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Protecting Critical Infrastructure When the Costs and Benefits are Uncertain

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Managing the Risk of Catastrophes: Protecting Critical Infrastructure in Urban Areas

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Managing Infrastructure Risk 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:

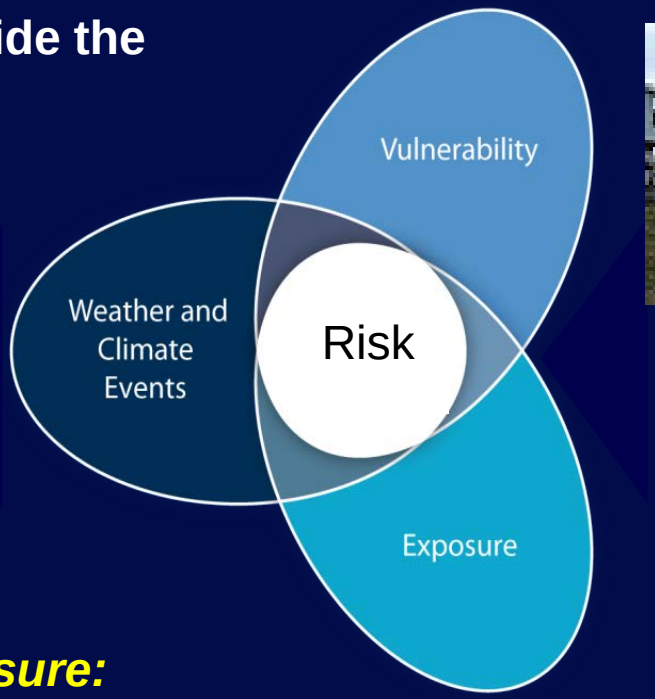
- Objective
- Subject to clear rules and procedures
- Accountable to public

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

Three Elements – Hazard, Exposure, and Vulnerability – Contribute to Risk

Climate Extremes:

The occurrence of a weather or climate event outside the expected norm



Vulnerability:

The predisposition of a person or group to be adversely affected

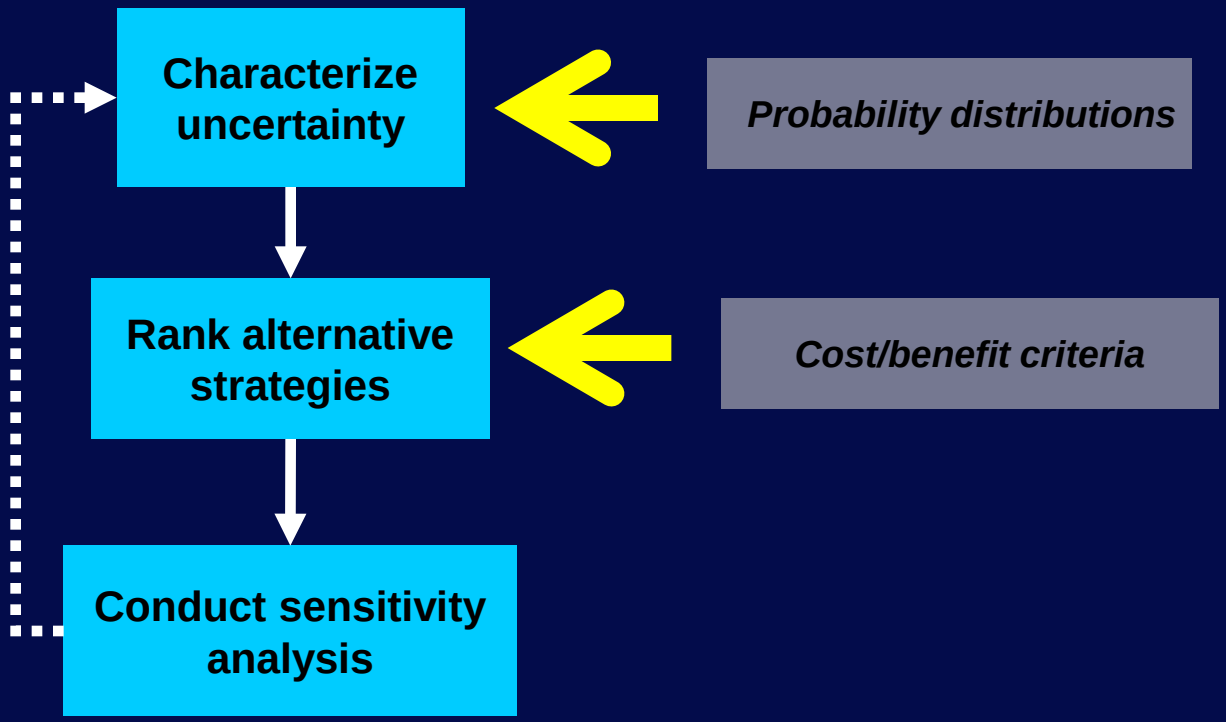
Exposure:

The presence of people and the things they care about in places that could be adversely affected

Traditional Risk Analysis Ranks Responses Based on Agreed Characterization of the Future

Predict then Act

- **Rank strategies contingent on characterization of uncertainties**



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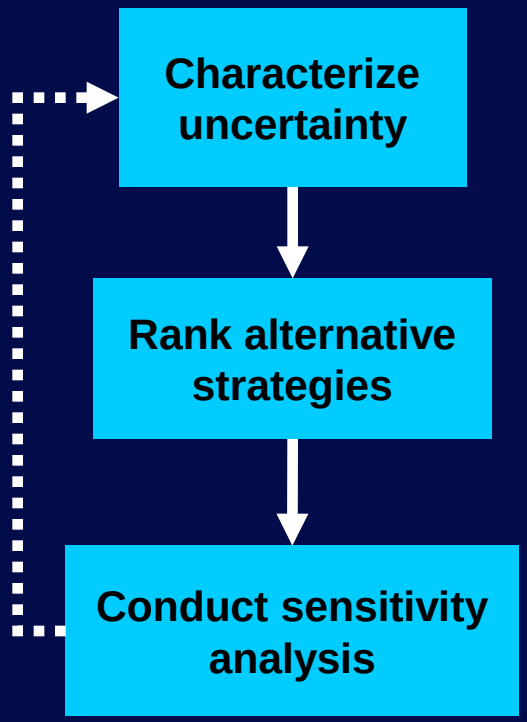


