RAND PARDEE CENTER

Informing Climate-Related Decisions When the Science is Uncertain

Robert Lempert

Director,

RAND Pardee Center for Longer Range Global Policy and the Future Human Condition

Climate Change and America's Infrastructure

January 29, 2013

Climate-Related Decisions Poses Both Analytic and Organizational Challenges

Climate-related decisions involve:

- Incomplete information from new, fast-moving, and sometimes irreducibly uncertain science
- Many different interests and values
- Long-time scales
- Near certainty of surprise

Public planning should be:

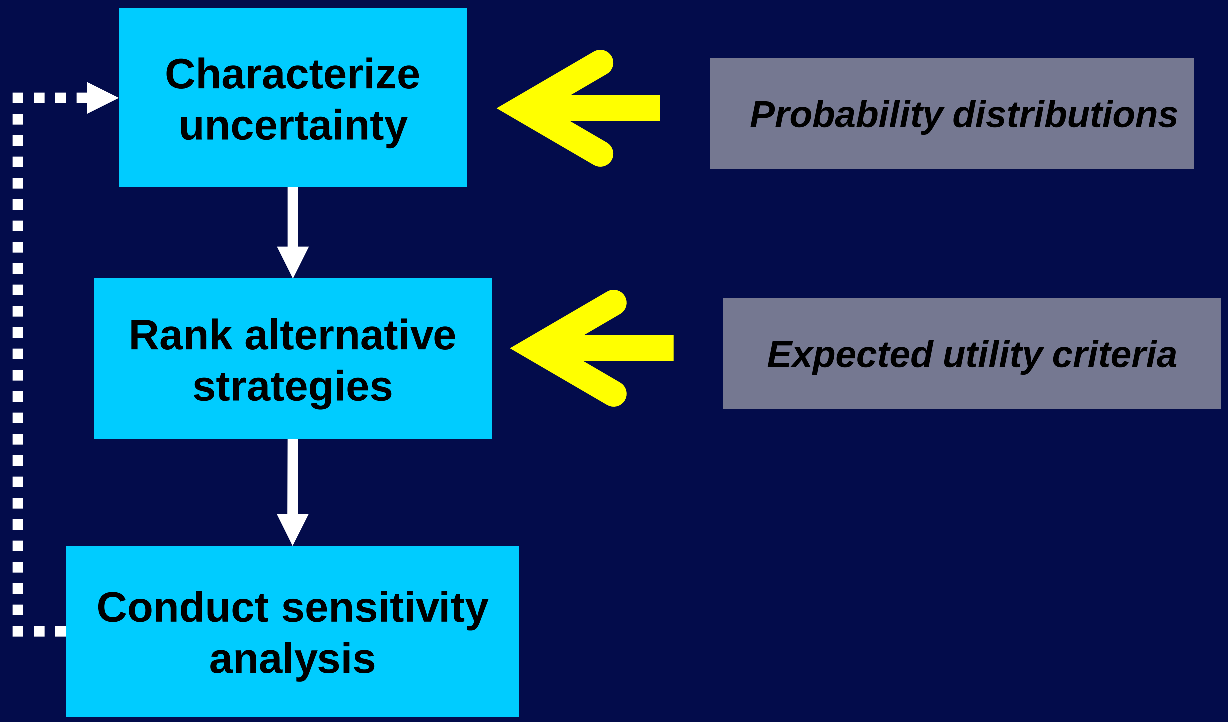
- Objective
- Subject to clear rules and procedures
- Accountable to public

How to make plans more robust and adaptable while preserving public accountability?

Traditional Risk Analysis Ranks Responses Based on Probabilistic Characterization of Uncertainties

Predict then Act

- Rank strategies contingent on characterization of uncertainties



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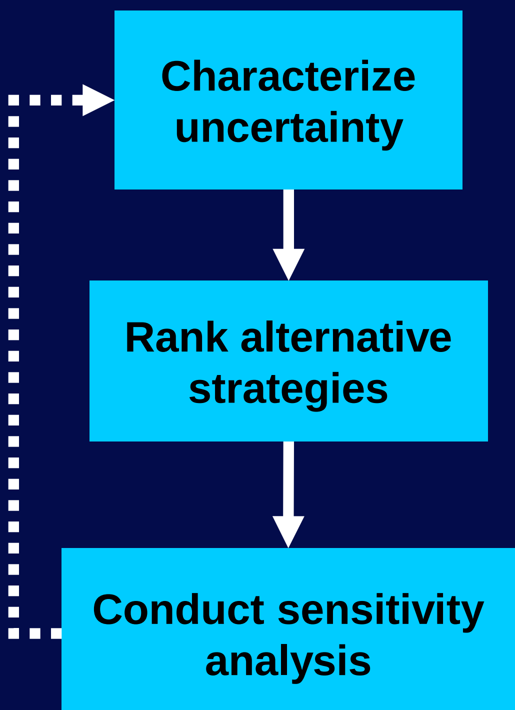


But climate change confronts decision makers with deep uncertainty, where

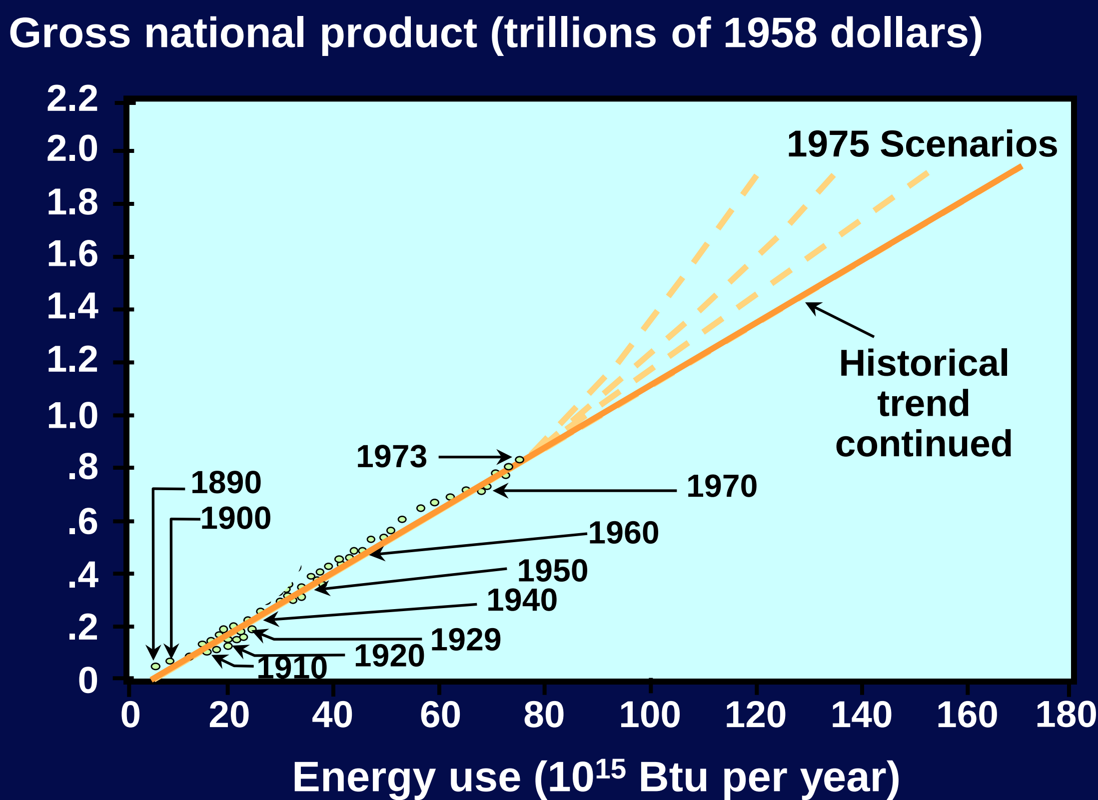
- They do not know, and/or key parties to the decision do not agree on, the system model, prior probabilities, and/or “cost” function

