Informing Adaptive Management: Innovations and Challenges

Robert Lempert

Director,

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

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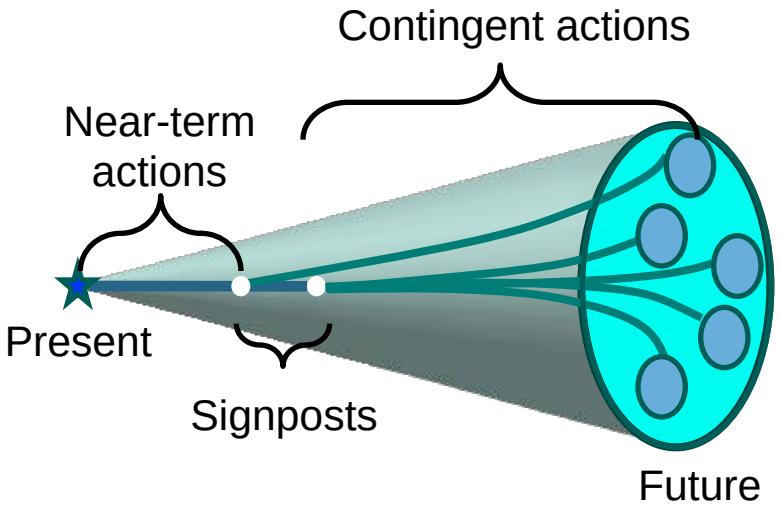
Useful to Distinguish Between Adaptive Plans and Process of Making Them

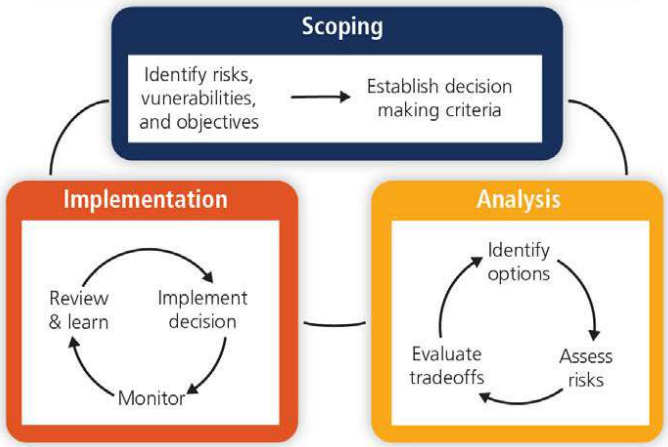
Attributes of:

- Adaptive plans themselves
  - Forward looking, to identify potential vulnerabilities and responses
  - Automatic adjustment, to monitor and respond to vulnerabilities
  - Integrated, combing management of multiple elements in holistic plan



- Process of developing plans
  - Iterative review and learning, to address emerging issues
  - Multi-stakeholder deliberation, to promote legitimacy and access information
  - Diversity of approaches, to gain knowledge about most effective approaches
  - Decentralized decision making, to improve flexibility and responsiveness

Iterative Risk Management



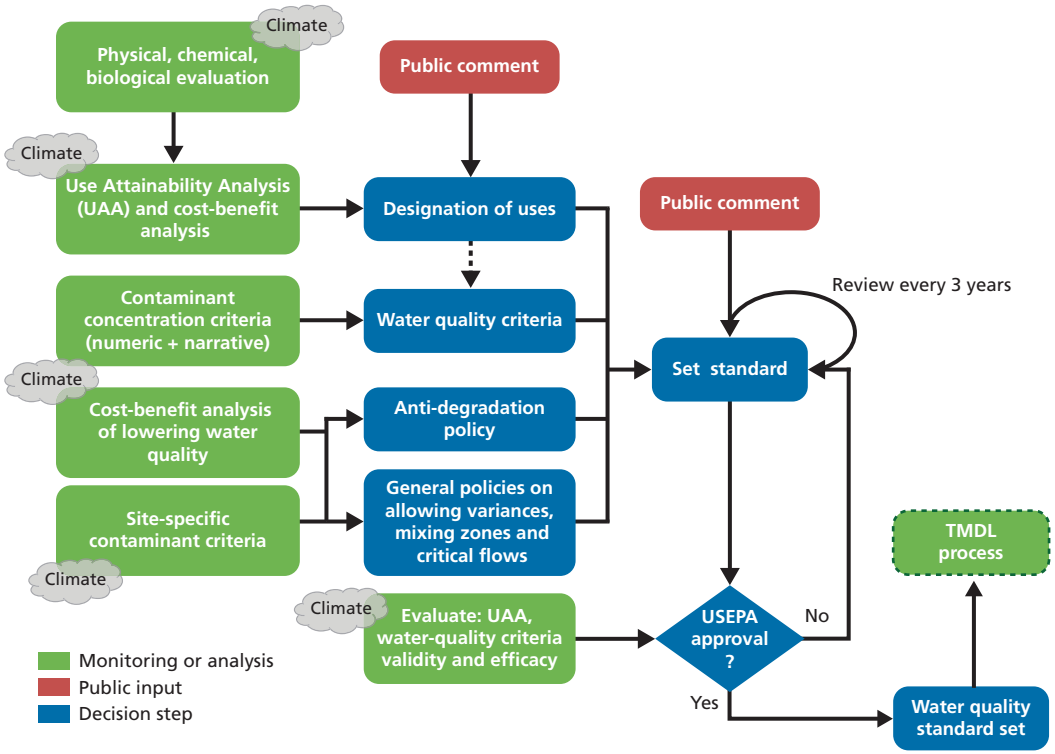
IPCC AR5 WGII

Fischbach et. al. (2015). Managing Water Quality in the Face of Uncertainty: A Robust Decision Making Demonstration for EPA's National Water Program, RAND. PR-1148-EPA

USEPA Follows Adaptive Decision Process, But Resulting Plans Less Often Adaptive

US EPA process for setting water quality standards includes:

- iterative review,
- multi-stakeholder deliberations,
- diversity of approaches, and
- decentralized decision making



Fischbach et. al. (2015)

