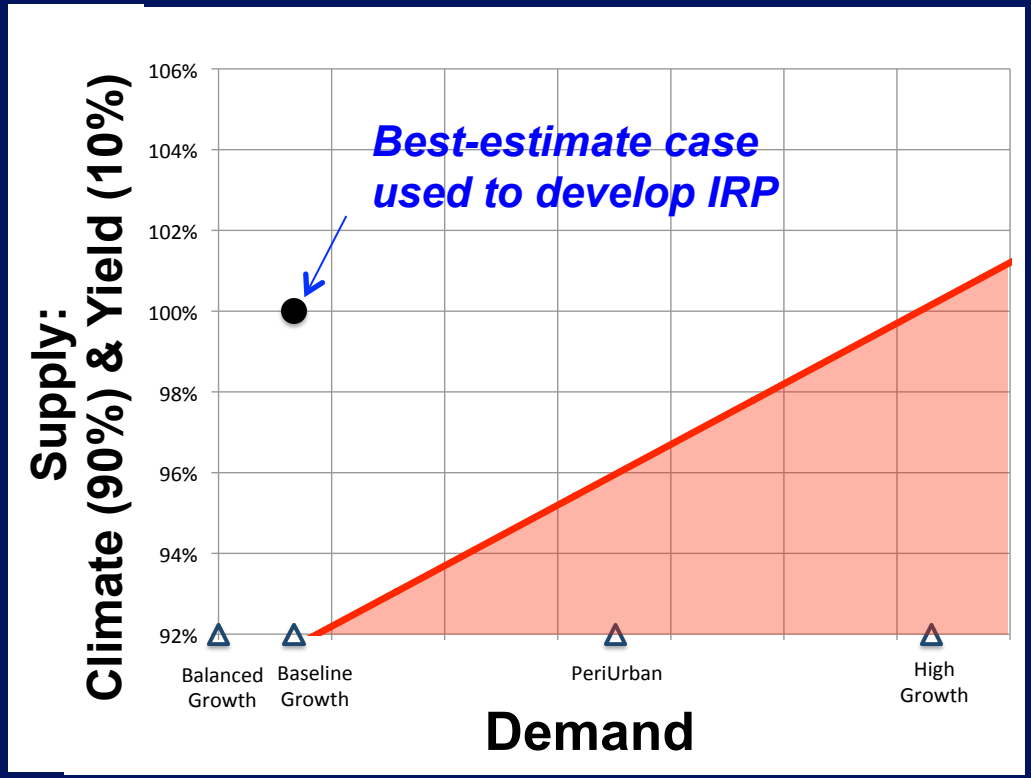
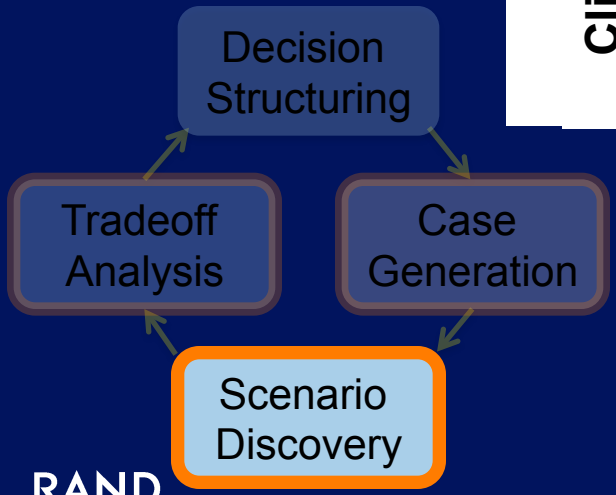
McJeon et. al. (2011)

"Scenario Discovery" Cluster Analysis Summarizes Conditions Where Met IPR Fails to Meet Goals



Range of climate model forecasts



Information useful for identifying key indicators for adaptive management

Parker et. al. (2013)

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Scenario Discovery Views Models As Exploratory, Rather Than Consolidative