Decisions can go awry if decision makers assume risks are well-characterized when they are not

- Uncertainties are underestimated
- Competing analyses can contribute to gridlock
- Misplaced concreteness can blind decision-makers to surprise

Believing Forecasts of the Unpredictable Can Contribute to Bad Decisions

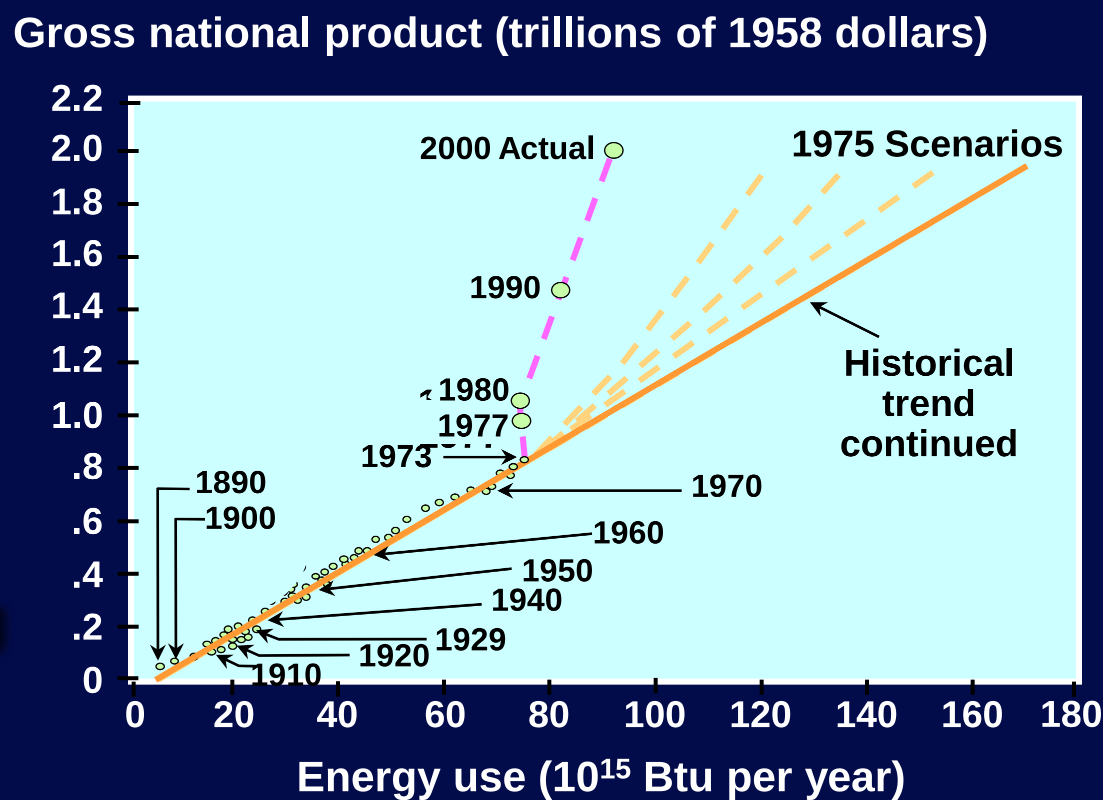
- **In the early 1970s forecasters made projections of U.S energy use based on a century of data**



Believing Forecasts of the Unpredictable Can Contribute to Bad Decisions

- **In the early 1970s forecasters made projections of U.S energy use based on a century of data**

… they all were wrong



Outline

- Do the Analysis Backwards
  - Infrastructure planning for Port of Los Angeles
- Embed analysis in process of stakeholder engagement
  - Louisiana Master Plan for a Sustainable Coast
- Observations

Agencies with Coastal Infrastructure Face Challenges from Potential Sea Level Rise

- **Global sea levels are expected to increase in the future**
- **But there is much controversy over extent and timing of sea level rise…**
- **… particularly so for low-probability, high-impact increases of 1+ meters over coming century**

This deep uncertainty complicates infrastructure investment decisions

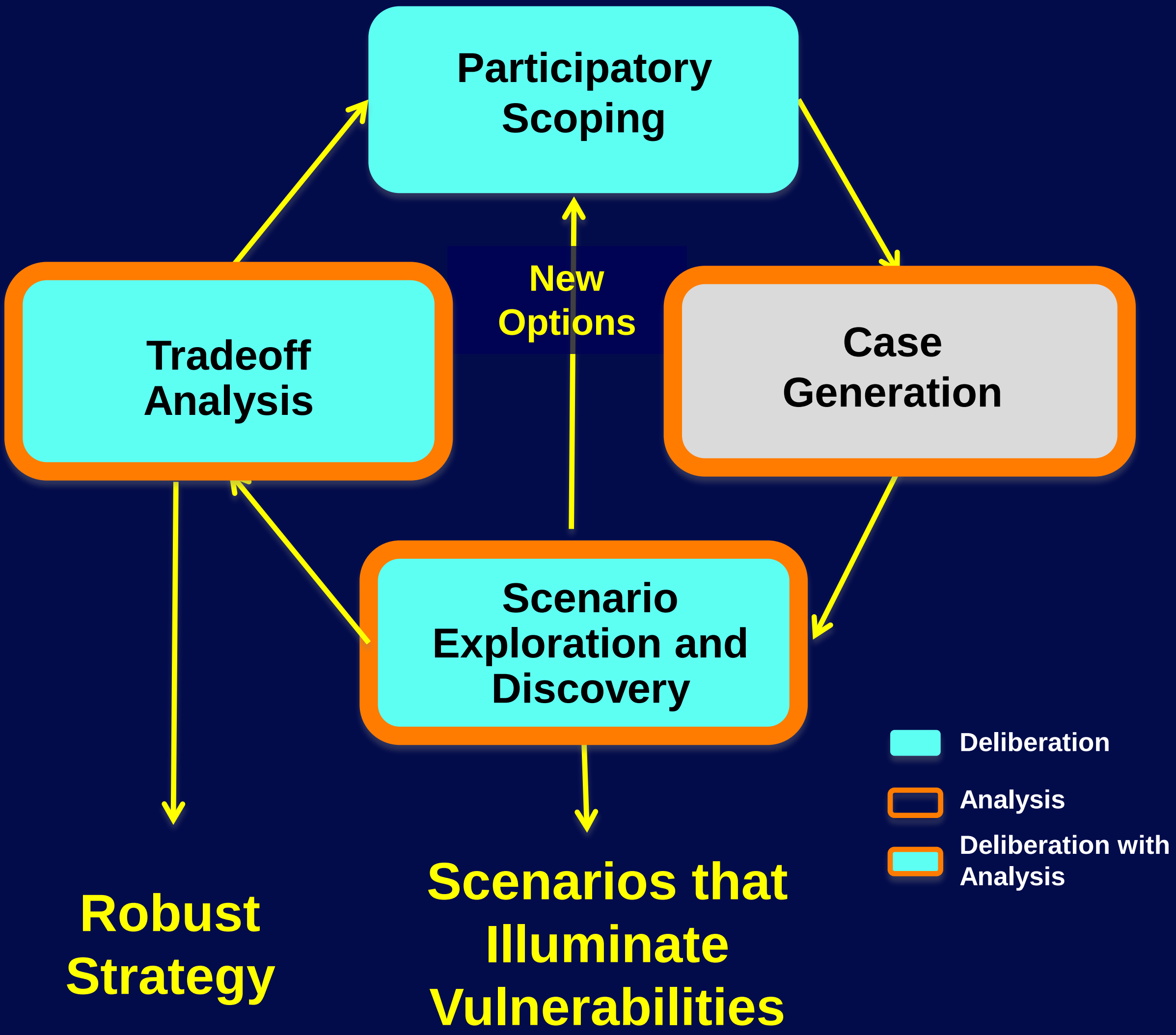
Robust Decision Making (RDM) Helps Inform Good Decisions Without Reliable Predictions