But many decisions involve deep uncertainty, where

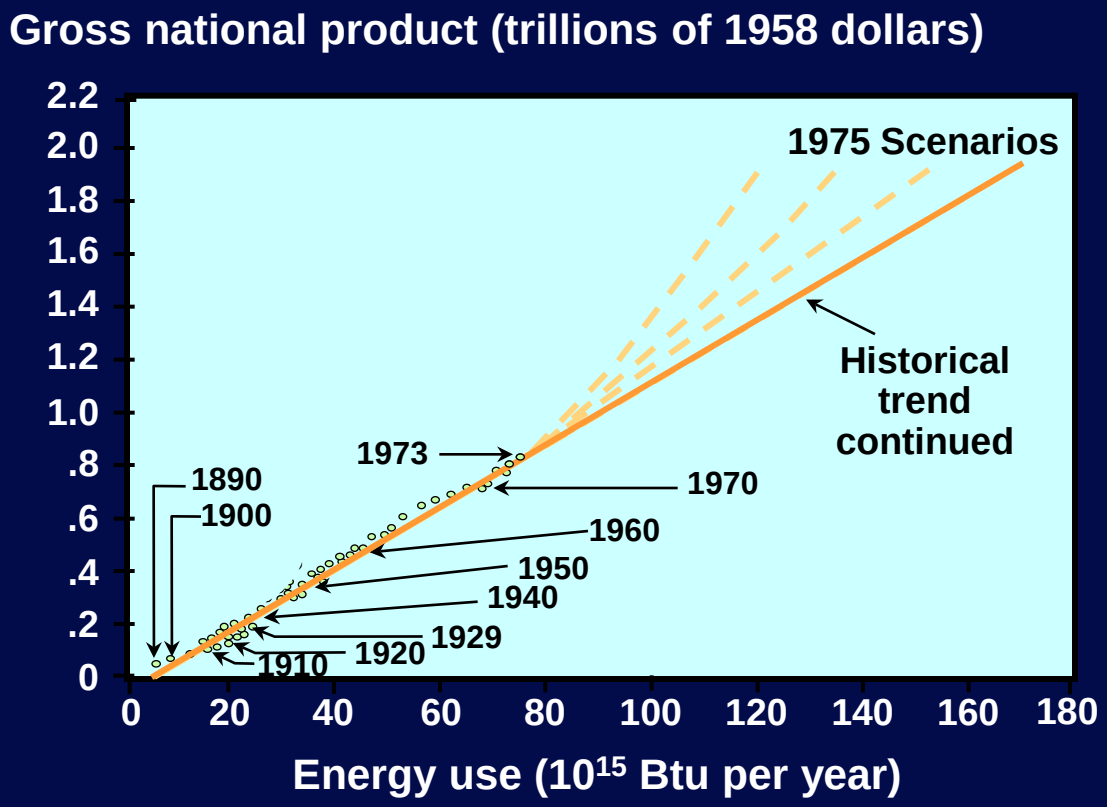
- Parties to a decsion do not know, and/or do not agree on, the system model, prior probabilities, and/or "cost" function

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

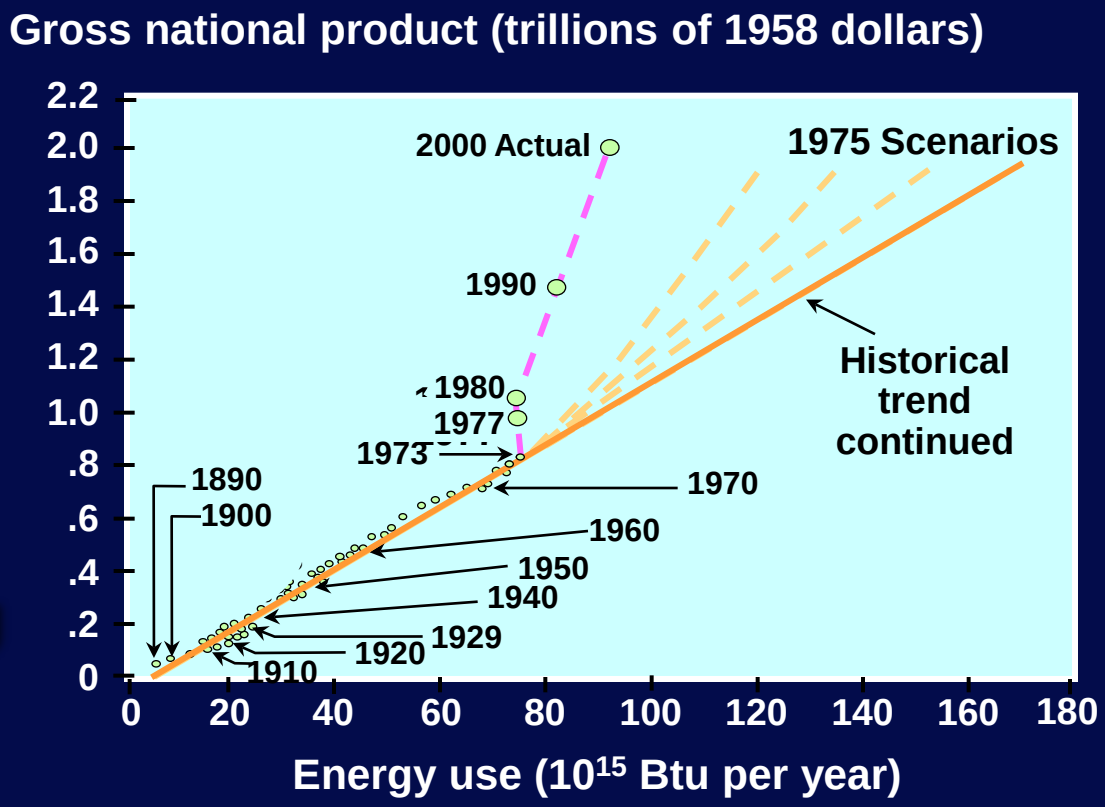
- In the early 1970s forecasters made projections of U.S energy use based on a century of data



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



We Are Biased Towards….