- Consolidative models:
  - Bring together all relevant knowledge into a single package which, once validated, can be used as a surrogate for the real world
  - Are often used for prediction
- Exploratory models:
  - Map assumptions onto consequences, without privileging any one set of assumptions
  - Cannot be validated
  - Can, when used with appropriate decision processes and experimental designs, provide policy-relevant information

Bankes (1993); Weaver et. al. (2013)

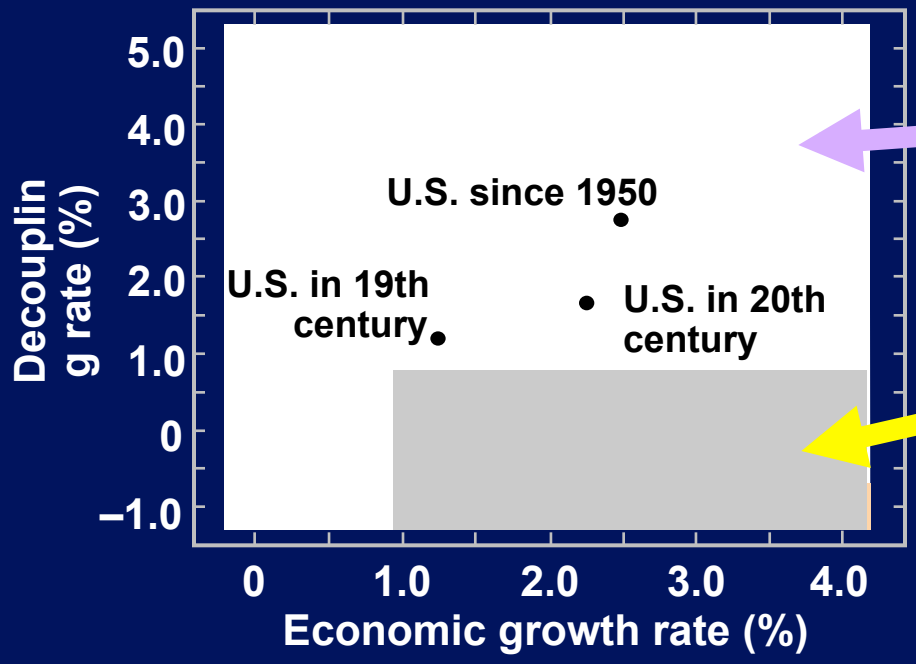
Such Scenarios Can Help Inform Development of Robust Adaptive Strategies

Analysis in "Shaping the Next One Hundred Years:"

- Asked what near-term actions can help ensure economic development and environmental quality over the 21st century?
- Suggested that an adaptive "safety valve" strategy would prove most robust

Stress-Tests Over Multiple Futures Helps Design "Safety Valve" Strategy

- Analysis considers 41 dimensions of uncertainty
- Scenario Discovery suggests two most important key driving forces describing futures in which candidate strategy performs poorly



In almost all other futures, cost constraints can start at low carbon prices

Low Global Decoupling Scenario requires cost constraints which engage only at high carbon prices

This is true no matter what is assumed about dozens of other driving forces

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Lempert, Groves, Popper, Bankes (2006)

This Information Helps Decision Makers Consider Tradeoffs Among Alternative Designs of "Safety Valve" Strategies