Key idea -- conduct the analysis "backwards":

•Start with strategy

•Use analytics to identify scenarios where strategy fail to meet its goals

•Use these scenarios to identify and evaluate responses



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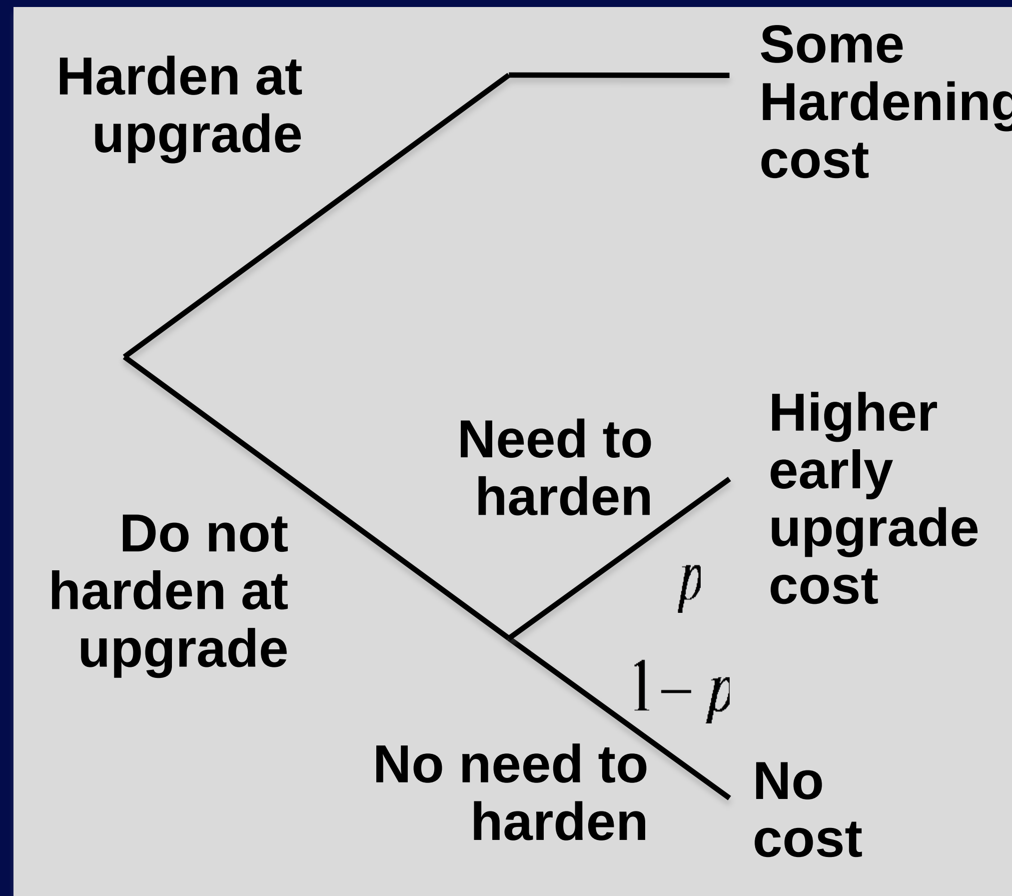
Should Port of Los Angeles Harden Terminals Against Risk of Extreme Sea Level Rise?

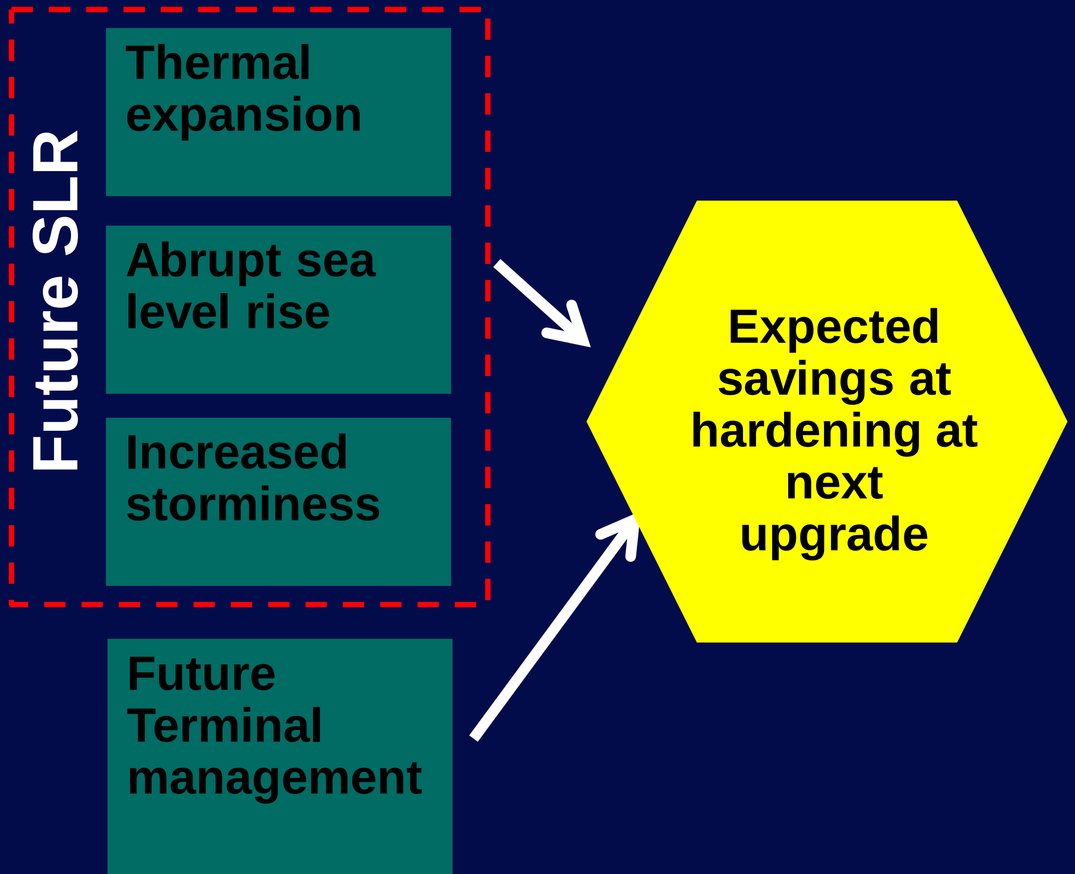
- Terminals are high above current sea level, so relatively invulnerable to all but the most extreme SLR
- Cost to harden at next upgrade is much lower than retrofitting between upgrades

Decision Challenge



Lempert, Robert, Ryan L. Sriver, and Klaus Keller. 2012. “Characterizing Uncertain Sea Level Rise Projections to Support Investment Decisions.” California Energy Commission. Publication number: CEC-500-2012-056