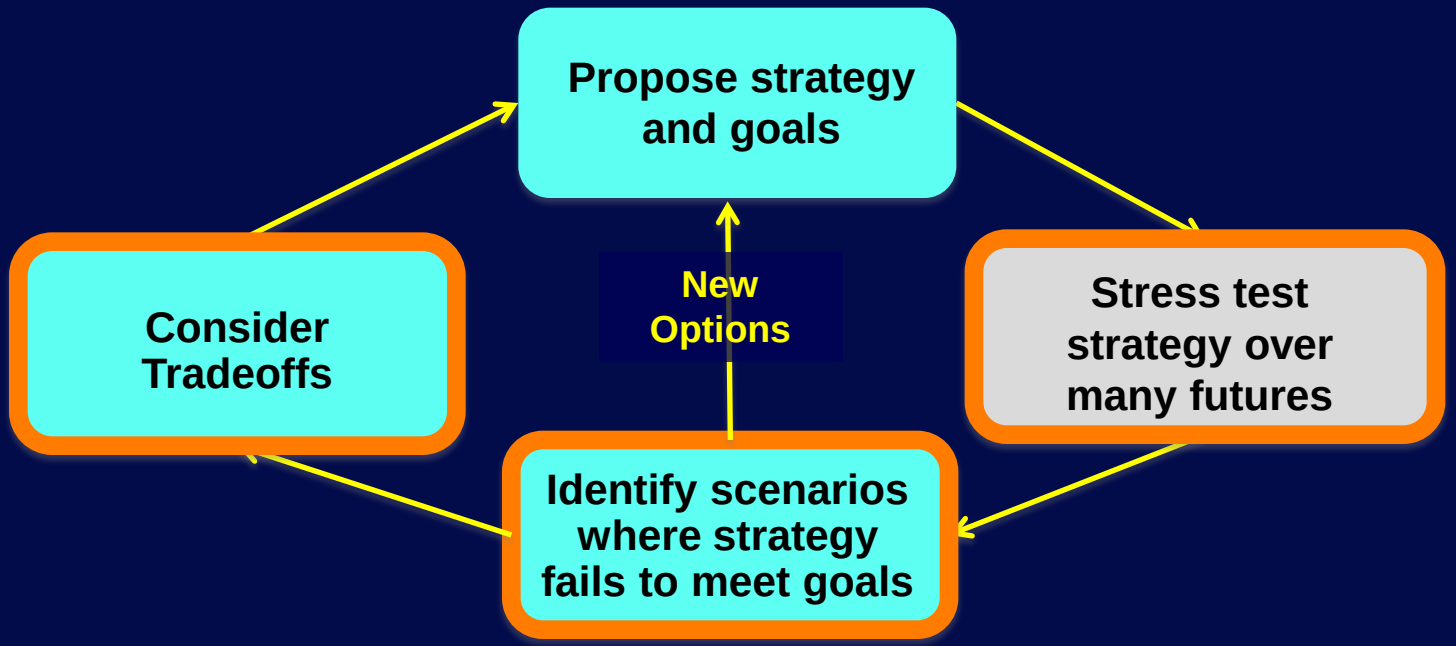
- **Predicting the future will look like the past**
- **High confidence in our predictions**

We Live in a Fast-Changing World….

Outline

- **Do the Analysis Backwards**
  - **Infrastructure planning for Port of Los Angeles**
- **Pursue Integrated and Adaptive Policies**
  - **Louisiana Master Plan for a Sustainable Coast**
- **Observations**

Running Analysis "Backwards" Helps Manage Risk Without Reliable Predictions



"Robust decision making" (RDM) help decision makers

- **Reach consensus even when they disagree on future expectations**
- **Reduce overconfidence and manage surprise**
- **Use quantitative analysis in situations when key data are missing or imprecise**

Should the Port of Los Angeles (PoLA) Harden Its Terminals Against Extreme Sea Level Rise at the Next Upgrade?

Yes. Hardening at the next upgrade is much less costly than discovering in the future that we are unprepared.

No. Our terminals are only vulnerable to *extreme* sea level rise and storm surge. Let's wait.

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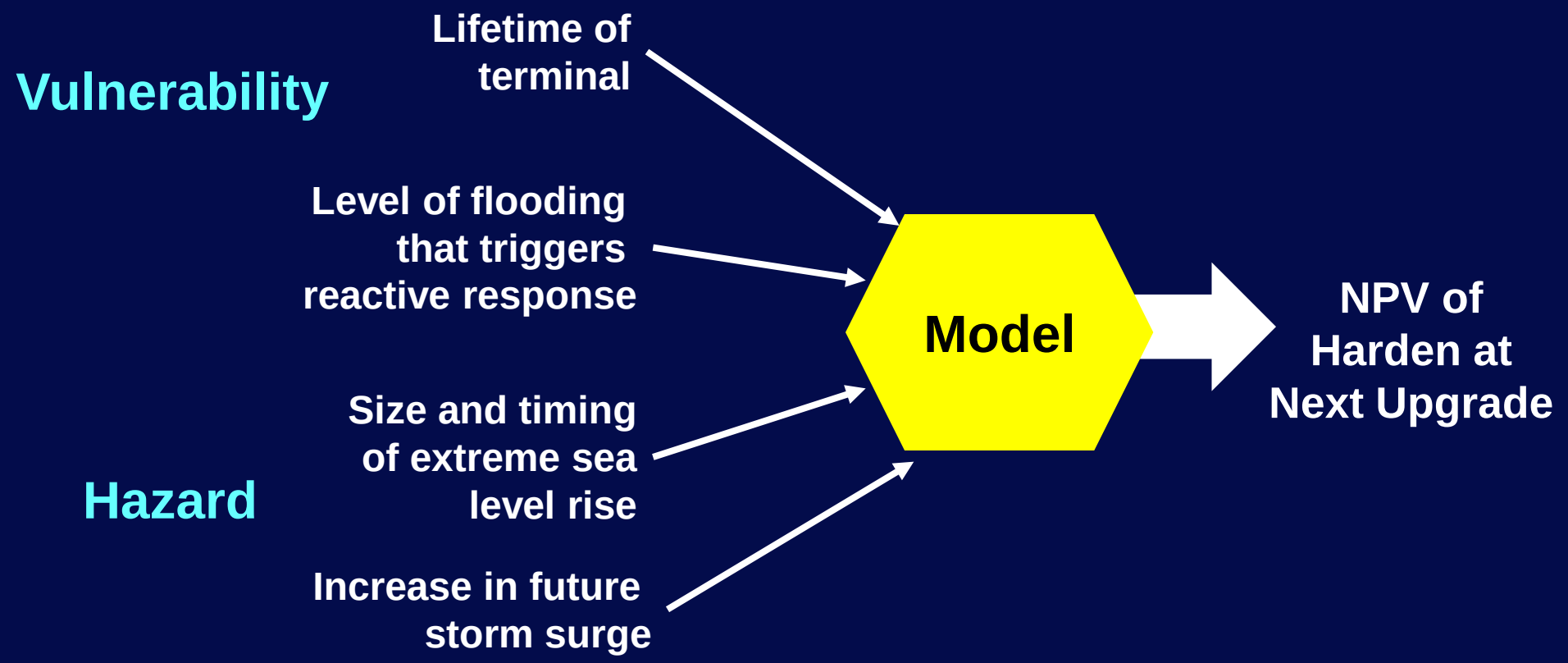
If We Harden at Next Upgrade, Do Net Benefits Exceed Costs?

