



INFRASTRUCTURE, SAFETY,
AND ENVIRONMENT

***Addressing Climate Change in
Long-Term Water Resource Plans***

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The end of the climate change sidebar in long-term water planning documents

- **Growing recognition that climate change will impact water management**
- **Many water management agencies have or are conducting detailed assessments of climate impacts on their water systems**
- **Results are significant enough to warrant incorporation into long-term planning**
- **Planning teams are experimenting with methods to incorporate climate change into assessments of water management strategies**

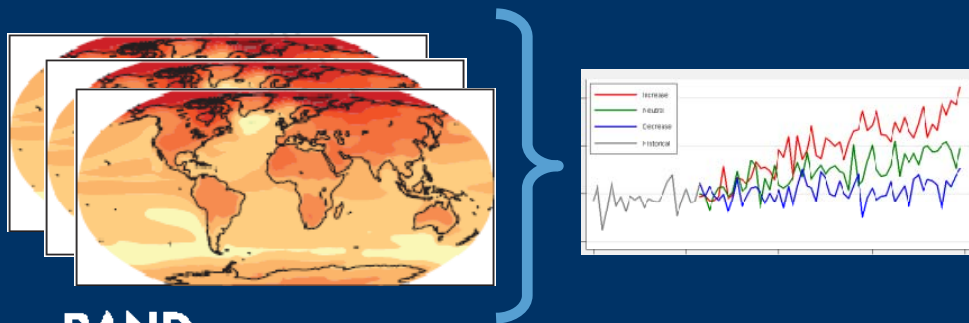
Downscaled climate projections and hydrologic models can help evaluate management strategies

Downscaled Climate Data

- Available sources include USBR/Santa Clara Statistically Downscaled GCM Data
 - 16 Global Climate Models
 - 3 Global Emissions Scenarios
 - Monthly temperature and precipitation from 2000-2100
 - 1/8 degree lat/lon

Models

- Rainfall/runoff models
 - Variable Infiltration Capacity (VIC)
 - PRMS (USGS)
- Water allocation models
 - CALSIM (DWR)
 - IRPsim (Metropolitan)
- Integrated management models
 - Water Evaluation and Planning (WEAP)