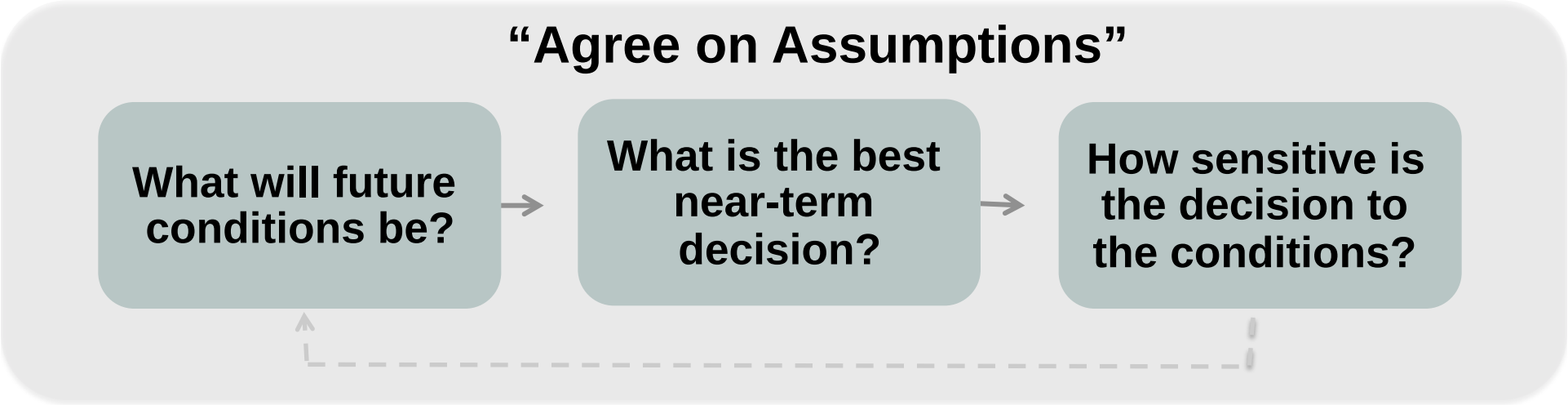
But in practice:

- TMDL (total maximum daily load) water quality standards do not easily change
- TMDL implementation plans commonly phrased as adaptive, but often rely mostly on unplanned learning

Outline

- Analytics for adaptive management
  - Water supply
  - Water quality (more regulatory)
- Observations on implementation
  - Thoughts on pacing problem

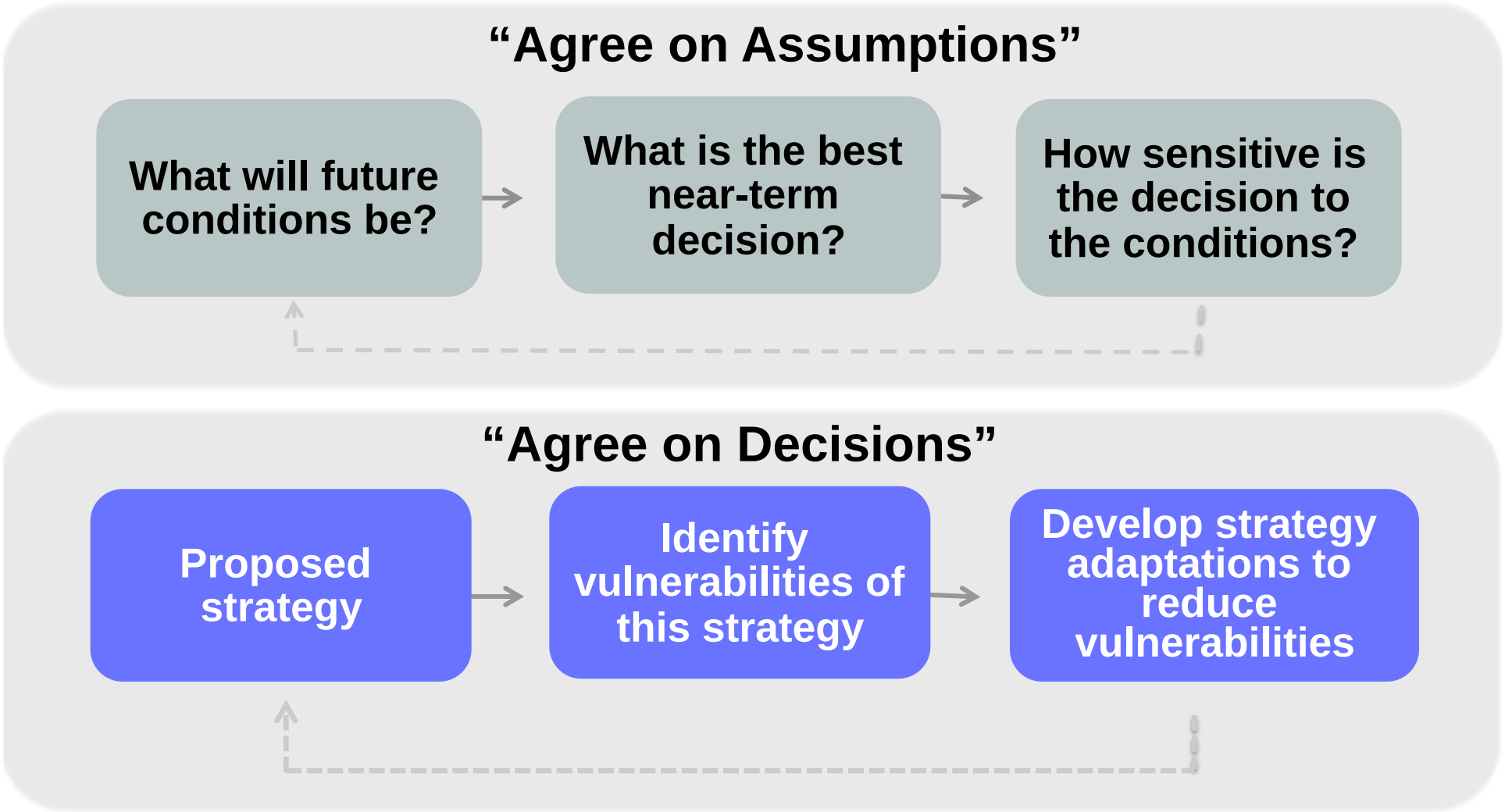
Traditional Risk Management Methods Work Well When Uncertainty is Limited



But under conditions of deep uncertainty:

- Uncertainties are often underestimated
- Competing analyses can contribute to gridlock
- Misplaced concreteness can blind decisionmakers to surprise

Under Deeply Uncertain Conditions, Often Useful To Run the Analysis "Backwards"



Kalra, N., S. Hallegatte, R. Lempert, C. Brown, A. Fozzard, S. Gill and A. Shah (2014). Agreeing on Robust Decisions: A New Process fo Decision Making Under Deep Uncertainty. WPS-6906, World Bank.

Under Deeply Uncertain Conditions, Often Useful To Run the Analysis "Backwards"

"Agree on Assumptions"

What will future conditions be? → What is the best near-term decision? → How sensitive is the decision to the conditions?