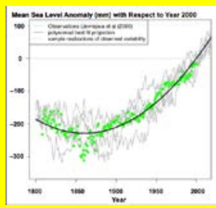
We Built a Simple Model to Evaluate Decision



Harden at next upgrade if we expect savings

Consider Parameters with Different Types of Uncertainty

Future SLR

Uncertainty	RDM Characterization of Uncertainty
SLR in 2011	**Well characterized joint probability distribution** 
Normal Rate of SLR	
Normal SLR Acceleration	
Rate of Abrupt SLR	**Deeply uncertain: 0 - 30 mm/year**
Year Abrupt SLR Begins	**Deeply uncertain: 2010 - 2100**
Increased storminess	**Deeply uncertain: Set of GEV distributions with scale ranging from 517mm to 569 mm;**

Future Terminal Management

Uncertainty	RDM Characterization of Uncertainty
Lifetime	**Deeply uncertain: 30 - 100 years**
Maximum Allowable Overtop Probability	**Deeply uncertain: 5 - 50%/year**
Decision Year	**Known at decision time: e.g. 2020**
Height Above Mean Sea Level	**Known at decision time: e.g. 2,804 mm**
Current Hardening Cost	**Known at decision time: e.g. 1%**
Discount Rate	**Known at decision time: e.g. 5%**

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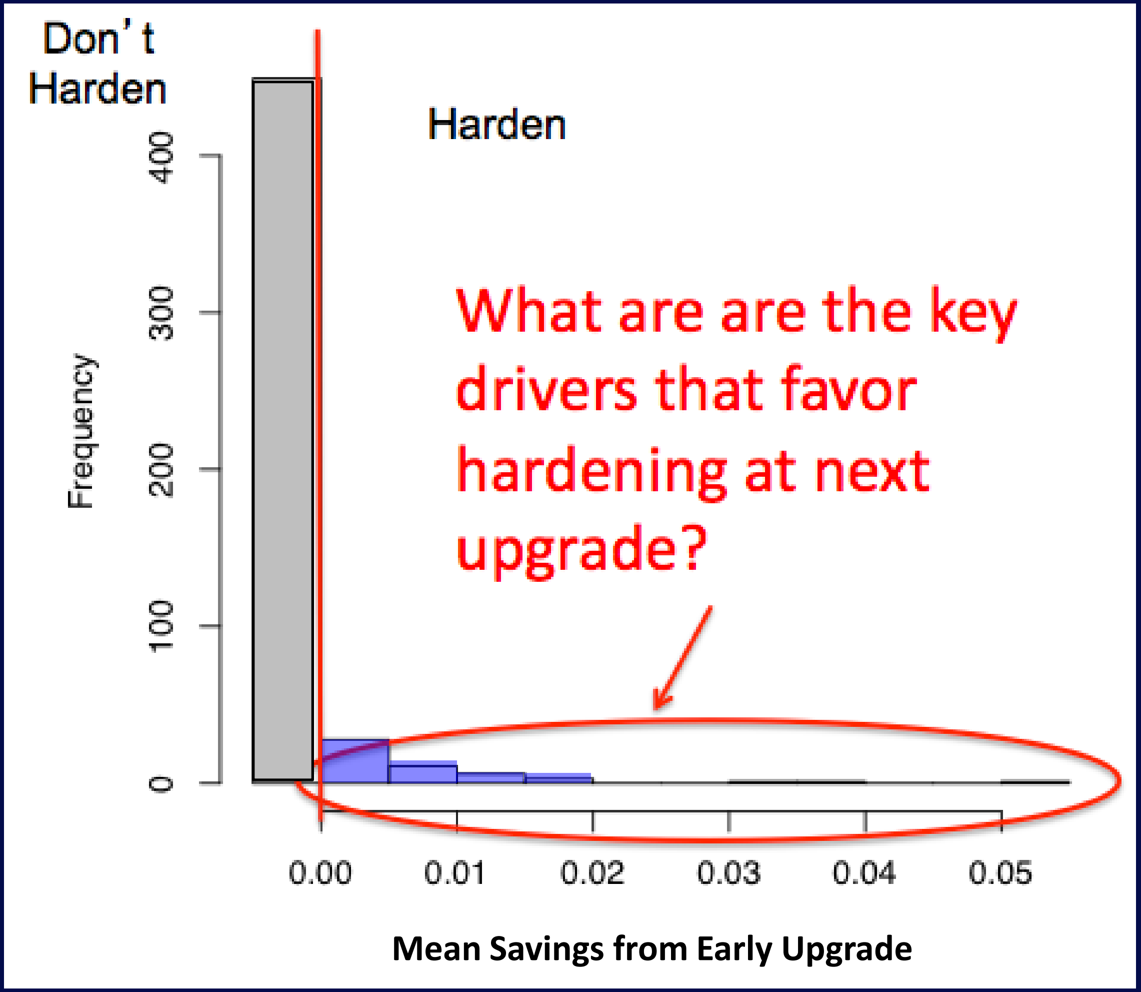
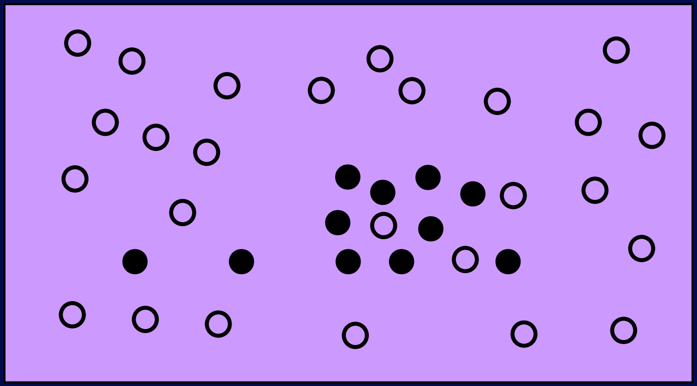
A Few Cases in the Sample Favor Hardening at the Next Upgrade

- Ran 500 case sample
  - Varied five deeply uncertain parameters
  - Used distributions for parameters with well-characterized uncertainties
- Calculated expected savings for each case



Scenario Discovery Provides an Approach for Computer-Assisted Scenario Development

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



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Bryant and Lempert (2010)

Scenario Discovery Provides an Approach for Computer-Assisted Scenario Development

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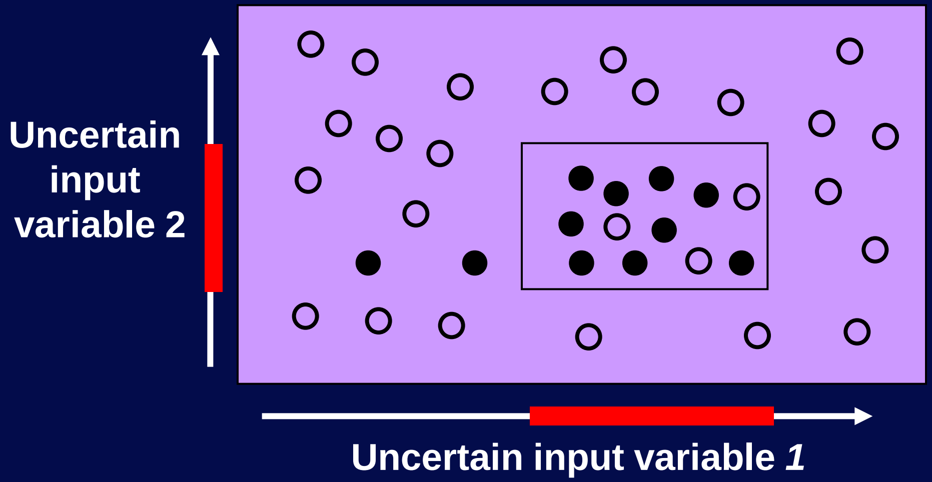
2. *Statistical analysis finds low-dimensional clusters with high density of these cases*