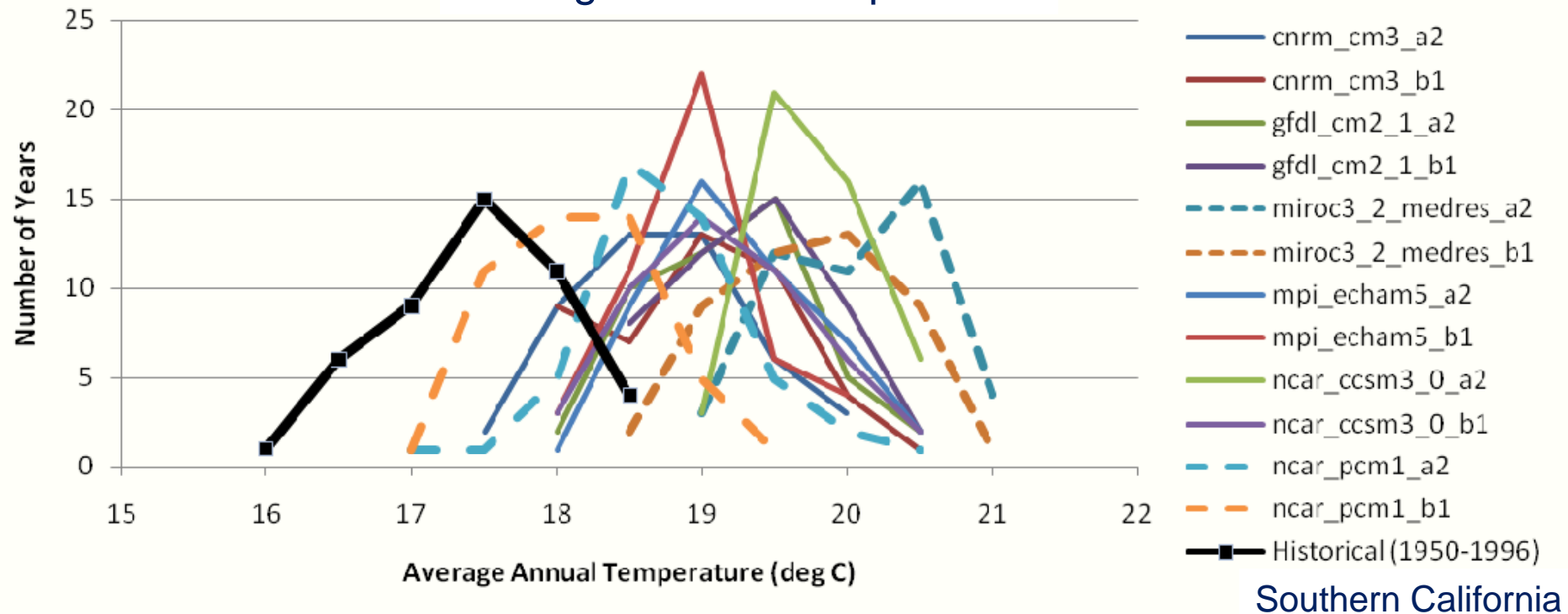


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But, projections of future climate are highly uncertain

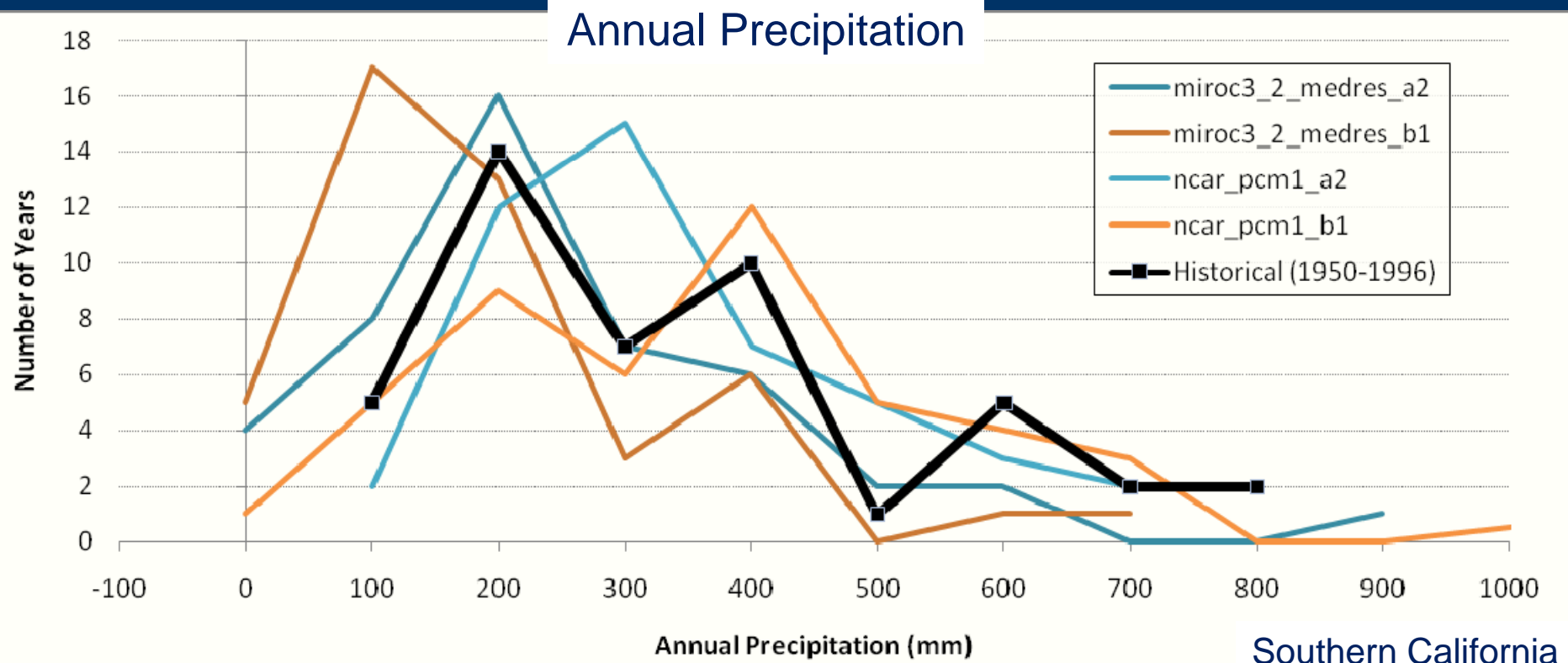
- Histograms of climate sequences corresponding to:
 - Historical period (1950-1996; black line)
 - GCMs at 2050 (other lines)