Calculate net present value (NPV)

NPV = Discounted Benefit - Discounted Cost

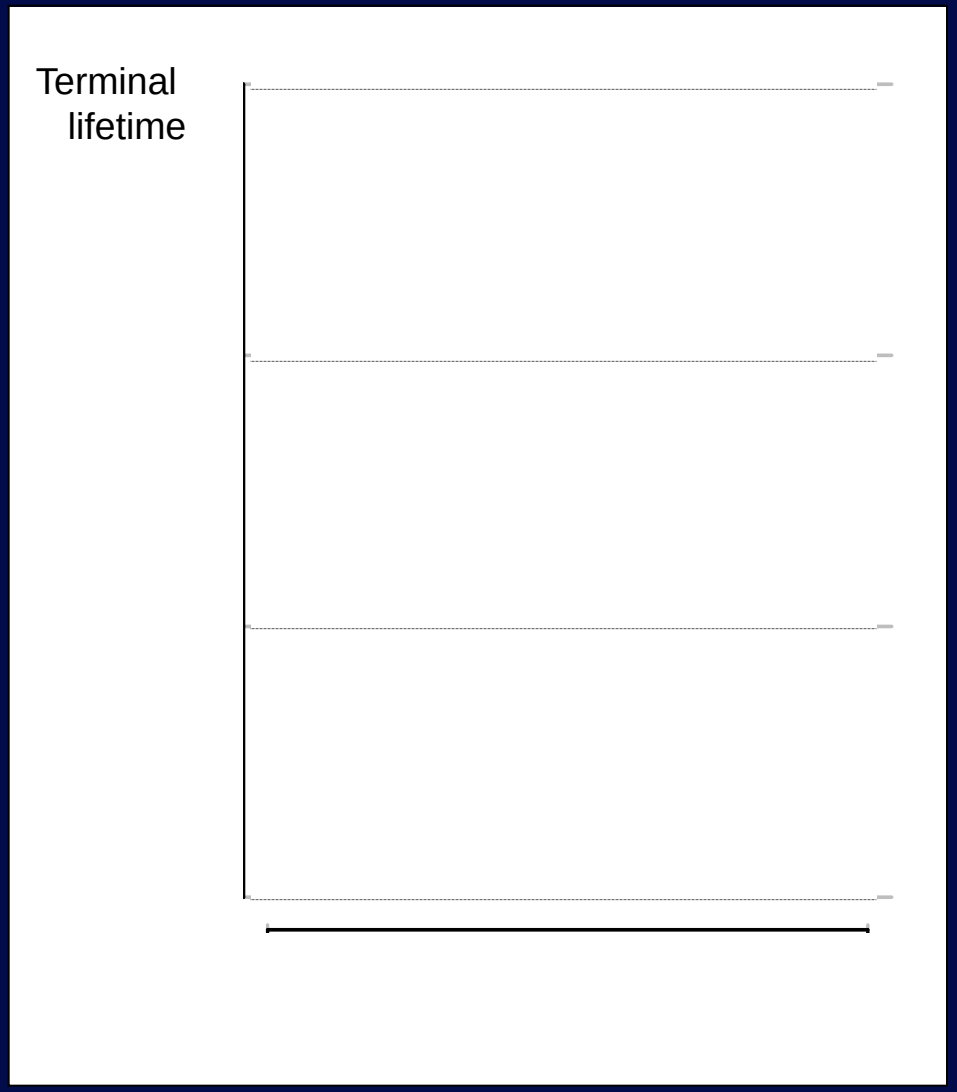
- Discounted Benefit → Avoided Cost of Reactive Future Response
- Discounted Cost → Cost of Hardening at Next Upgrade

Cost Benefit Calculation Depends On Four Parameters About The Future



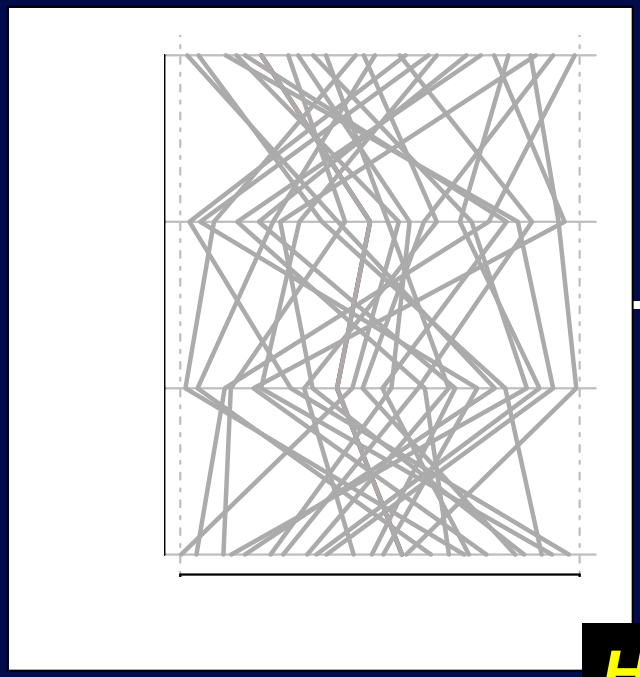
R. Lempert, R Sriver, and K Keller. 2012. "Characterizing Uncertain Sea Level Rise Projections to Support Investment Decisions." California Energy Commission. CEC-500-2012-056