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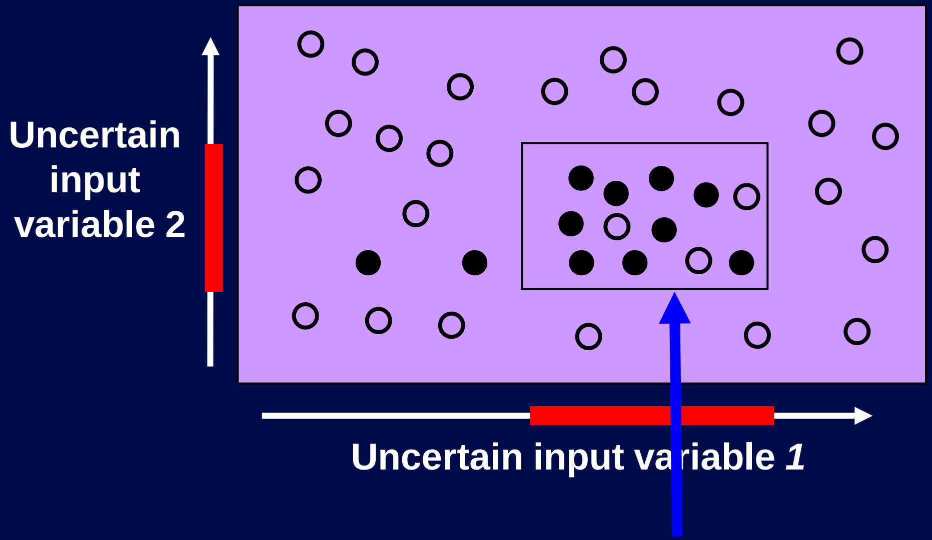

3. ***Clusters represent scenarios and driving forces of interest to decision makers***

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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)**

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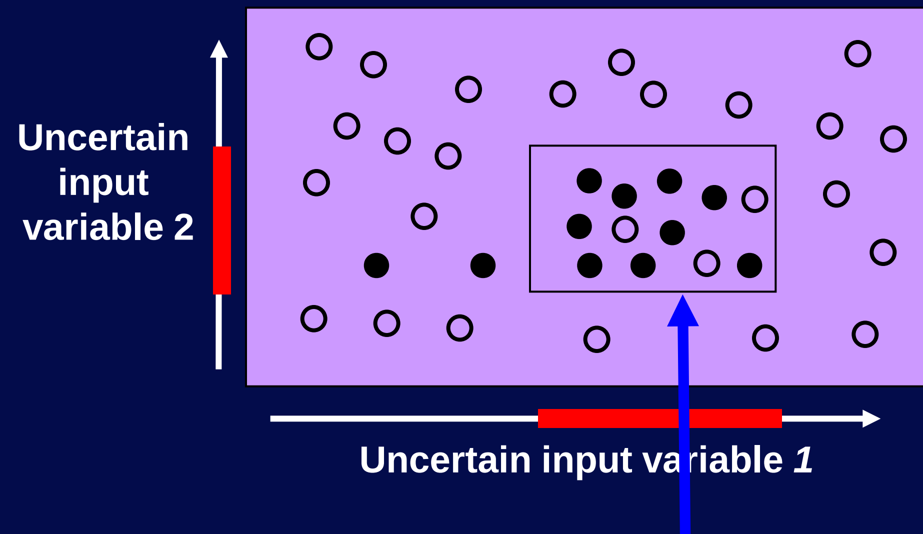
2. Statistical analysis finds low-dimensional clusters with high density of these cases



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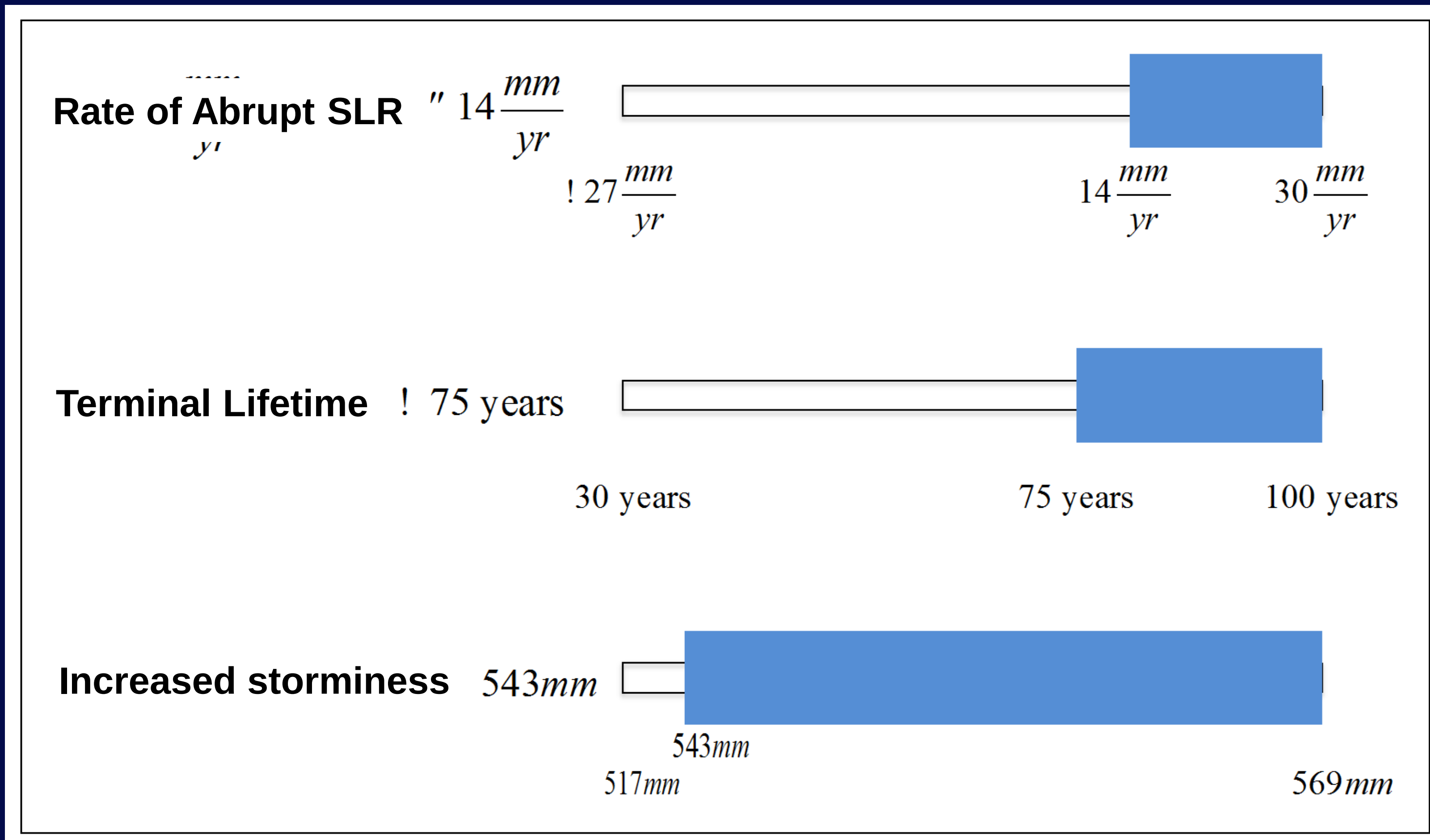
Bryant and Lempert (2010)