Choose this strategy if odds of scenario are high

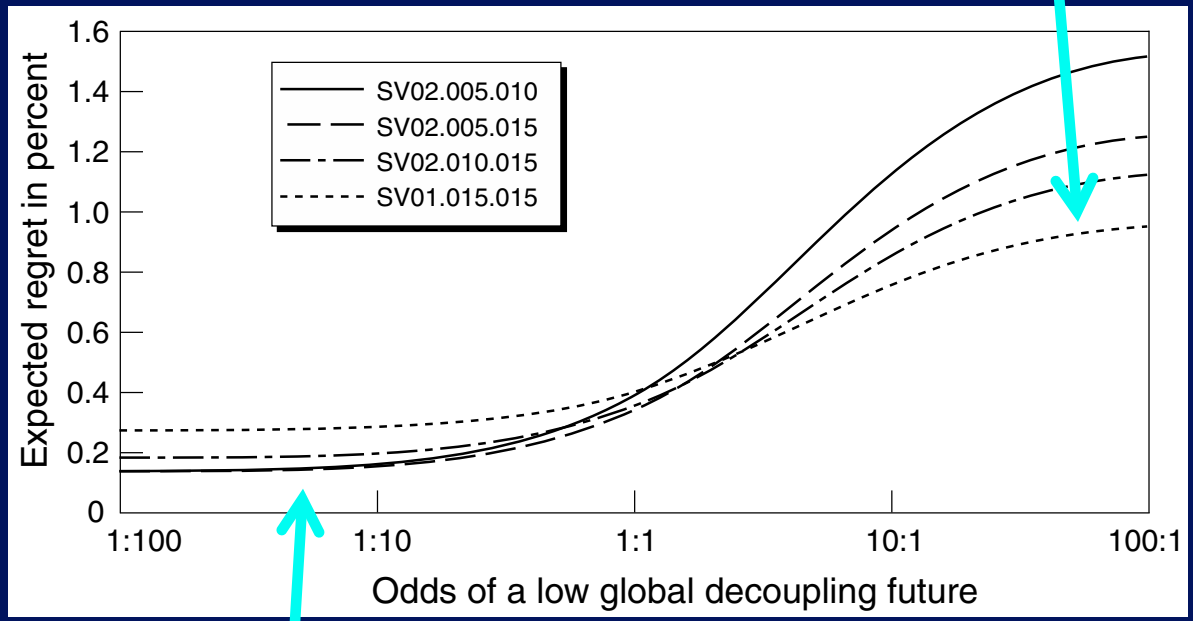
Emissions intensity target (north and south)

↓

SV02.005.015

↑

Cost threshold (north and south)



Choose this strategy if odds of scenario are low

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Lempert, Groves, Popper, Bankes (2006)

Formal Evaluation Helps Improve Decision Aids

- Parker et. at (2013) used surveys and interviews to evaluate interpretability and usability of scenario discovery decision aids
- Surveys found:
  - Users understand information in scenario discovery displays
  - Linear combinations of axis can increase comprehensive, but only when conceptually similar axes (e.g. cost parameters) are combined
- Interviews, comparing Intuitive Logics and Scenario Discovery, found:
  - IL scenarios were easier to understand and favored for scoping
  - SD scenarios conveyed more information and were favored for illuminating tradeoffs and choices
  - Significant interest in processes that combine these two approaches

Parker et. al. (2013)

Scenario Discovery Helps Reconcile Scenario Plausibility with Probabilistic Information