Average Annual Temperature



But, projections of future climate are highly uncertain

- Histograms of climate sequences corresponding to:
 - Historical period (1950-1996; black line)
 - Select GCMs at 2050 (other lines)



There are different approaches to addressing climate change uncertainty in water planning

- **Deterministic projections with safety factors**
 - **Pros:** Familiar methodology
 - **Cons:** Uncertainty about the future may require large safety factors; Conceals important information about variability
- **Scenario analysis**
 - **Pros:** Explicitly reflects uncertainty; Provides opportunity for “what-if” analyses
 - **Cons:** Small number of scenarios may not reflect all important uncertainties; Difficult to inform decisions
- **Probabilistic or Risk Assessment**
 - **Pros:** Explicitly reflects uncertainty; Provides straightforward guidance on policy choice in the form of optimal strategies
 - **Cons:**

Identifying optimal strategies can be problematic

- Requires consensus on underlying probabilities
- Optimal solution may be brittle
- Option space must be articulated at beginning of analysis
- Single objective function required



MWD's 2003 IRP Update

“...the Preferred Resource Mix was found to satisfy the ... water supply reliability objective of 100 percent full service water demands at the retail level, under foreseeable hydrologic conditions.”

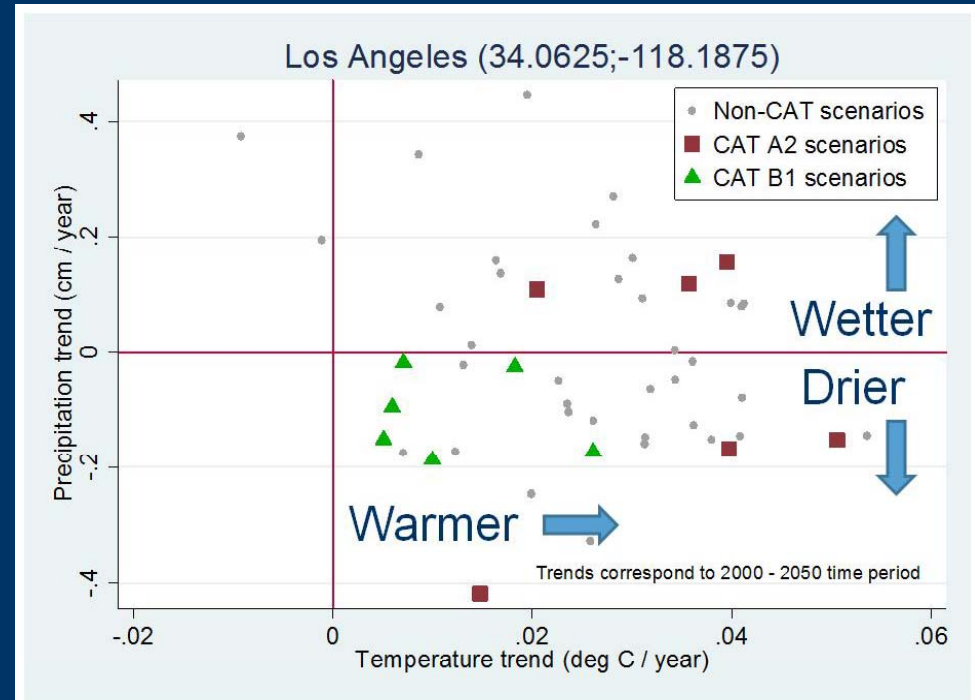
MWD's website, May '09

“... Metropolitan has ... initiate[d] mandatory conservation throughout Southern California.... Without the Plan, Metropolitan's reserve levels could [be] reduced by as much as 60%, or 650,000 acre-feet.”