Approach Identifies Scenario Where Hardening at Next Upgrade Passes Cost-Benefit Test

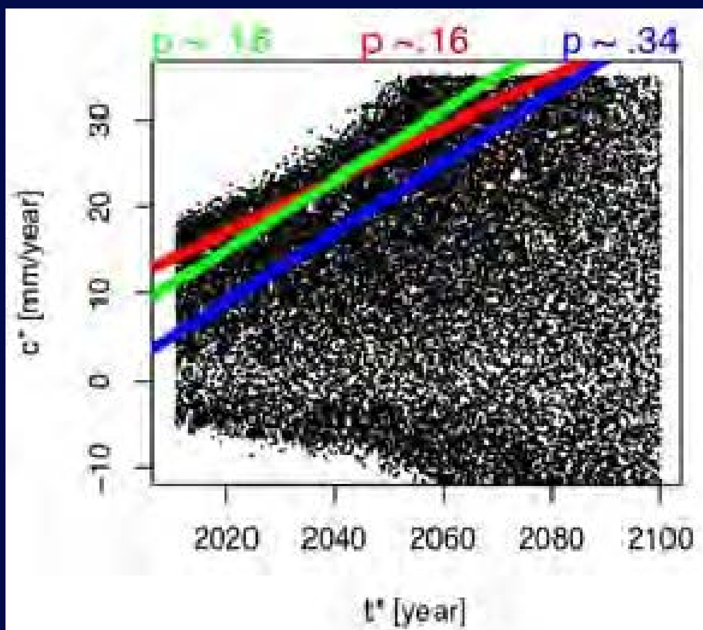


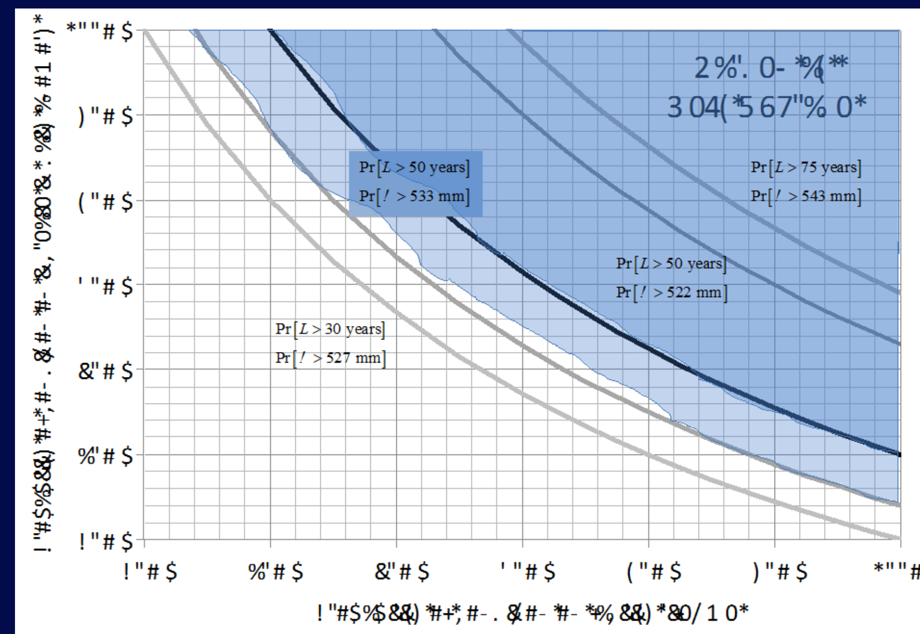
Range required to pass cost-benefit test

Evidence Suggests this Scenario is Insufficiently Likely to Justify Hardening

Available science suggests probability of exceeding abrupt SLR threshold ~ 16%

Passing cost benefit test thus requires high probability of long lifetime and increased storminess





Little evidence to suggest actual likelihood lies in blue region

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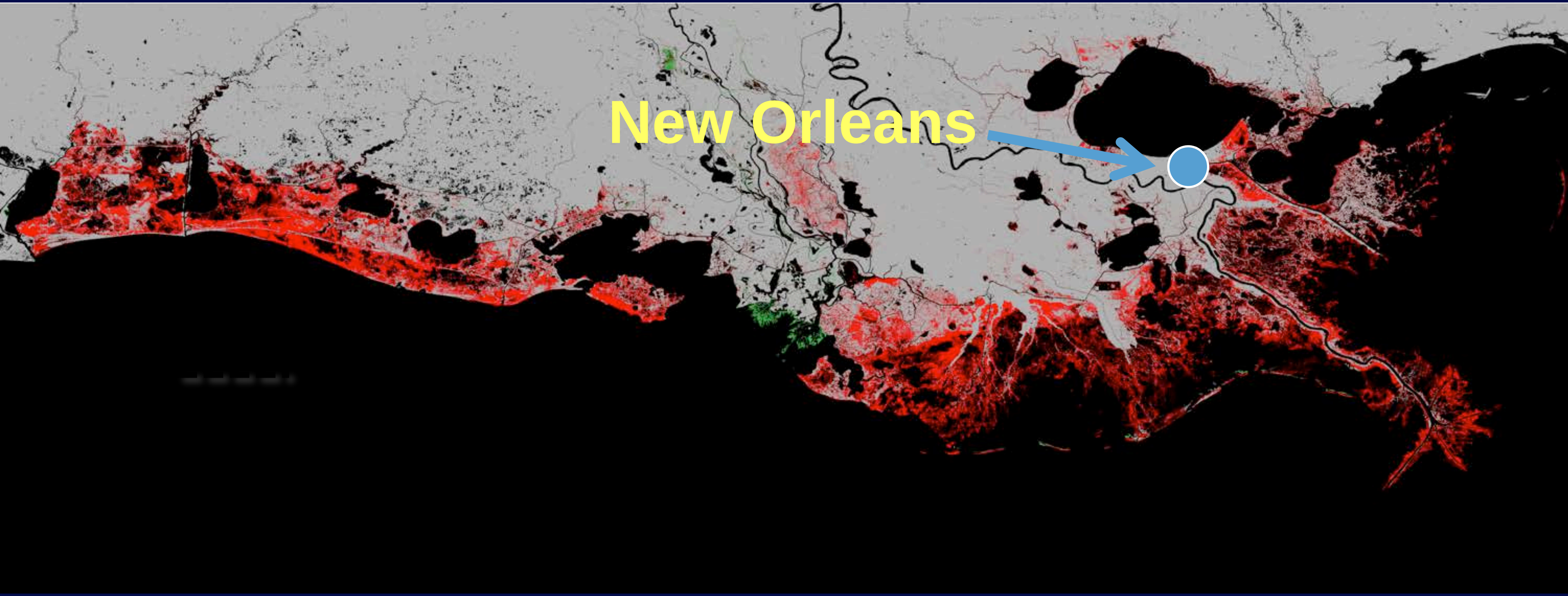
Louisiana Faces Significant Challenge of Coastal Land Loss