Each Parameter Could Take On A Plausible Range Of Values



Let's Examine The NPV of Hardening For Many Alternative Futures

Considered 500 Futures

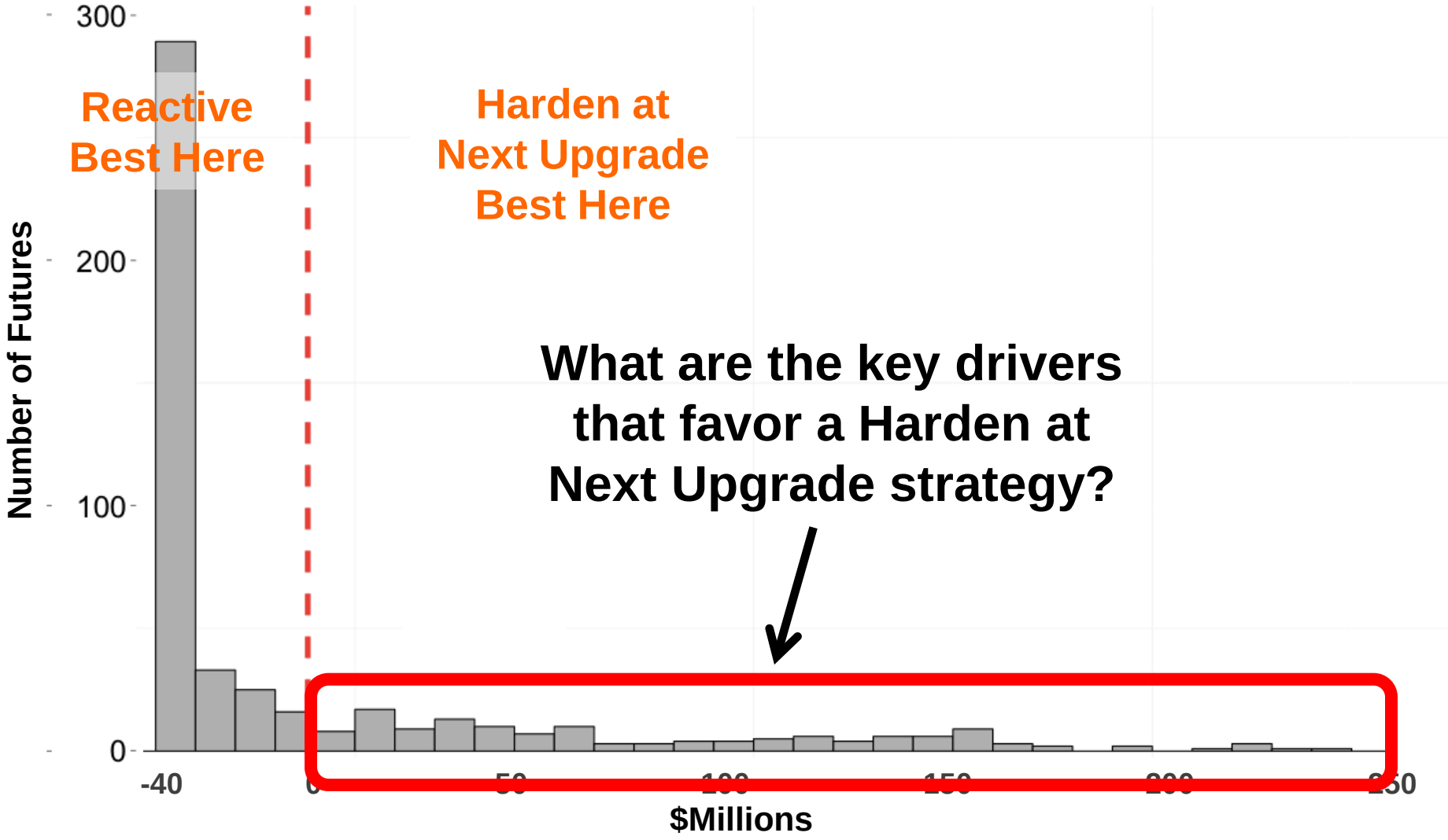


Model

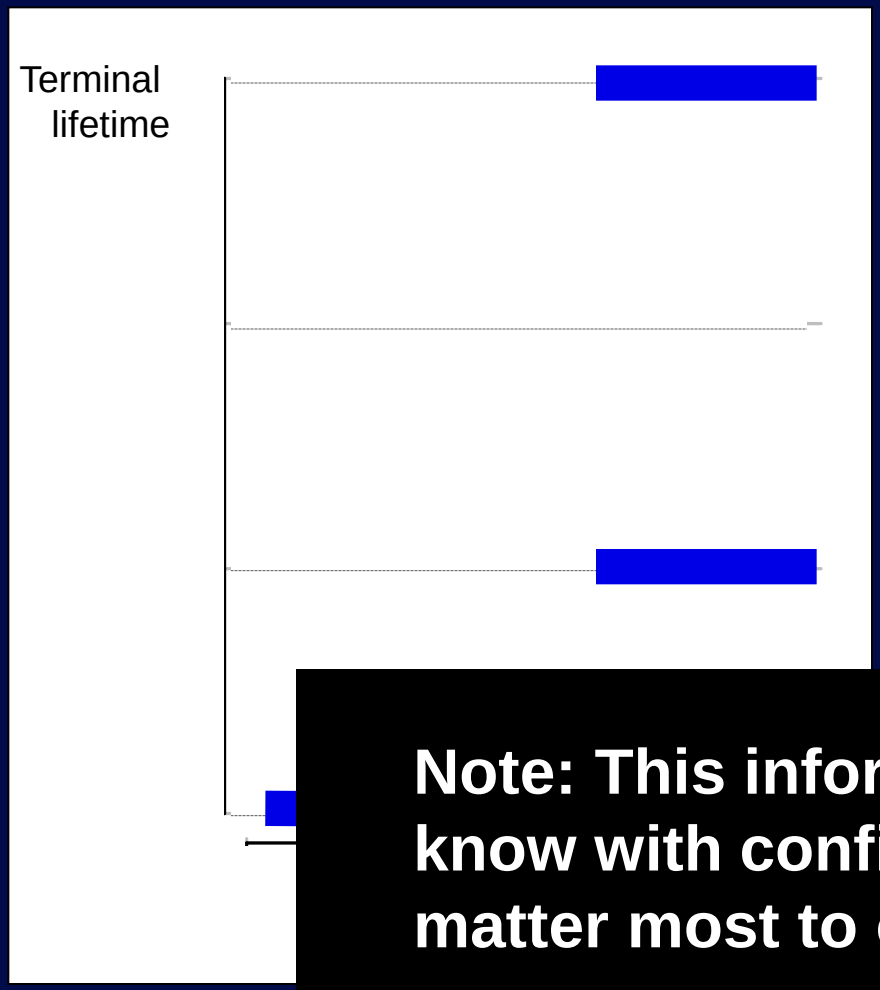
NPV of early hardening in each of 500 futures

Helps reduce gridlock:
Each stakeholder's expectations can be one of our futures.

Consider Range of Performance Over These Futures



Summarize Conditions Where Harden Strategy Passes Cost-Benefit Test



IF

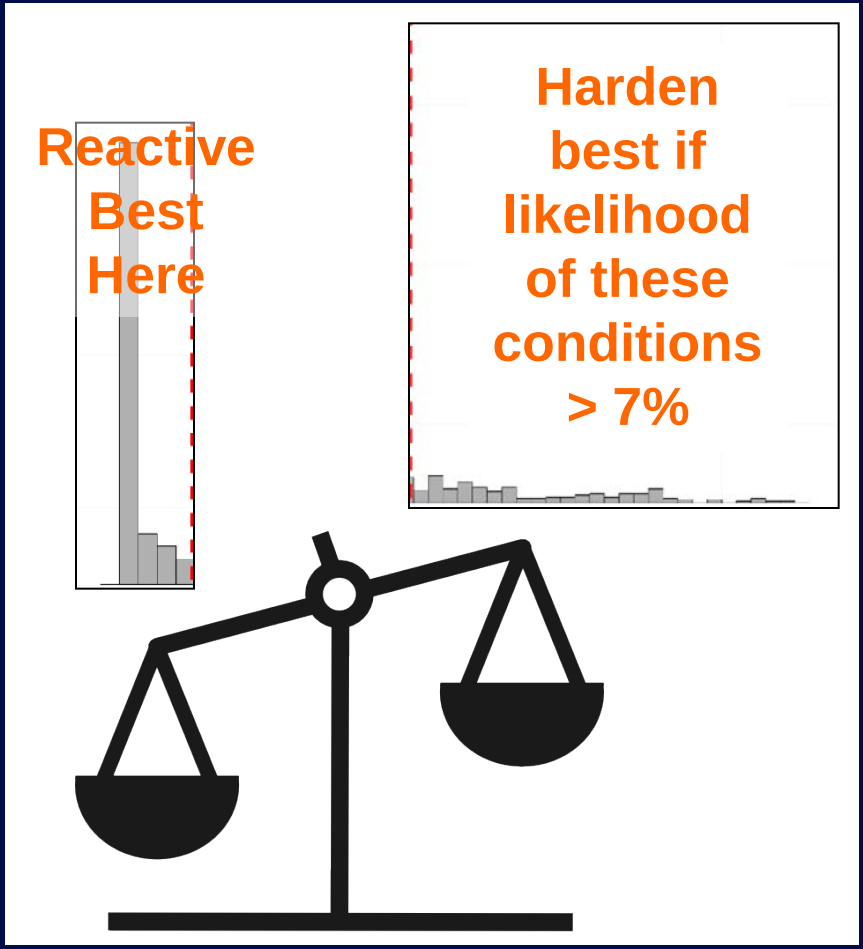
- Abrupt SLR > 14mm/yr
- Lifetime > 75 years
- Storminess change > +5%