"Agree on Decisions"

Proposed strategy → Identify vulnerabilities of this strategy → Develop strategy adaptations to reduce vulnerabilities

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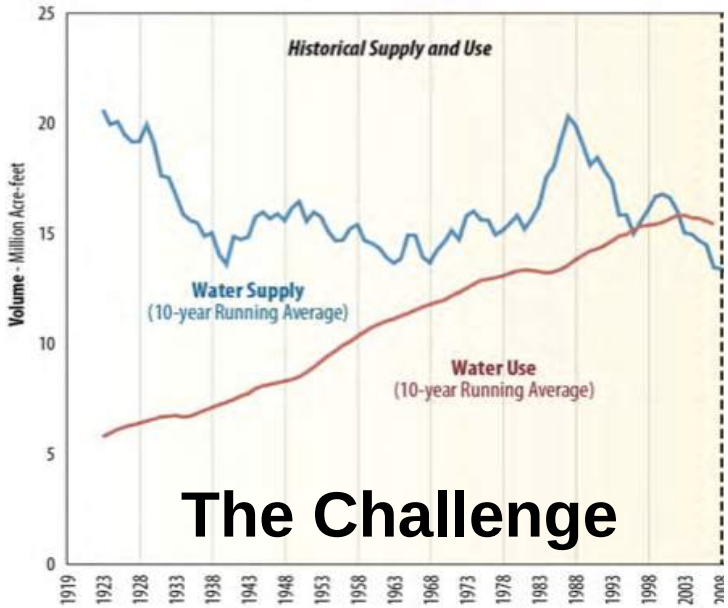
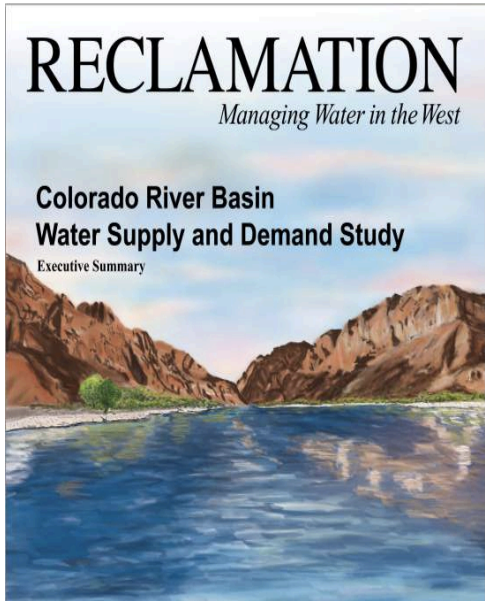
Used Robust Decision Making to Develop Adaptive Management Plans for Colorado Basin

In collaboration with seven states and other users, Bureau of Reclamation:

- Assessed future water supply and demand imbalances over the next 50 years
- Developed and evaluated opportunities for resolving imbalances



The Study



Analysis Stress Tests Current and Proposed Managements Plans Over Many Futures

Strategies
- Current management plan
- Adaptive response strategies
  - Hundreds of distinct options
  - Organized as act, monitor, respond adaptive strategies

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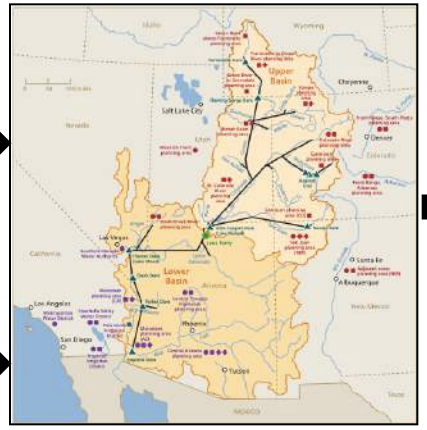
Uncertainties (24,000 futures)

Climate projections (1,000)
- Recent historic
- Paleo records
- Model projections
- Paleo-adjusted model projections

Several demand projections

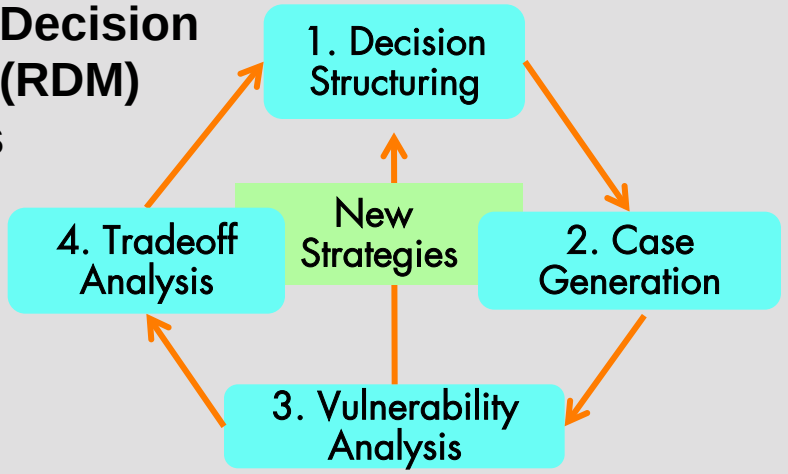
Behavior of future decision makers

Large scale hydrological simulation model:
RiverWare™ (CADSWES)



Outcomes
- 26 measures of environmental, economic, water supply, energy, and recreational performance

Robust Decision Making (RDM) process

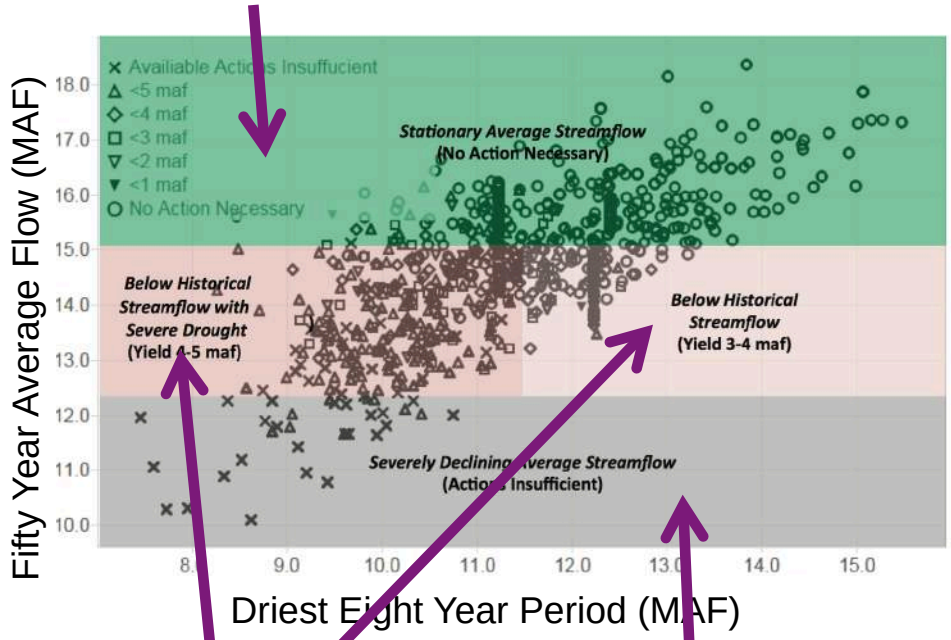


Analysis Illuminated Vulnerabilities of Plans and Helped Identify Responses

Key drivers of vulnerability for current river management plan are both climate-related:

- Fifty year average river flow
- Driest eight year period

Business as Usual



Two Adaptive

Transformative

Analysis suggests rule-based adaptive strategies, which include:

- Near-term actions
- Trends to monitor
- Contingency actions

Four policy-relevant scenarios emerge from analysis

Bloom, E. (2015). Changing Midstream: Providing Decision Support for Adaptive Strategies Using Robust Decision Making, RAND: RGSD-348

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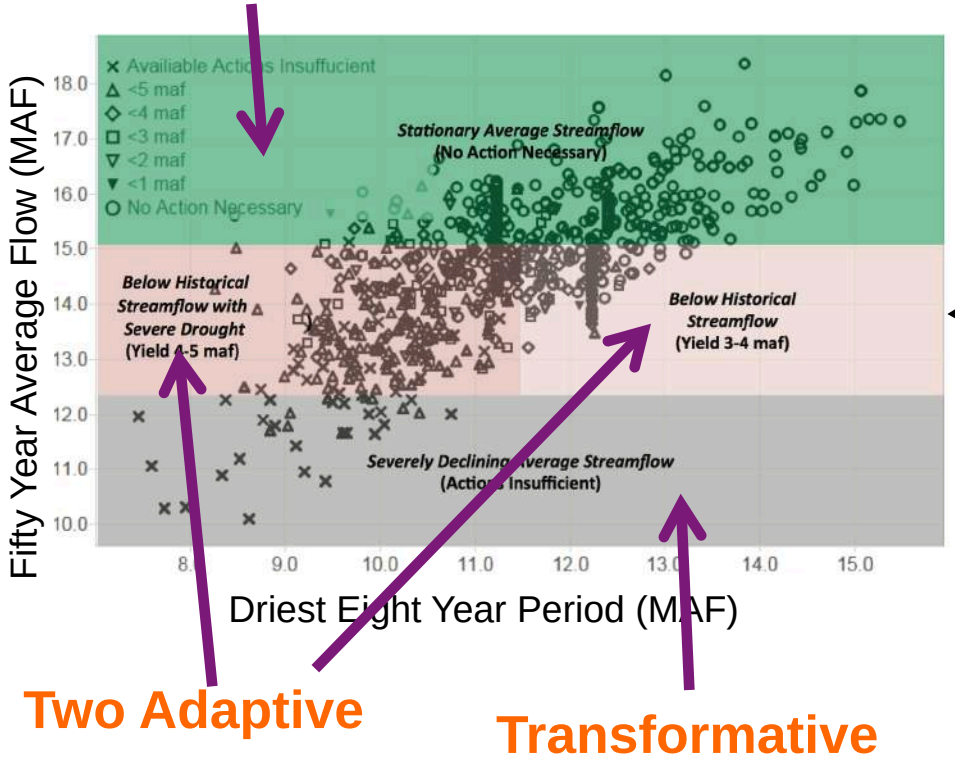

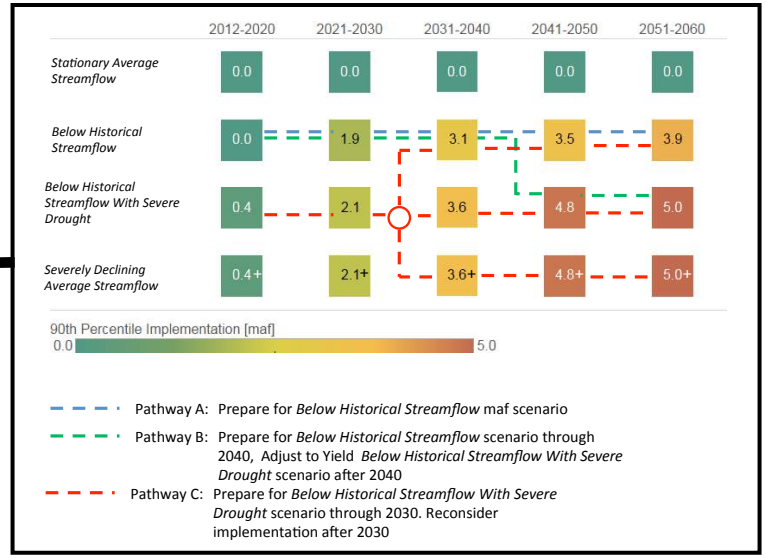

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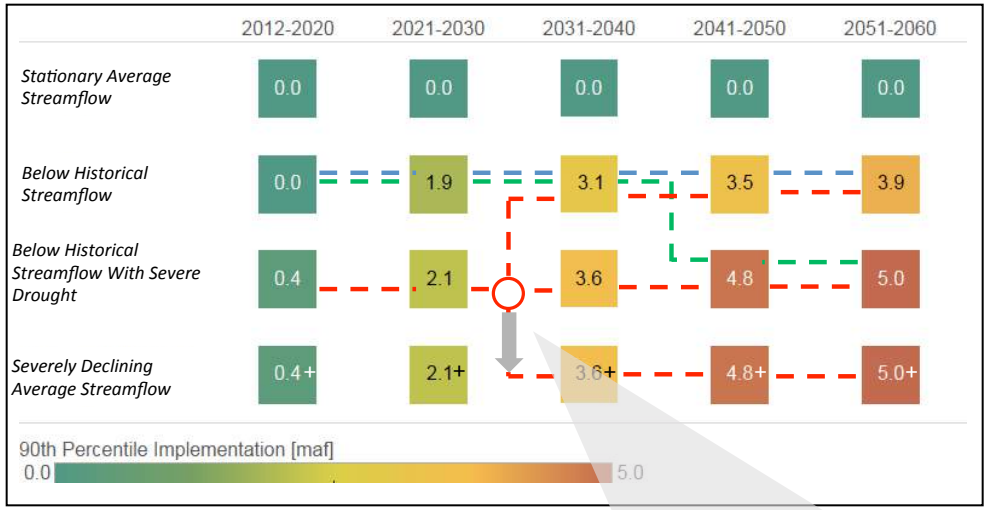
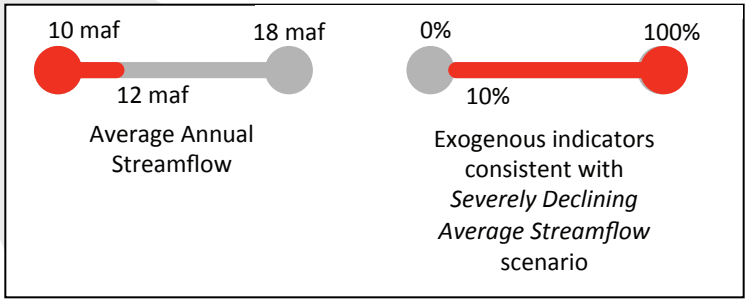
Haasnoot, M., J. H. Kwakkel, W. E. Walker and J. ter Maat (2013). Global Environmental Change 23(2): 485-498.