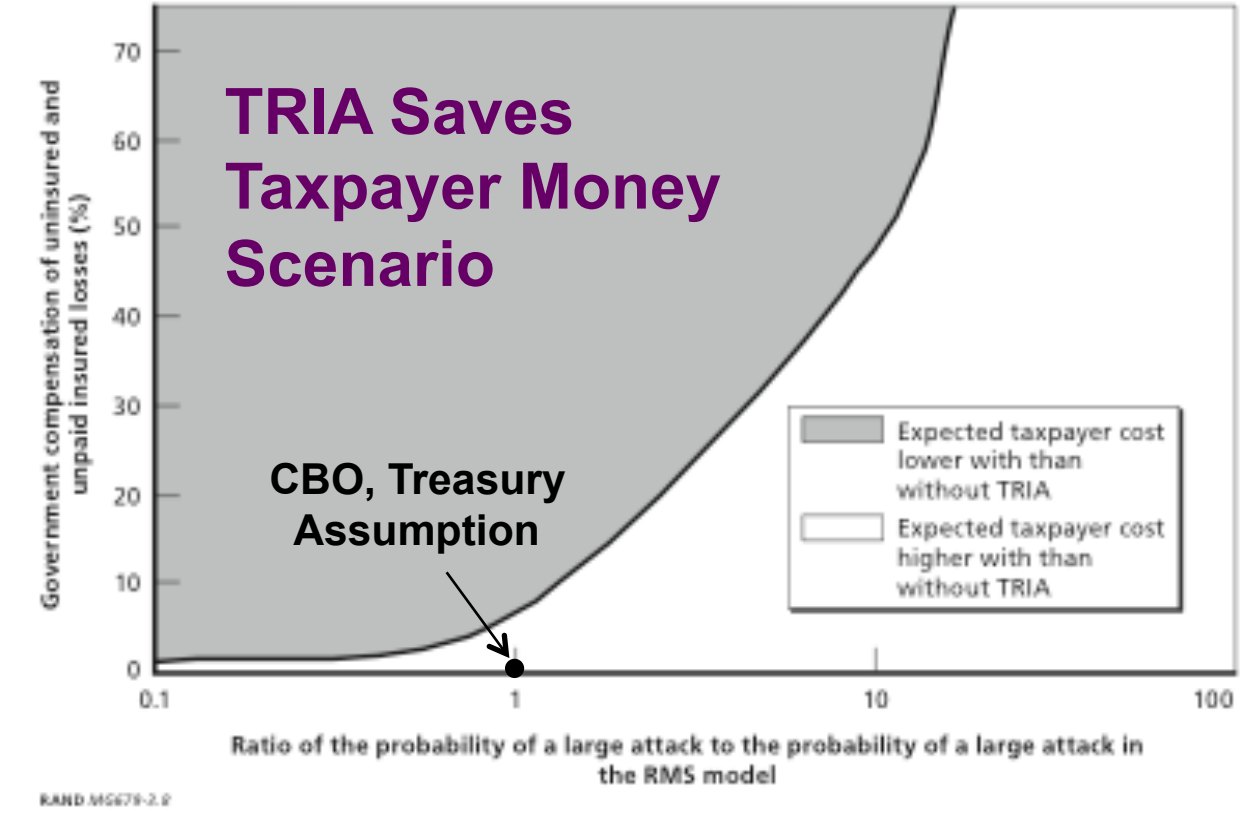
- **Placing probabilities on scenarios can disrupt the sense of 'plausibility, not probability' that makes scenarios cognitively less threatening**
- **But how to use scenarios for decision making?**

One solution -- find find probability thresholds for scenarios, beyond which decision makers might find it prudent to consider alternative strategies

Some Strategies Are Robust Over a Wide Range of Probability Estimates

This chart:

- **Shows expected cost to taxpayers from re-authorizing U.S. Terrorism Risk Insurance Act**
- **Quoted on floor of US Senate by a proponent**
- **Called "insidious" by opponents**
- **Usefully informed Congressional debate**



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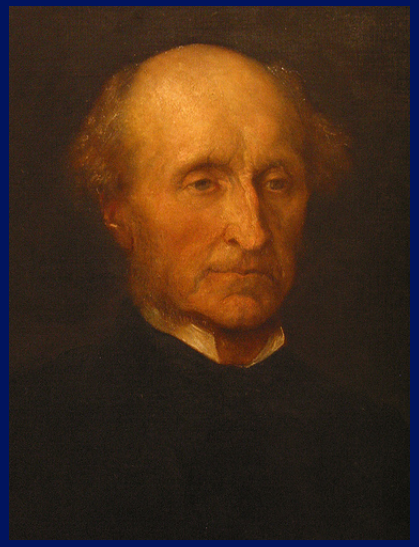
- Decision aids to help with choosing scenarios
- Context and vision

Can New Analytics Facilitate Improved Conversations in Democratic Societies?