Robust decisionmaking (RDM) offers an alternative approach for addressing climate uncertainty in long-term water planning

- 1. Evaluates a large set of plausible climate change conditions (and other uncertainties)**
 - Treats scenarios equally (initially)
- 2. Identifies under which scenarios promising scenarios perform poorly**
 - Vulnerabilities are “Policy Relevant Scenarios”
- 3. Iteratively refines robust strategies (adds adaptivity)**
- 4. Presents residual uncertainty to decision maker, allowing them to consider likelihoods and impacts on choices**

T and P trends from 48 GCM simulations



- Probabilities of future conditions considered at end of process, once their significance is understood
- Failure modes extensively considered (even if not viewed as highly likely)

RDM is being used for several long-term water planning processes

- Inland Empire Utilities Agency 2005 UWMP Climate Change Assessment
- California Water Plan Update 2009
- Metropolitan Water District (MWD) 2009 IRP Update
- Denver Water 2009 IRP (evaluating method along side more traditional scenario analysis)

Metropolitan Water District is using RDM to identify robust strategies for its 2009 IRP

- **Planning context**

- MWD supplies 18 million people through 26 cities and water districts in Southern California with about ½ their water supply
- Regional growth and new restrictions on supply pose serious challenge

- **IRP will address new uncertainties**

- Future hydrologic conditions
- Demographic and economic growth
- Energy and strategy implementation costs
- New regulation and restrictions on supplies
- Customer response to various agency programs

- **Evaluate strategies according to performance metrics**

- Reliability
- Cost
- Water quality and salinity
- Environmental protection

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CDM and RAND are working together to support the MWD 2009 IRP Update

Analysis begins by evaluating “Nominal Plan”

- **Use previous IRP Update’s “Preferred Resource Mix”**
 - Reflect most recent projections
 - Extend time period to 2040
- **If additional actions required, derive from expanded development of identified resources**
 - e.g. modest new efficiency, recycling, groundwater use

“Nominal Plan” evaluated against large ensemble of scenarios

- **Experimental Design**

- Span plausible conditions
- Not a statement of likelihood

- **Performance of Plan**

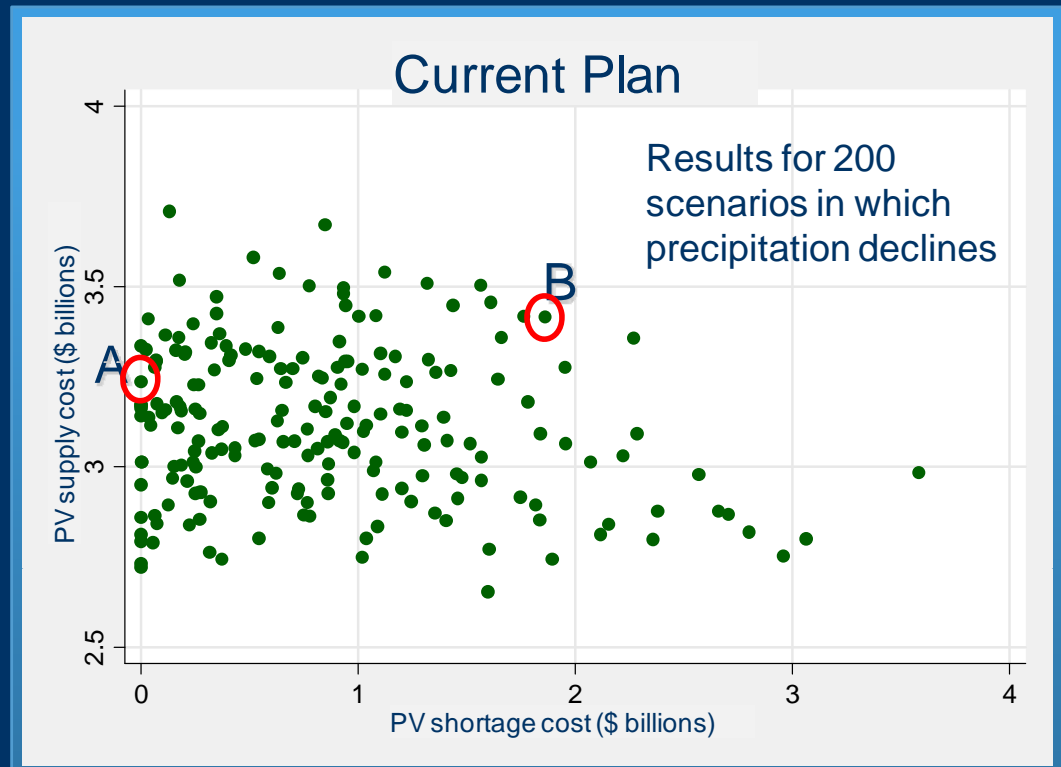
- Model calculates a score for “Nominal Plan” for each scenario and performance metric

Example

Scenario uncertainty:

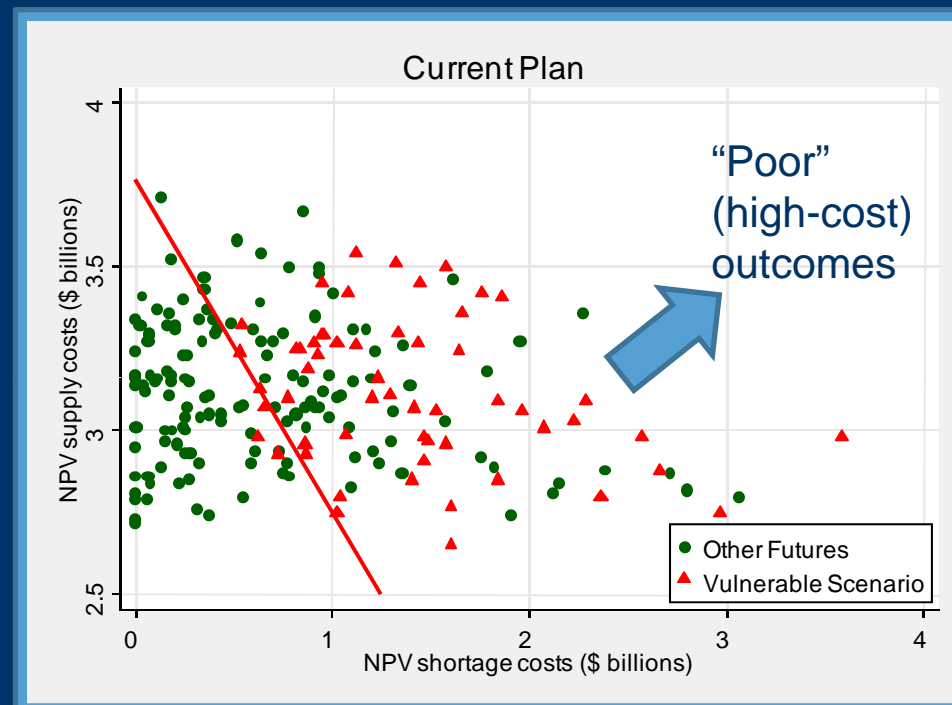
- Future climate
- Changes in groundwater
- Development of recycling
- Groundwater replenishment
- Reliability of imports
- Costs of imported supplies
- Costs of water use
- Costs of efficiency

Performance of “Current Plan” based on two cost metrics evaluated against 200 scenarios



Statistical analyses identify and characterize key vulnerabilities

- Performance thresholds for each metric define outcomes “good enough”
- Statistical tools characterize the scenarios that lead to “poor” outcomes
- Summarize robustness across metrics
 - E.g. counts of “poor” outcomes for each metric