Analysis Suggests Signposts That Accompany Each Path

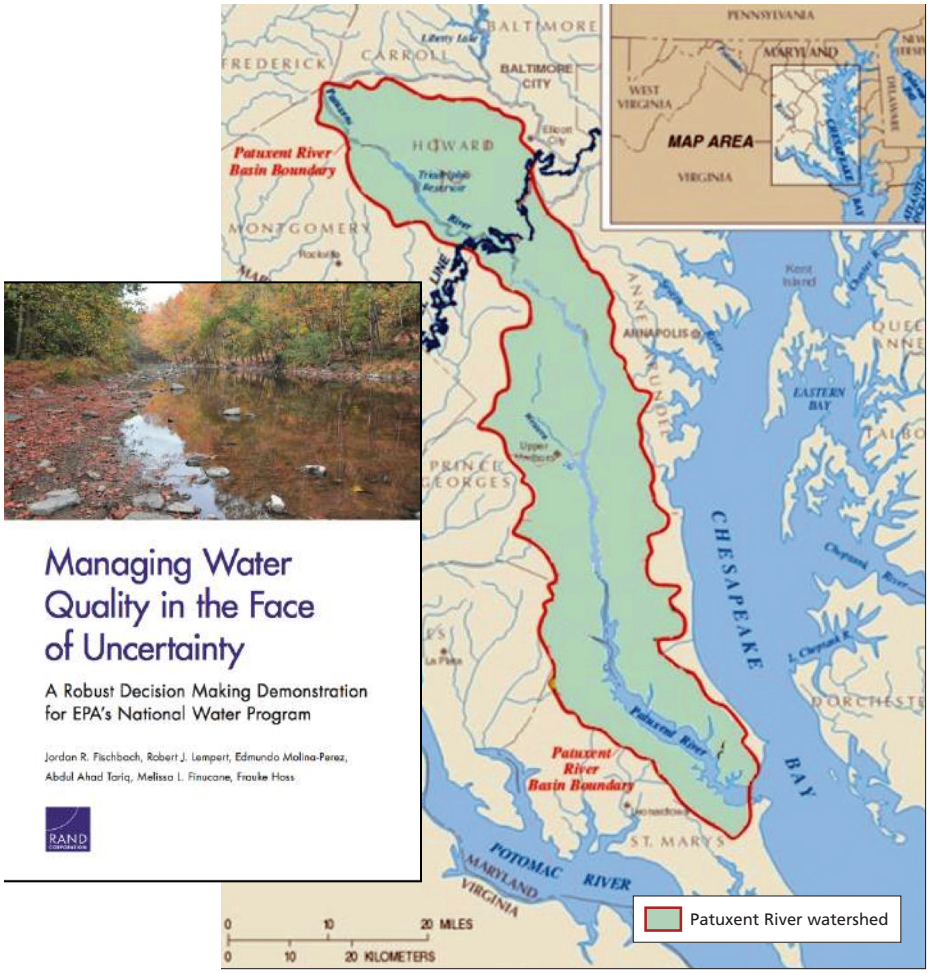




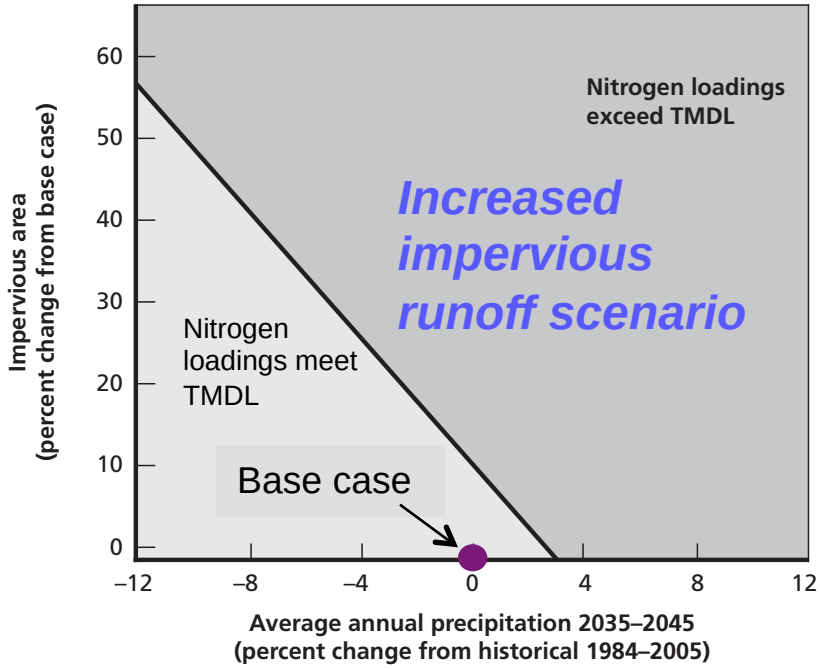
This adaptive strategy monitors:

- Average streamflow
- Any available decadal climate forecasts

Consider Same Process in Regulatory Context



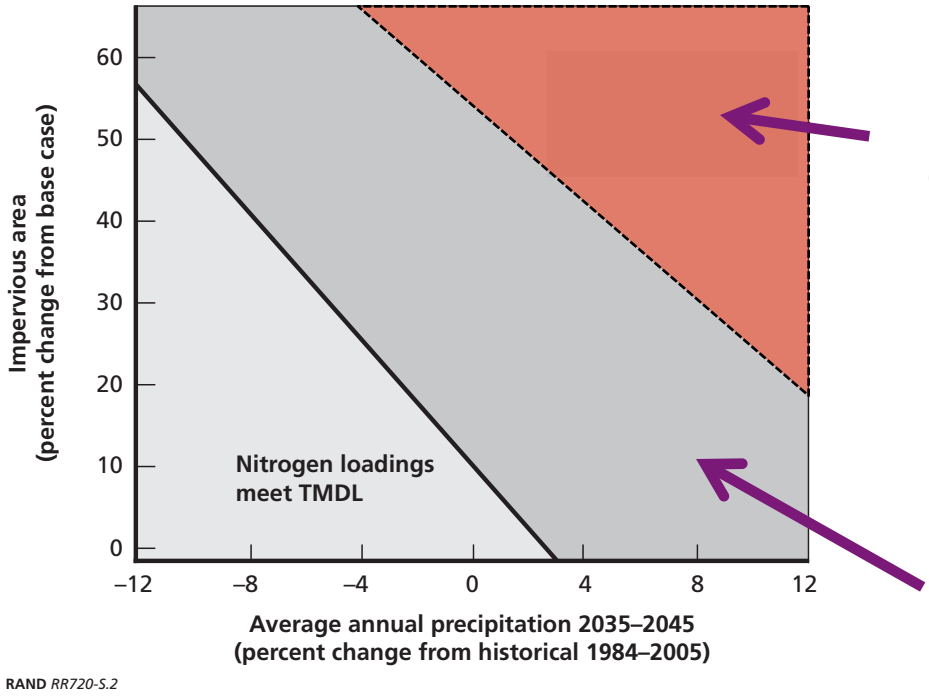
- Patuxent basin is heavily urbanized tributary of Chesapeake Bay
- Maryland's TMDL implementation plans for Patuxent based on historic climate and expected land use
- Analysis stress-tests current plans against wide range of climate and land use futures



Fischbach et. al. (2015)

Scenario Maps Inform Components of Adaptive Strategies

Effective signposts may include building permits and other development trends

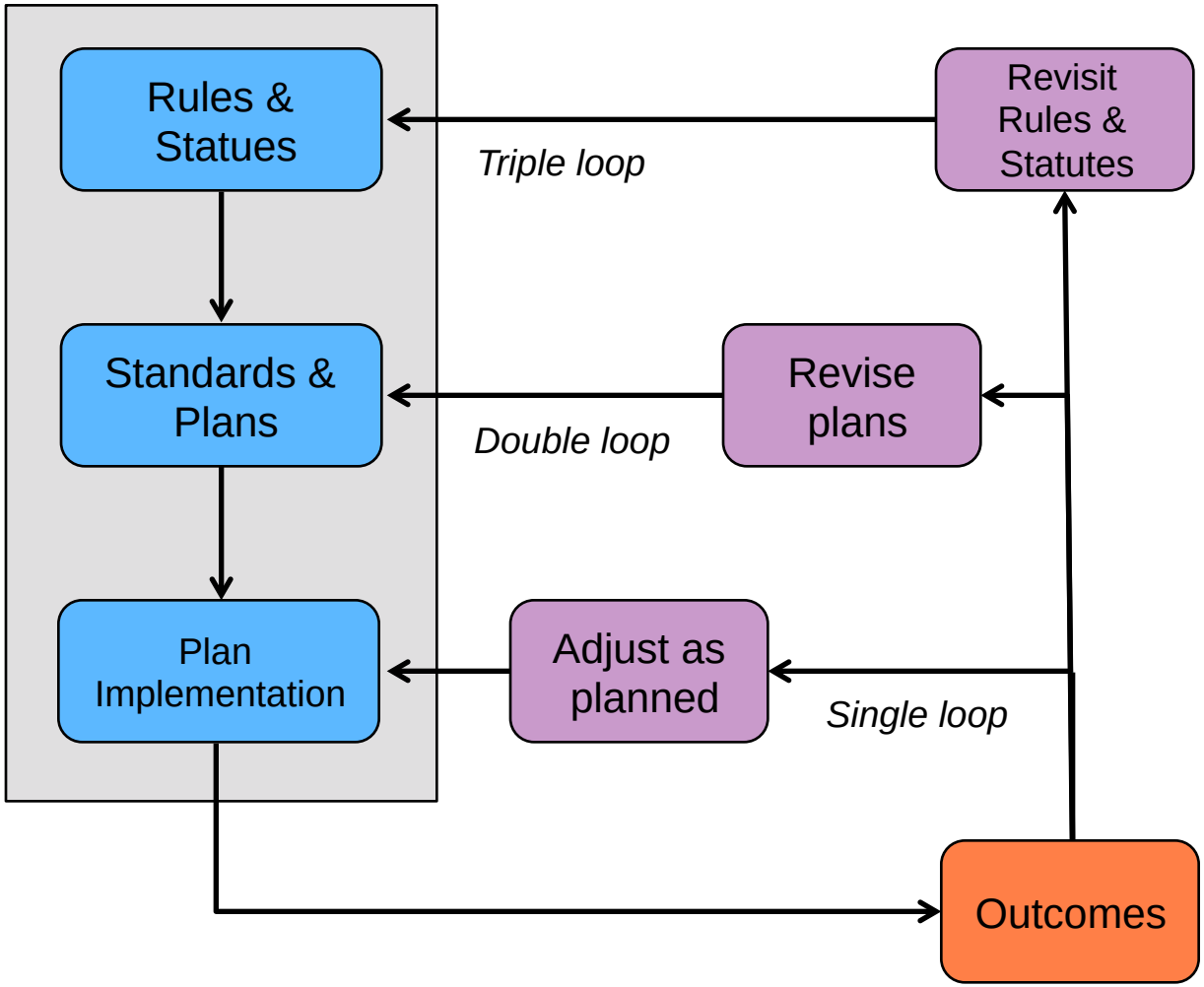


In this region, no set of existing practices can easily meet targets

In this region, can cost-effectively meet targets by expanded deployment of existing BMPs, e.g. additional wet ponds and wetlands