Mill saw representative government as a "cognitive process, fashioned to maximize the production, accumulation, and implementation of politically relevant truths" *Stephen Homes*



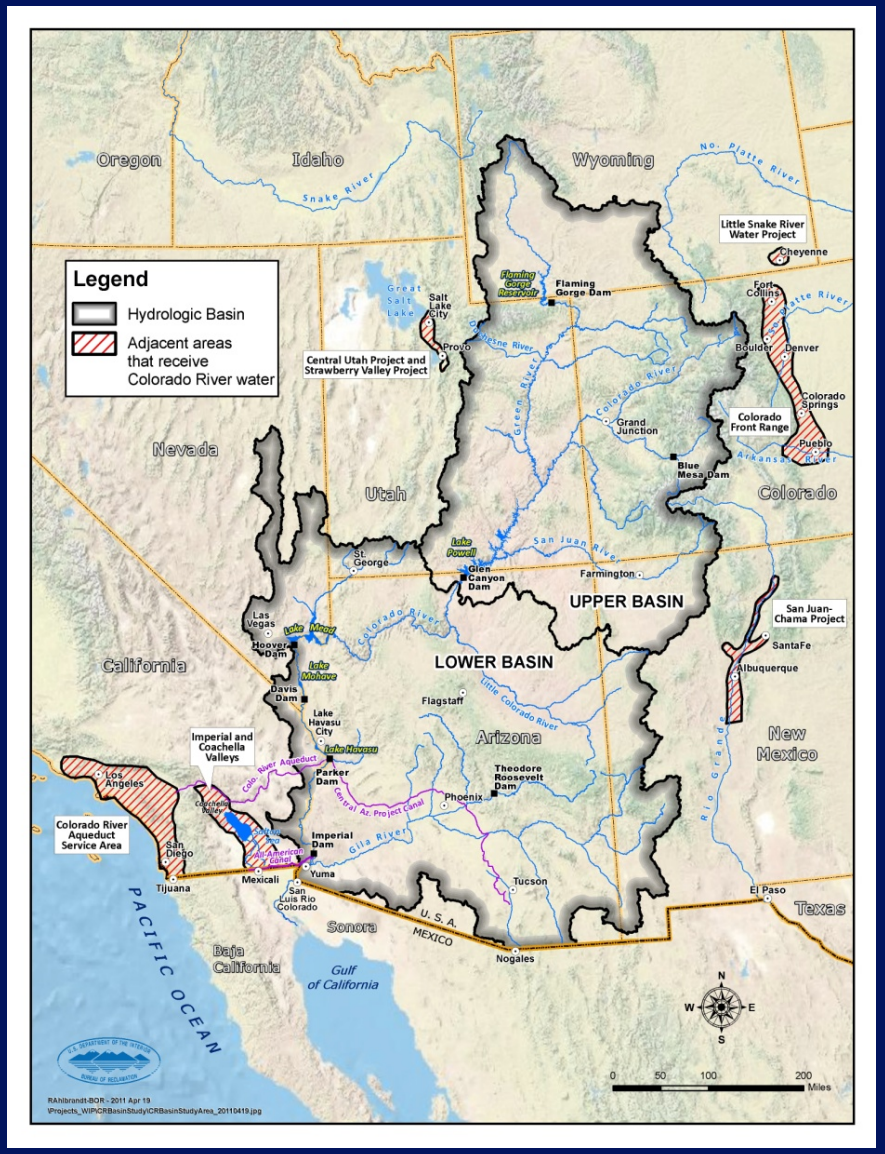
Lippman doubted whether the common voter pays enough attention to be trusted with many of the most important questions facing society

These Analytics Seem Consistent with Principles of Ethical Reasoning in Sen's Idea of Justice

- Recognize as fundamental attributes:
  - Diversity of priorities, goals, and values
  - Irreducible uncertainty regarding consequences of our actions
- Pursue relational, not transcendental reasoning:
  - Transcendental reasoning seeks agreement on vision of ideally just world, and uses this vision to guide choice of near-term actions
  - Relational reasoning seeks agreement on which non-ideal options before us are more just than others
- Employ public deliberation as central to process of social choice:
  - Facilitate re-examination and iterative assessment
  - Demand clear explication of reasoning, logic, and values
  - Recognize "open impartiality" that accepts legitimacy and importance of views of others