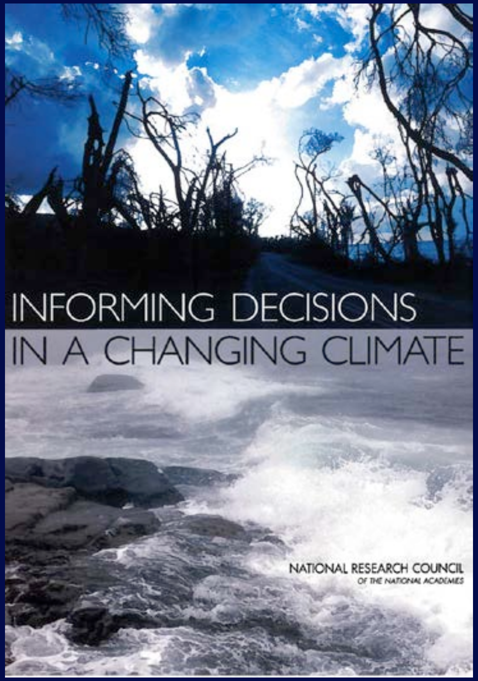


Estimated loss of 1,800 square miles of land over next 50 years without additional restoration or revised river management

Land loss **Land gain**

ʻDecision Supportʼ Concept Helps Organize Insights Relevant to Addressing Climate Challenge

Decision support represents a set of processes intended to create the conditions and appropriate use of decision-relevant information



Evidence from many fields suggests principles of effective decision support

1. Build from users' needs
   - Co-production of knowledge between information providers and users
2. Emphasize decision processes over information products
3. Employ a multidisciplinary and multi-organization approach
4. Embed decision support in enduring institutions and networks that link users and providers
5. Design decision support for learning

"Deliberation with Analysis" Offers an Effective Decision Support Process

<u>Deliberate:</u>

- Participants to decision define objections, options, and other parameters

<u>Analysis:</u>

- Participants work with experts to generate and interpret decision-relevant information

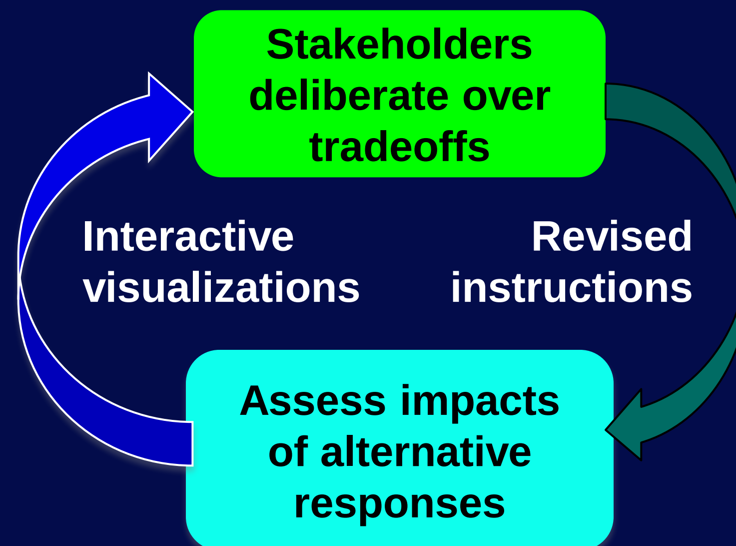
NRC (2009) p. 78

Decision Support Process Helped Louisiana Develop Master Plan for a Sustainable Coast

Louisiana faces increased flooding risk and serious coastal land loss due to sea level rise, land subsidence, lack of river-borne sediments, and any changes in storm intensity

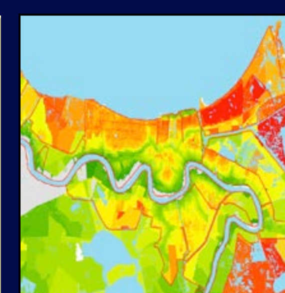
- ***RAND helped the state develop a comprehensive coastal master plan***

Dozens of workshops with many stakeholders over two years



Planning Tool and Risk Assessment Model

Compares consequences of alternative combinations of 100's of responses



Integrates scientific information from multiple sources to estimate risk to different communities and industries

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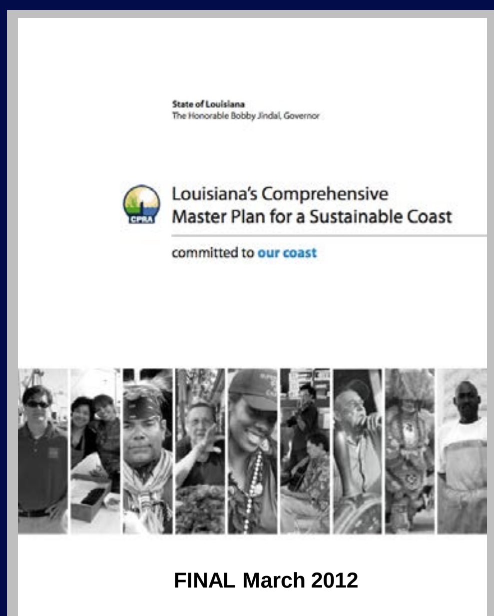
- ***Louisiana legislature unamimously approved plan in May 2012***



Stakeholders deliberate over tradeoffs

Interactive visualizations

Revised instructions

Assess impacts of alternative responses

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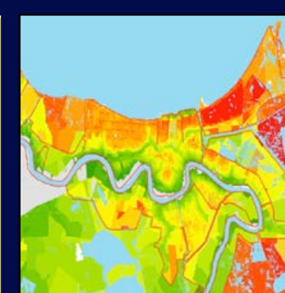
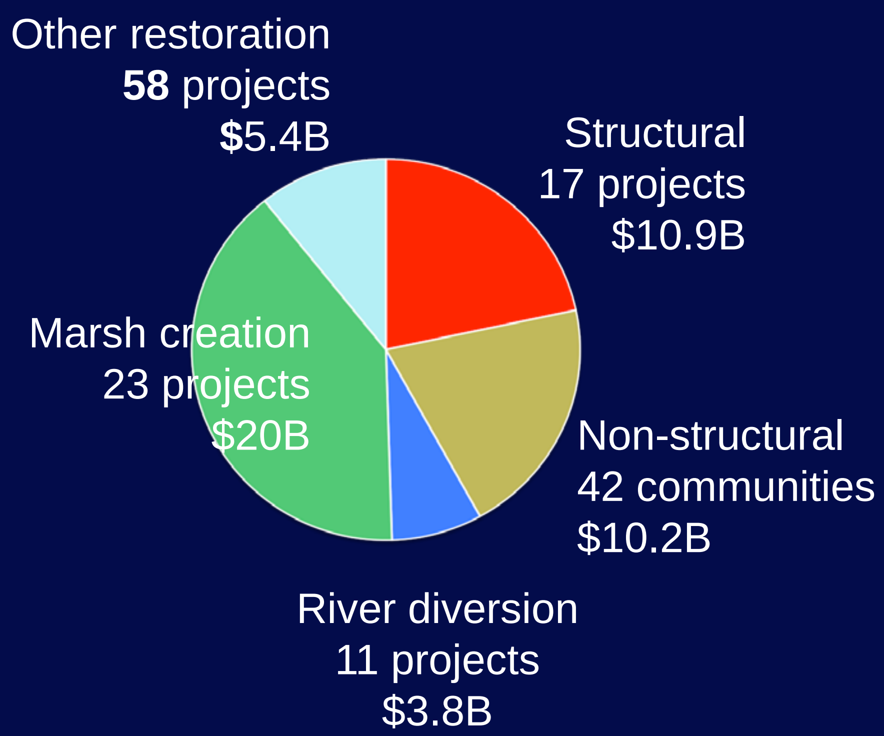