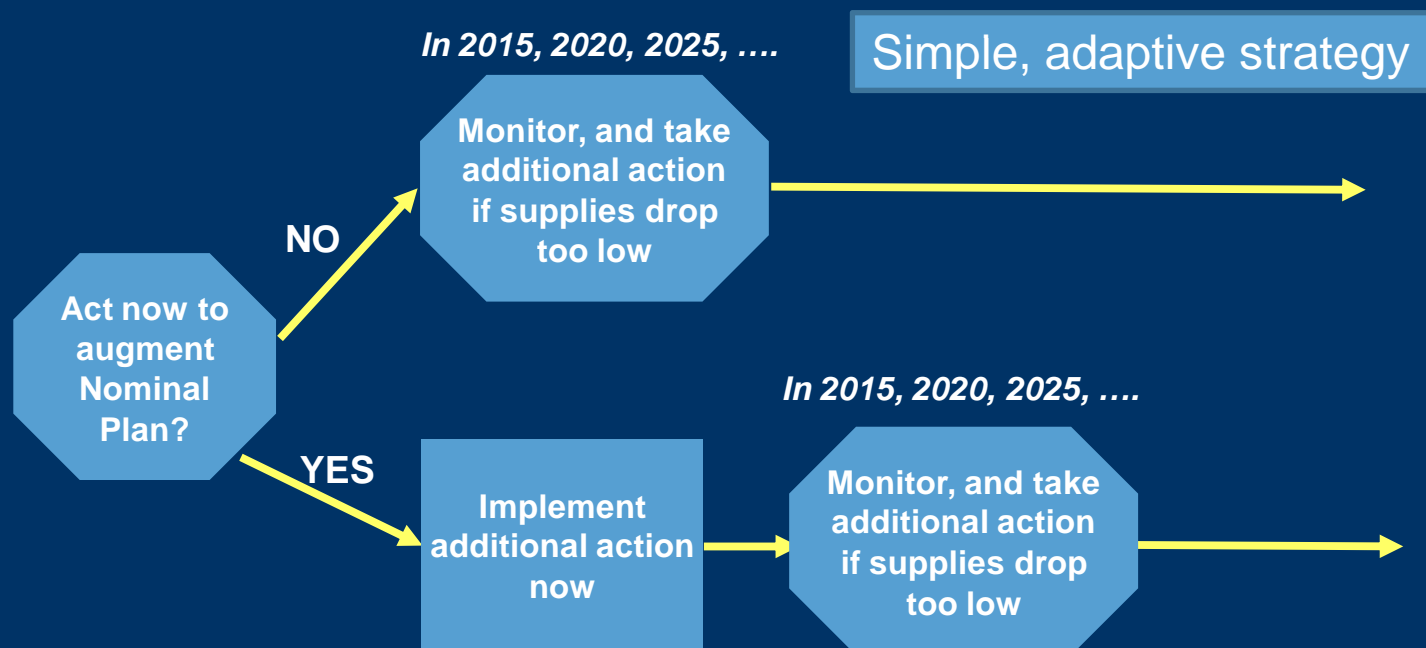


Three concurrent conditions lead to about half of poor outcomes

1. Warming and drying climate
2. Declines in groundwater percolation
3. Strong climate impacts on imports

Develop more robust strategies through adaptivity

- Vulnerabilities reveal key weaknesses and suggest hedging actions
- Some weakness occur in out-years and in only some scenarios – suggests adaptive strategy

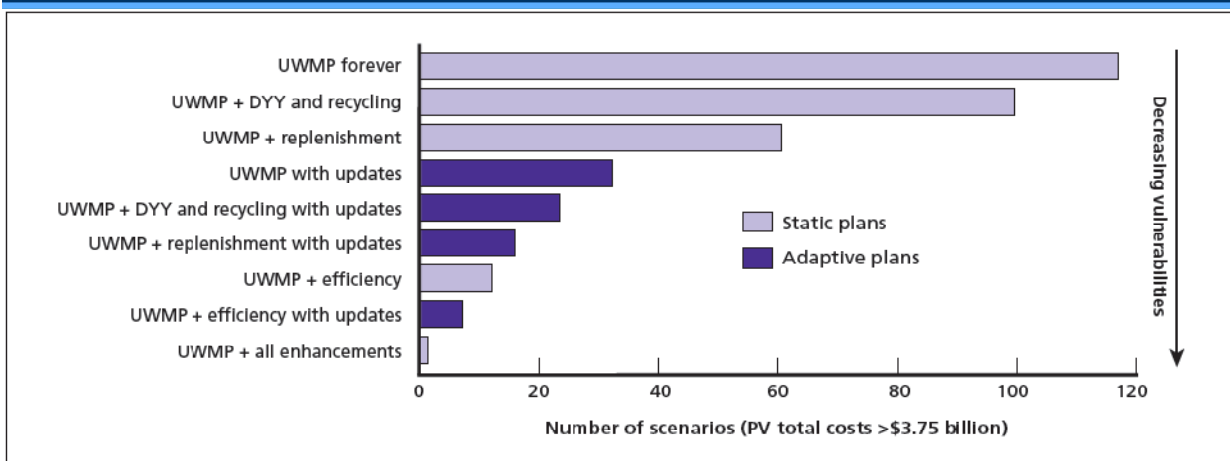


Evaluate new strategies against ensemble of scenarios

- **New strategies**
 - Will have fewer and possibly different vulnerabilities
 - Will be more robust across more performance metrics

Example Output

Strategies ranked by # of high cost outcomes



Robustness of four strategies for three performance metrics

	M1	M2	M3
Strat 1	Green	Red	Yellow
Strat 2	Red	Green	Light Green
Strat 3	Yellow	Green	Light Green
Strat 4	Green	Light Green	Green

Present key performance tradeoffs

- No strategy is perfect
 - No strategy will eliminate ALL vulnerabilities
 - No strategy will perform equally well across ALL metrics
- Final tradeoffs permit Metropolitan to weigh risks and performance across metrics

of High Cost Futures



References

RDM Methodology

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