Colorado River System Under Significant Stress

- River provides water and power to forty million Americans
- Demand now exceeds supply
- Region suffering from long-term drought
- Climate change may cause further imbalances

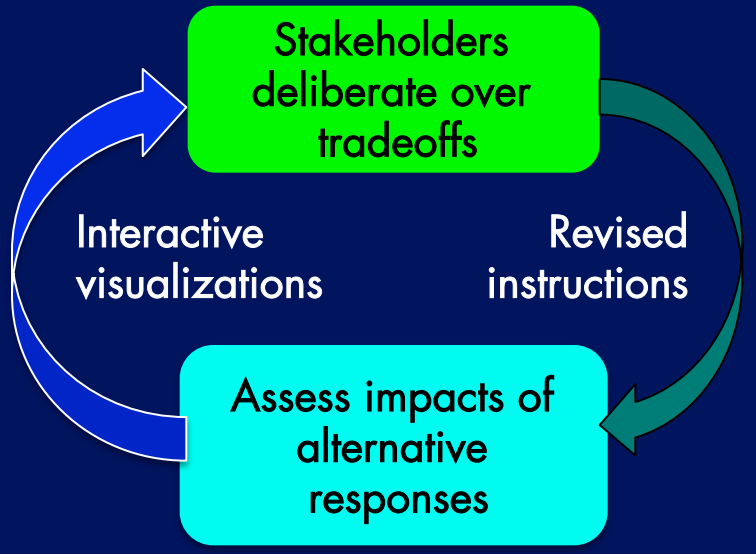


RAND

Scenarios That Emerge From Analysis Helped Inform New Management Plans for Colorado River

Representatives of federal government, seven states, and other major users participated in analytically-facilitated deliberations over challenges facing the river system