No effective signposts currently exists

Consider Adaptive TMDL Plans in the Context of Triple Loop Learning



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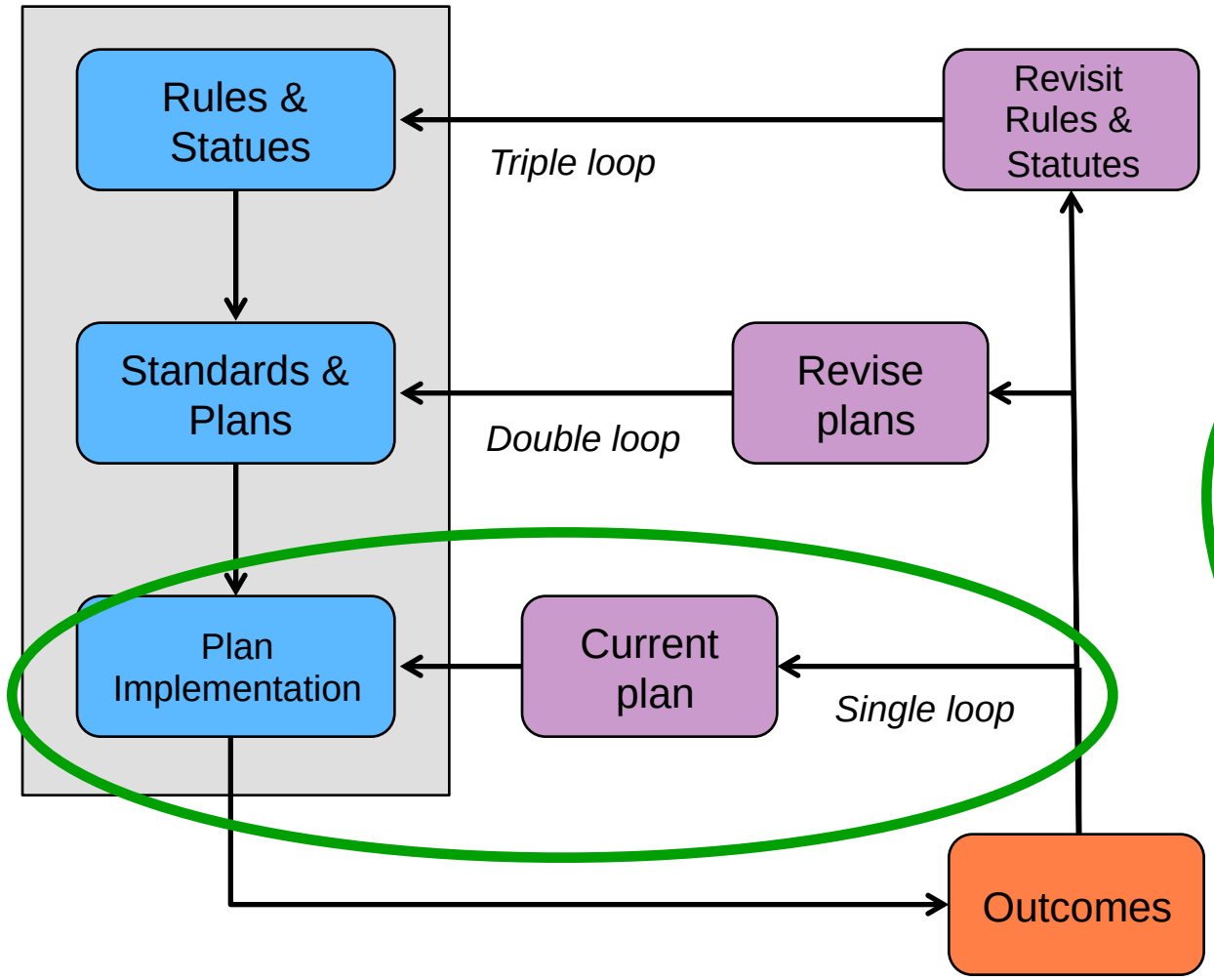
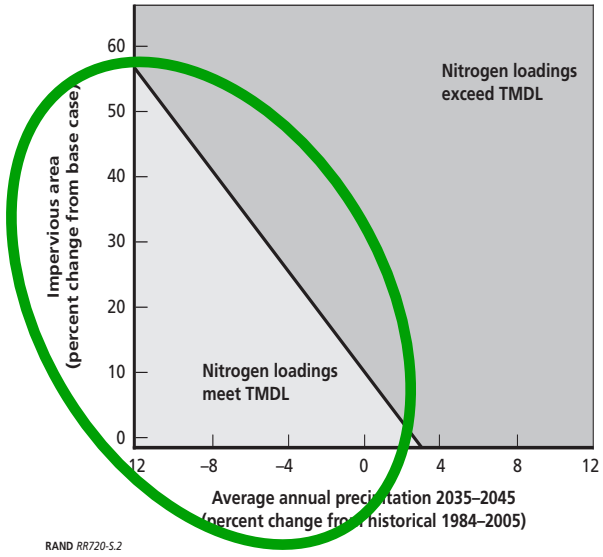
Current TMDL Planning Generally Employs Unplanned Learning





In this region, plan meets goal

Fischbach et. al. (2015)