THEN

- Hardening at the next

Note: This information is something we can know with confidence – the conditions that matter most to our decision

Little Evidence to Suggest These Conditions Sufficiently Likely To Justify Hardening Terminals at Next Upgrade



- Best science suggests likelihood of fast SLR < 16%
- No PoLA experience with lifetimes that long
- No study suggests storminess increase sufficiently large

But answer is different for other PoLA infrastructure

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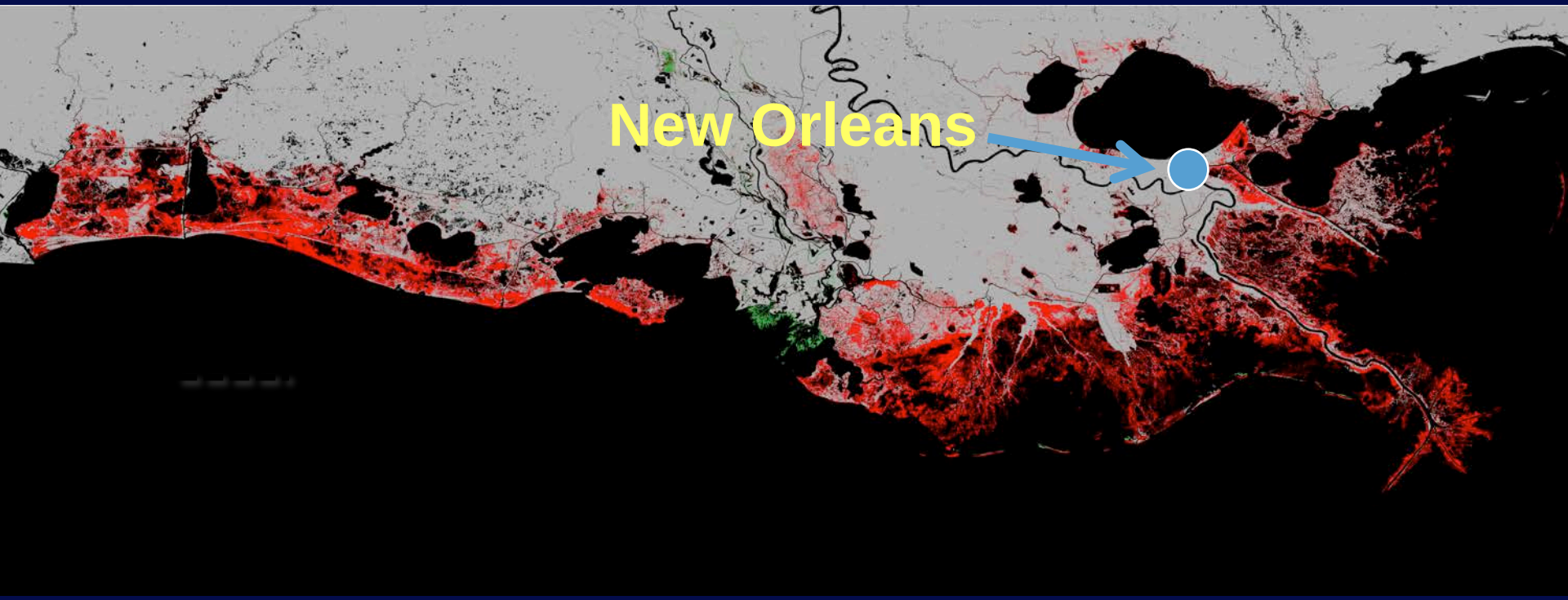
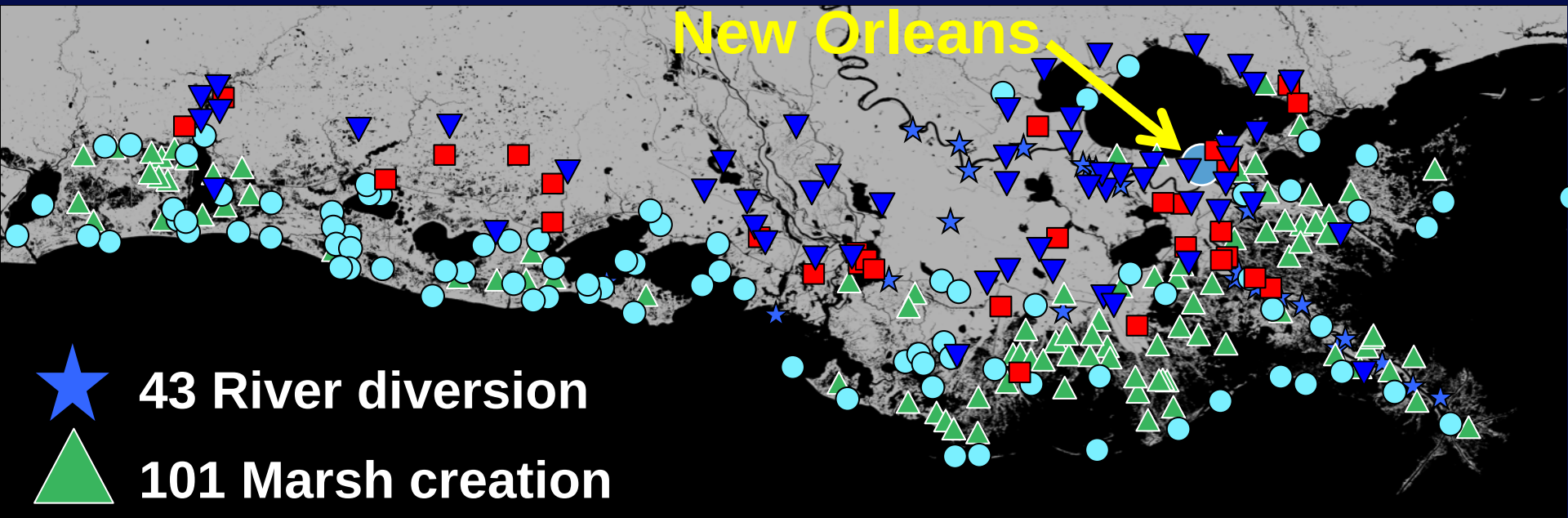
Louisiana Faces Significant Challenge of Flood Protection and Coastal Land Loss