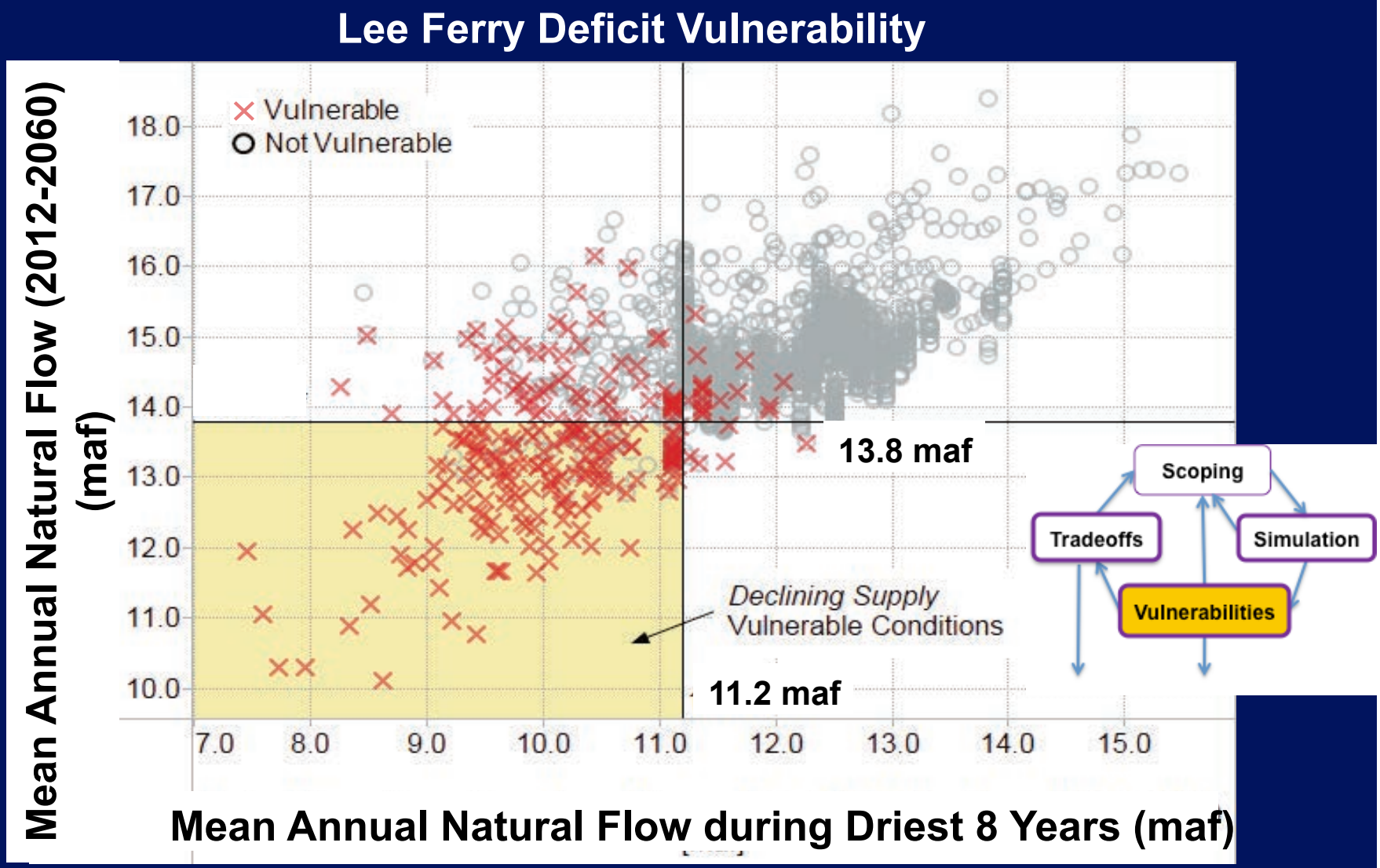
Dozens of workshops and meetings with stakeholders