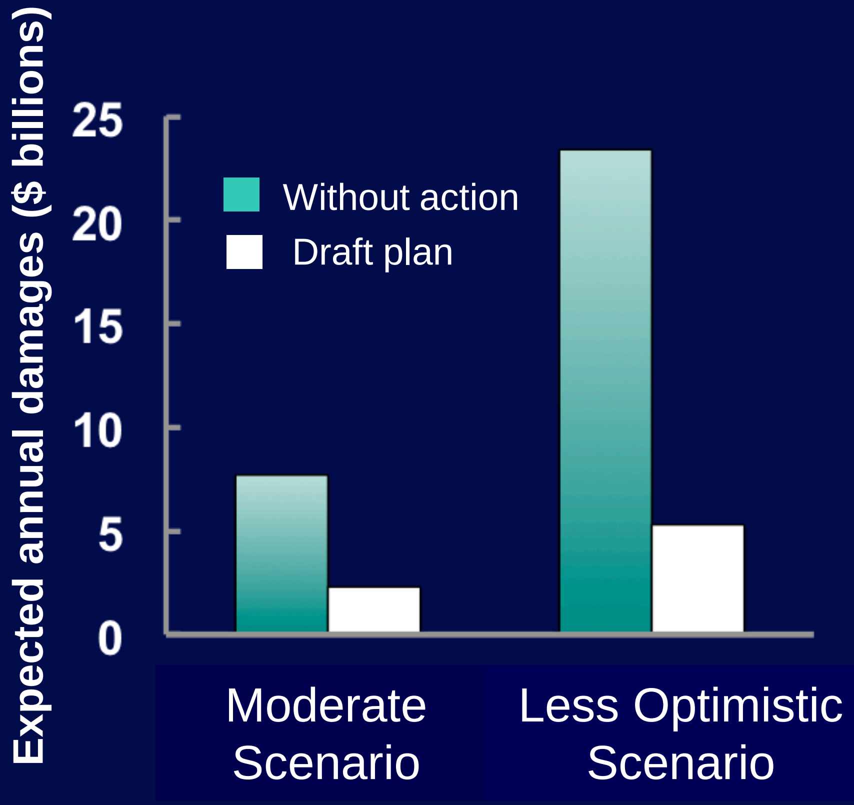
Integrates scientific information from multiple sources to estimate risk to different communities and industries

Resulting Integrated Risk Management Plan Includes 151 Projects Over 50 Years

Portfolio of projects meets needs of diverse stakeholders



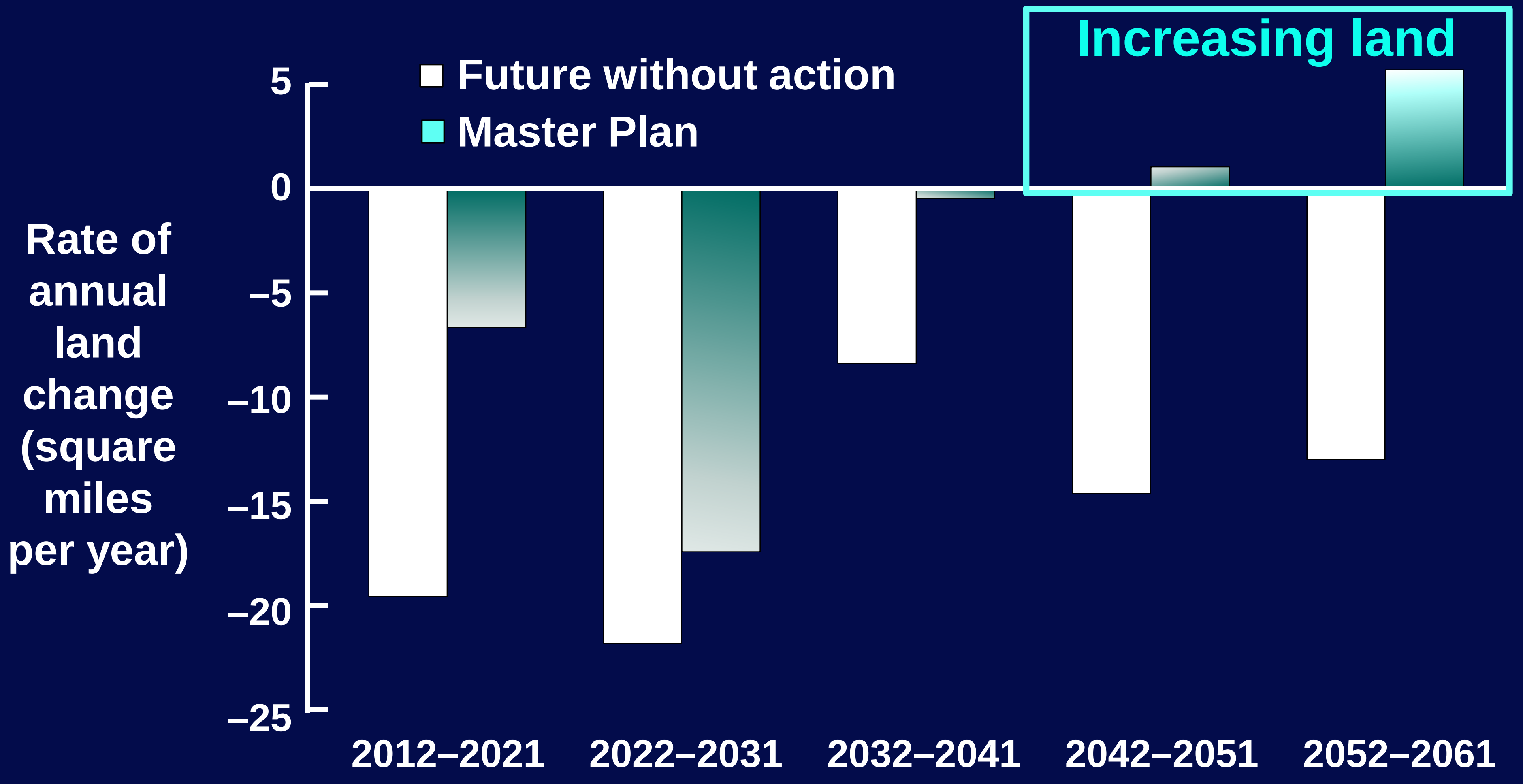
Plan robust over two scenarios



J Fischbach, D. Johnson, D. Ortiz, B. Bryant, M. Hoover, J. Ostwald (2012) Coastal Louisiana Risk Assessment Model Technical Description and 2012 Coastal Master Plan Analysis Results, RAND TR-1259-CPRA

D. Groves, C. Sharon, D. Knopman (2012) Planning Tool to Support Louisiana's Decisionmaking on Coastal Protection and Restoration, RAND TR-1266-CPRA

State Choose Plan That Balances Near- and Long-Term Benefits



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- Flexible and robust plans often provide the best response to the uncertainty inherent in many climate-related decisions
- But traditional planning methods can make it difficult to develop and articulate robust and flexible plans
- New methods can improve climate-related decisions by:
  - Embedding analytics in a “deliberation with analysis” process of stakeholder engagement
  - Running the analysis “backwards” to identify vulnerabilities of plans and robust responses

More Information

http://www.rand.org/international_programs/pardee/

http://www.rand.org/gulf-states/policy-spotlights/coastal-management.html

Thank you!