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

Land loss **Land gain**

Hundreds of Different Projects Can Contribute to Restoration and Risk-Reduction



- 43 River diversion
- 101 Marsh creation
- 96 Other restoration
- 34 Structural risk reduction
- 112 Non-structural risk reduction

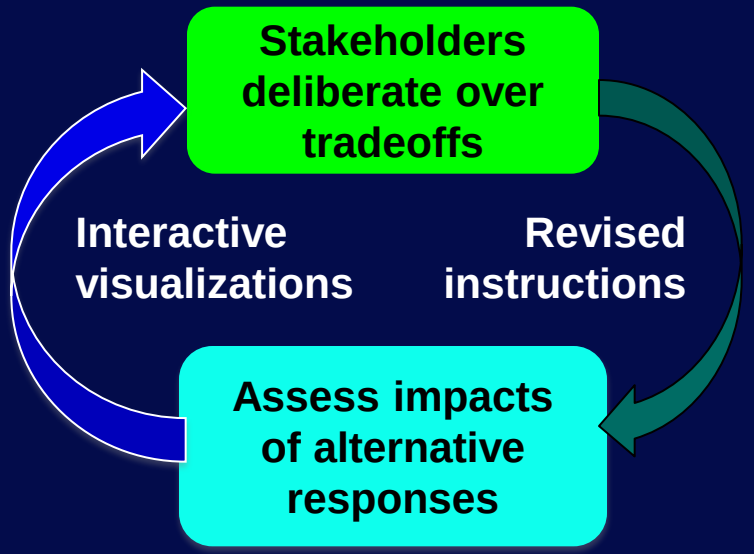
Must choose in face of:

- Uncertain science
- Conflicting values
- Budget constraint

Deliberation with Analysis Process Helped Louisiana Develop Integrated Coastal Plan

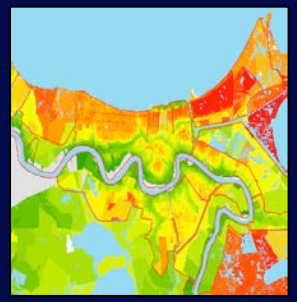
Many iterations using risk models to test and compare plans

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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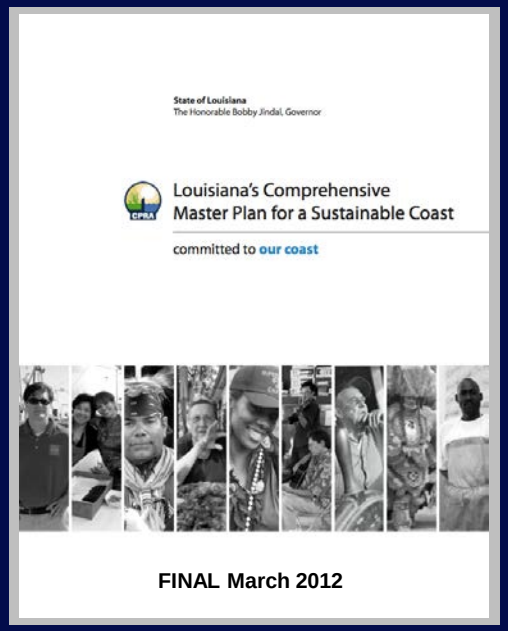
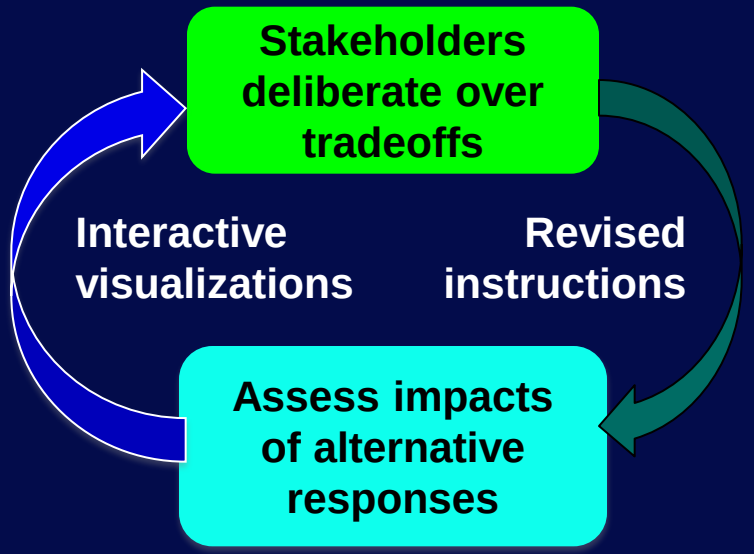
Many iterations using risk models to test and compare plans

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





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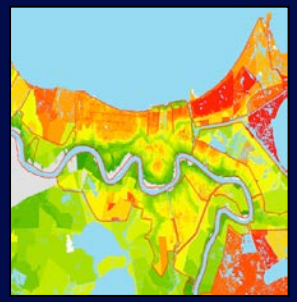
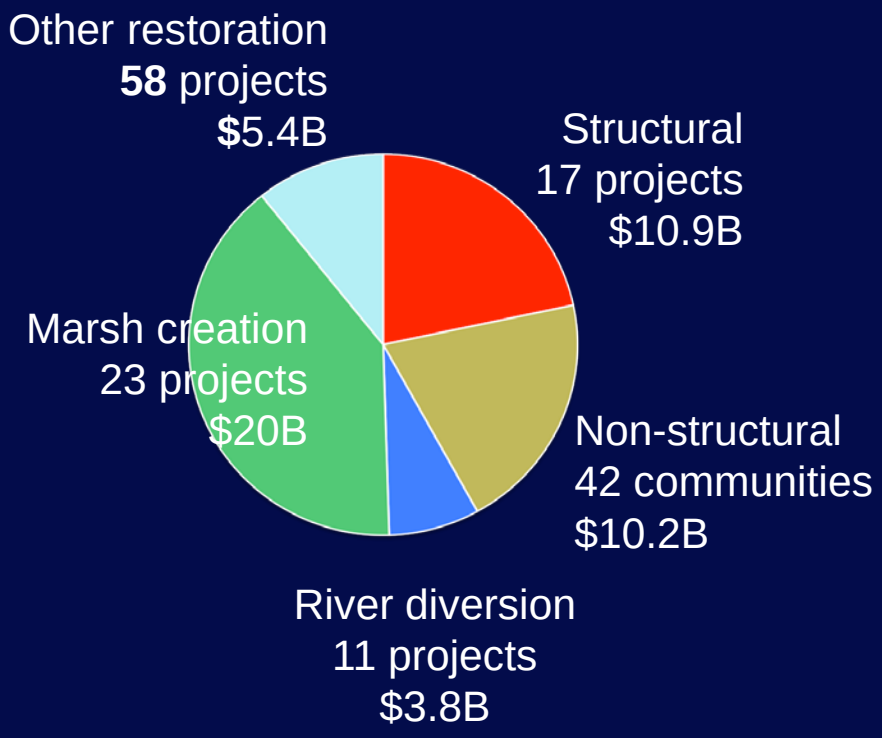