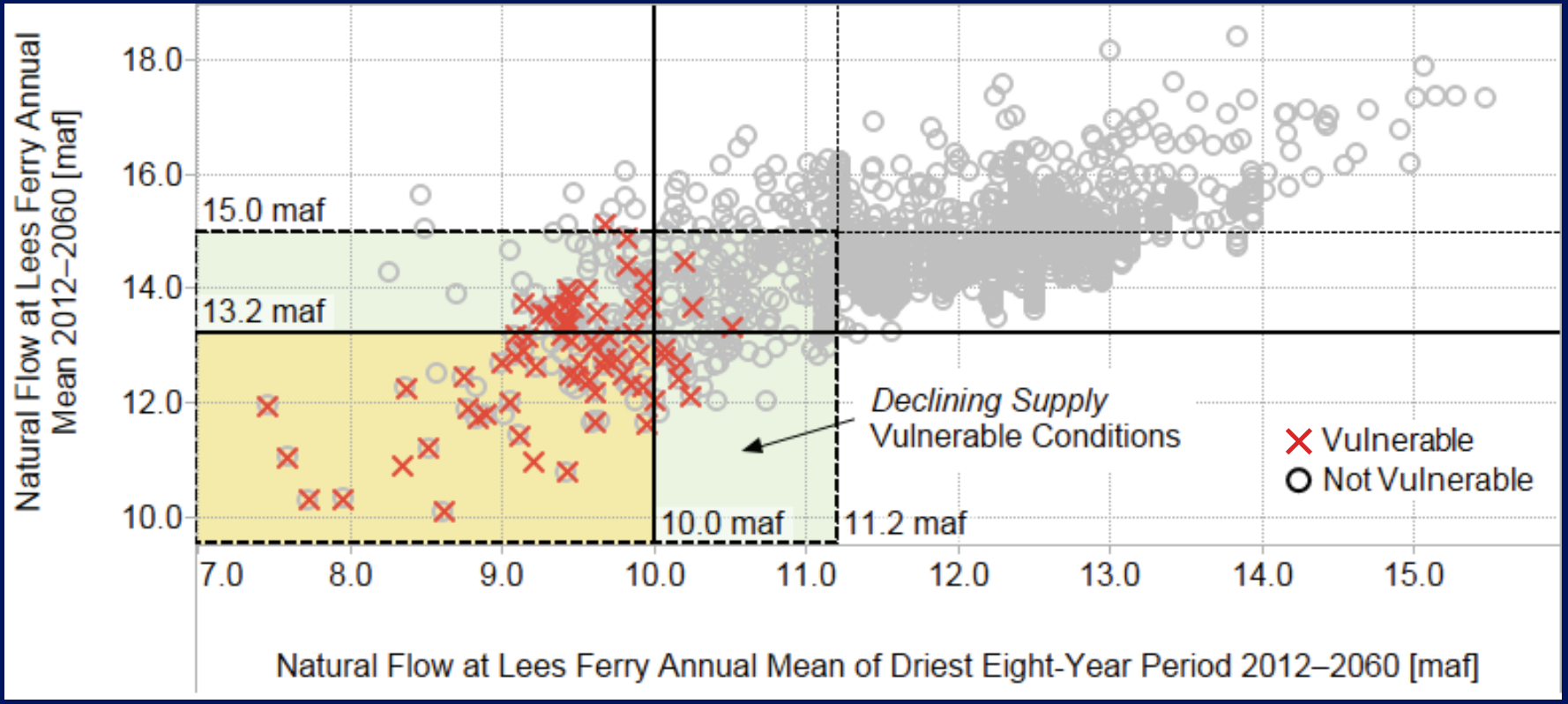
Planning Tool and Risk Assessment Model

Groves. Fischbach, Bloom, Knopman and Keefe. Adapting to a Changing Colorado River: Making Future Water Deliveries More Reliable Through Robust Management Strategies. RAND Corporation, 2013.

Scenarios Helped Diverse Stakeholders Agree on Vulnerabilities of Plan



Scenarios Helped Diverse Stakeholders Agree on How Adaptive Responses Options Might Reduce Vulnerabilities



Some Questions for Our Workshop

- To what extent can quantitative decision aids help improve the choice of scenarios?
  - What tools, methods, and concepts can most usefully, contribute and under what circumstances?
- Can organizations like the IPCC move from providing scenarios as *products* to scenarios as *services*?
- Can scenario choice become sufficiently systemized to help make vulnerability analysis as common as prediction among public agencies?

Thank you!

More Information

http://www.rand.org/pardee

http://www.rand.org/methods/rdmlab.html

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Glossary

This slide provides a glossary of terms commonly used in robust decision making (RDM) analyses. Such a glossary is useful because many of these terms (e.g. future, scenario, strategy) have many different meanings across the different scholarly and practice communities with which RDM analysts interact.

- A future, plausible future, and future state of the world (all synonymous terms) is a specific set of assumptions about the future. RDM represents uncertainty with sets of multiple futures. An RDM analysis typically represents each future with a vector of specific values for each of the uncertain input parameters to a simulation model.
- A strategy (often used synonymously with policy) represents a distinct choice facing a planner or decision maker, and is often defined by the amount, location, and timing of different investments, programs, or policy options.
- A case is a run of the simulation model for one future and one strategy. RDM analyses typically generate databases of many simulation model runs. Each entry in such a database is a case. Each database entry typically includes numbers describing the future, the strategy, and the metrics that result from pursuing the strategy in that future.
- A metric (or performance metric) is some criteria of interest to decisions makers that they can use to judge the relative desirability of various cases.
- A scenario or decision-relevant scenario is a set of cases that share some decision-relevant attribute. For instance, the regions shown on slides 30, 33, 37, 43, and 44 are all scenarios.