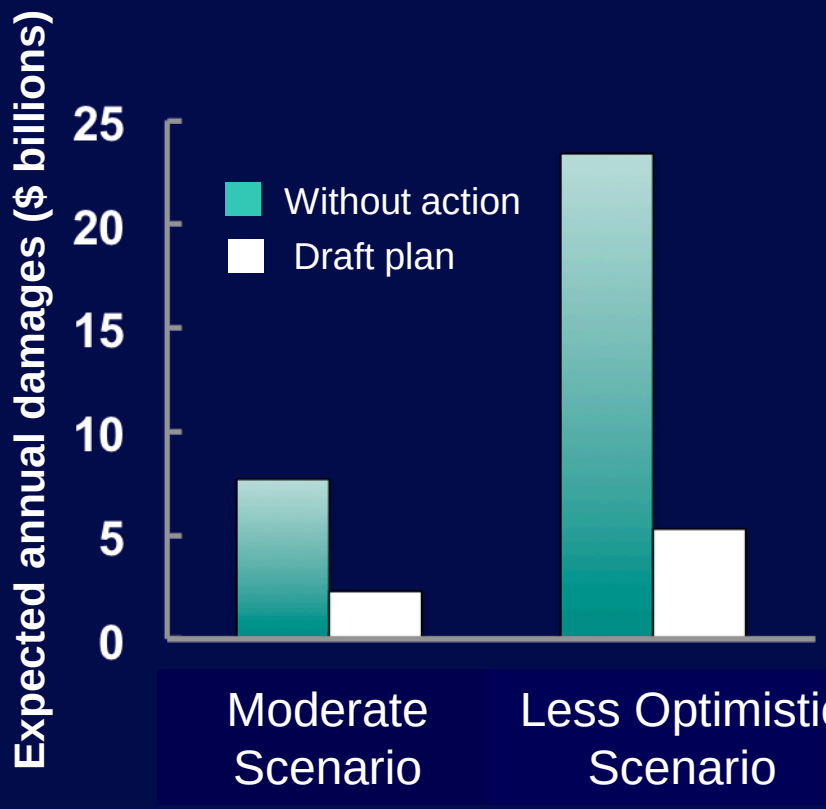
Integrates scientific information from multiple sources to estimate risk to different communities and industries

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

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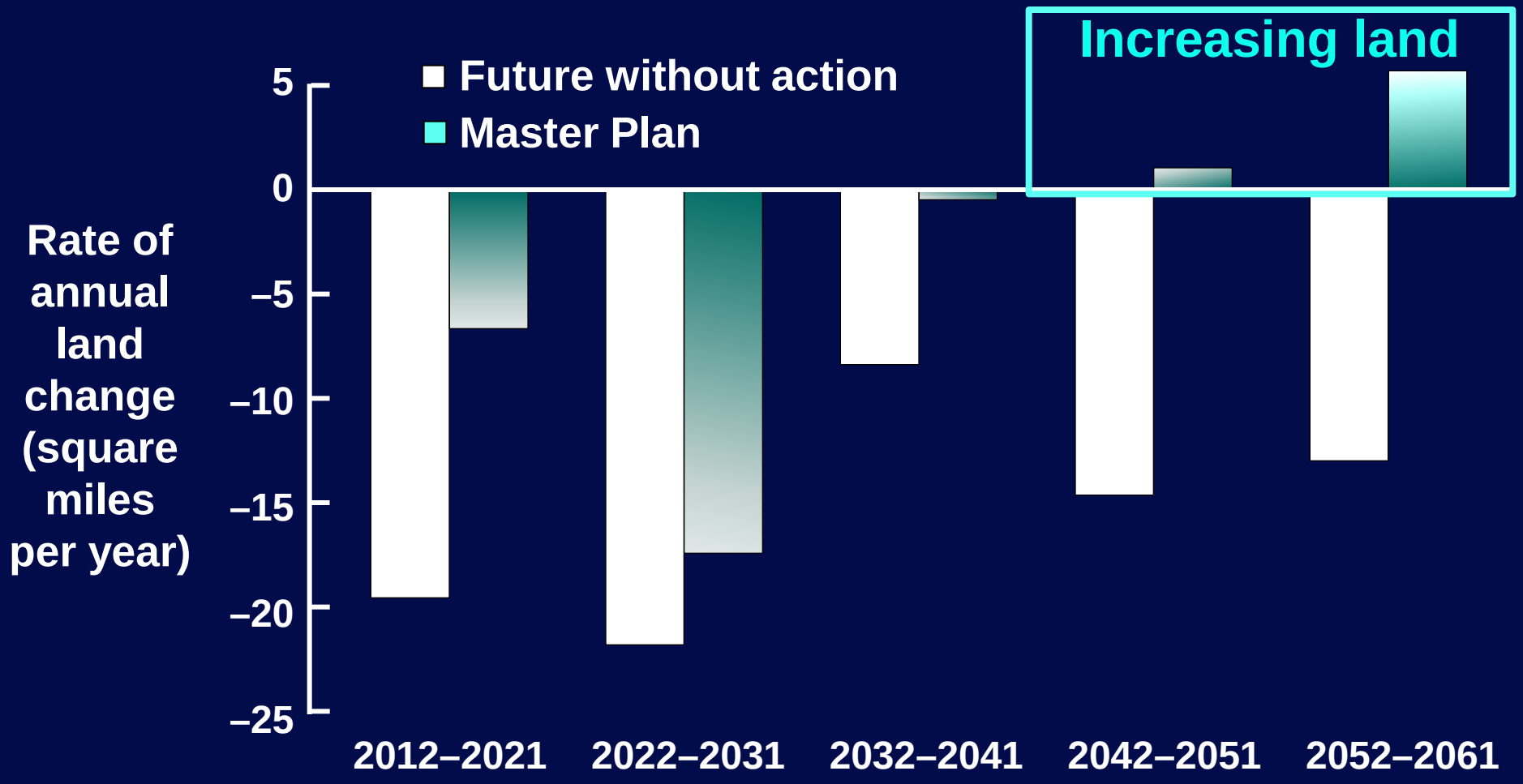
State Choose Plan That Balances Near- and Long-Term Benefits



Observations

- **Protecting critical infrastructure from hard-to-predict risks requires integrated and adaptive management**
- **Conducting the analysis "backwards (start with a strategy and stress test it over many futures):**
  - **Helps reduce prediction bias and the risks of the surprise**
  - **Facilitates integrated planning**
  - **Helps open the process to stakeholder deliberation**

More Information

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

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

Thank you!