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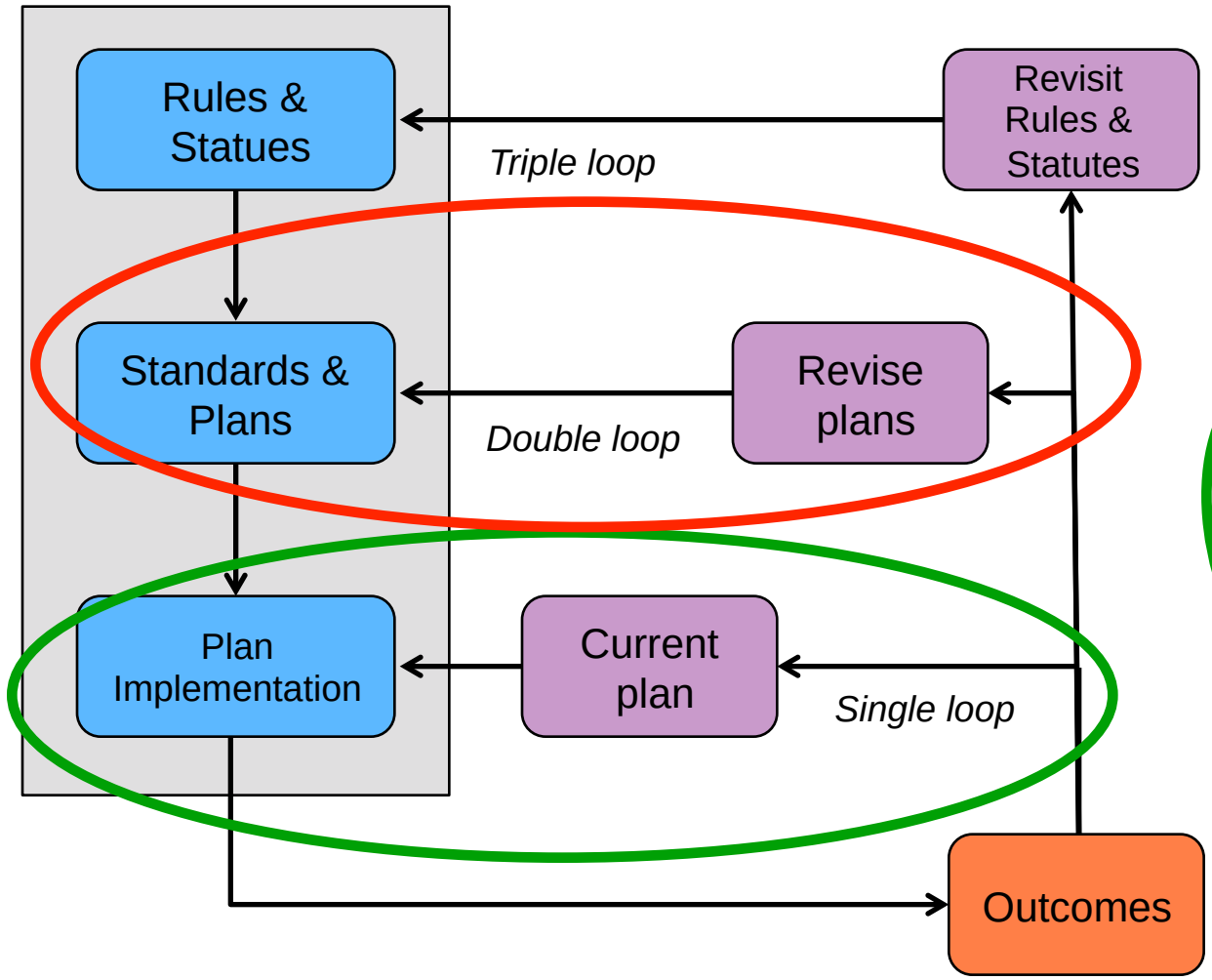
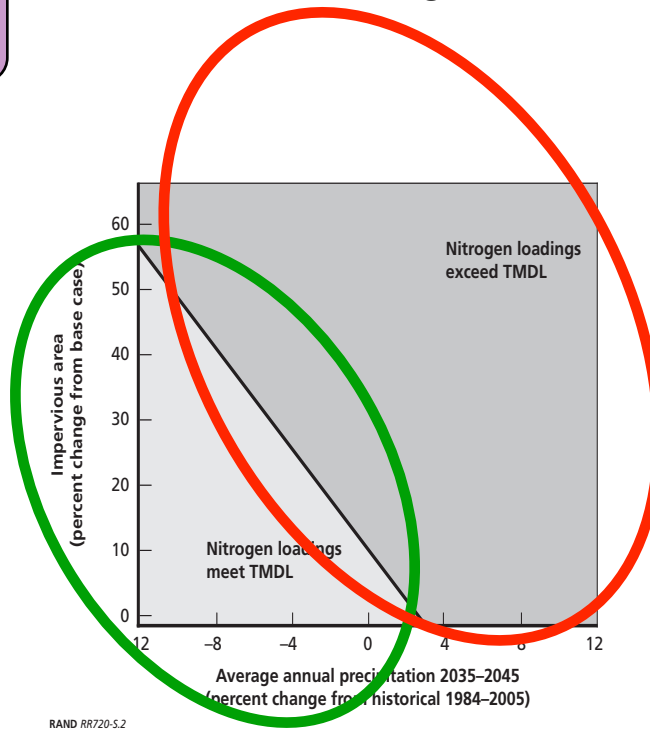


In this region, plan fails to meet goal



In this region, plan meets goal

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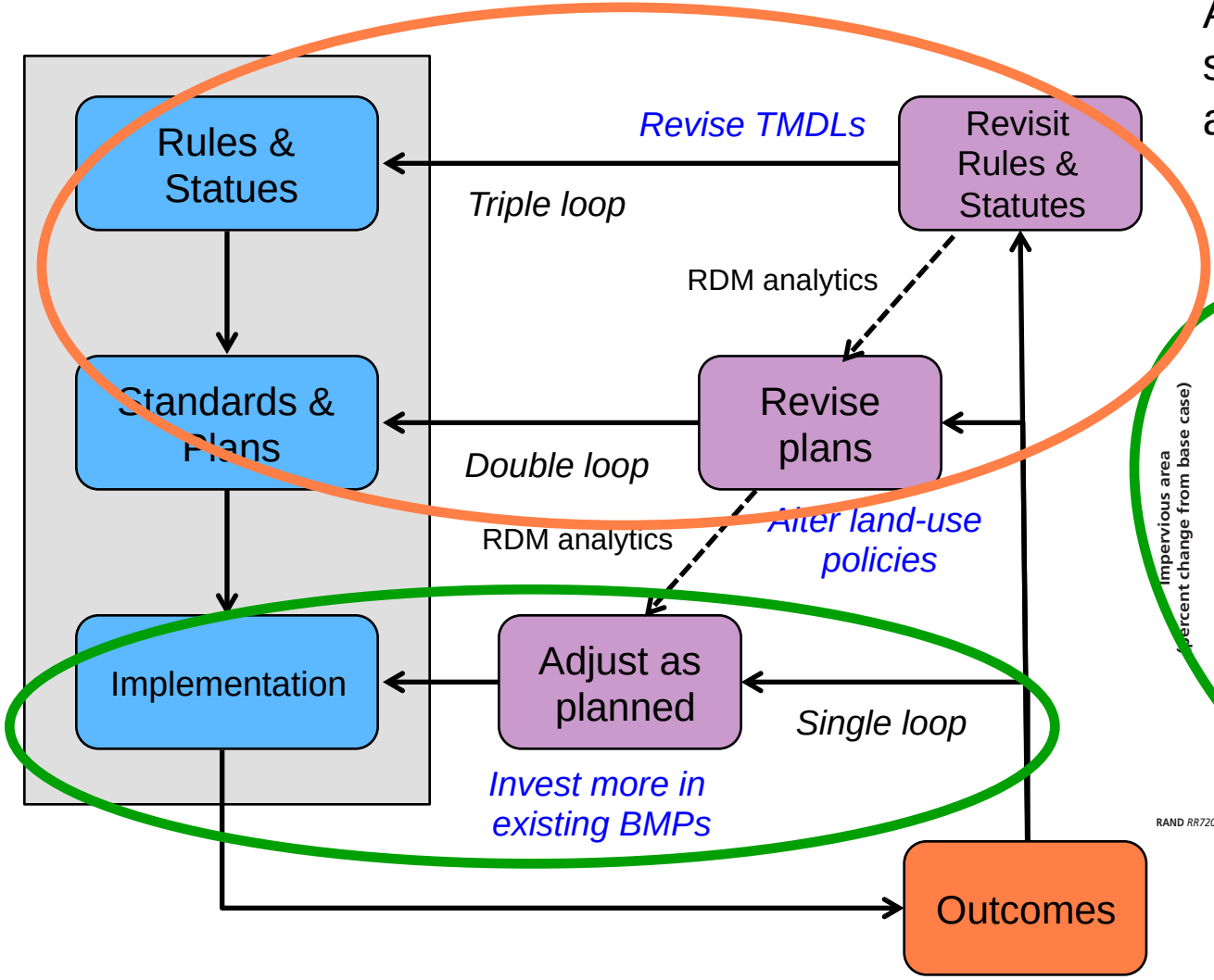
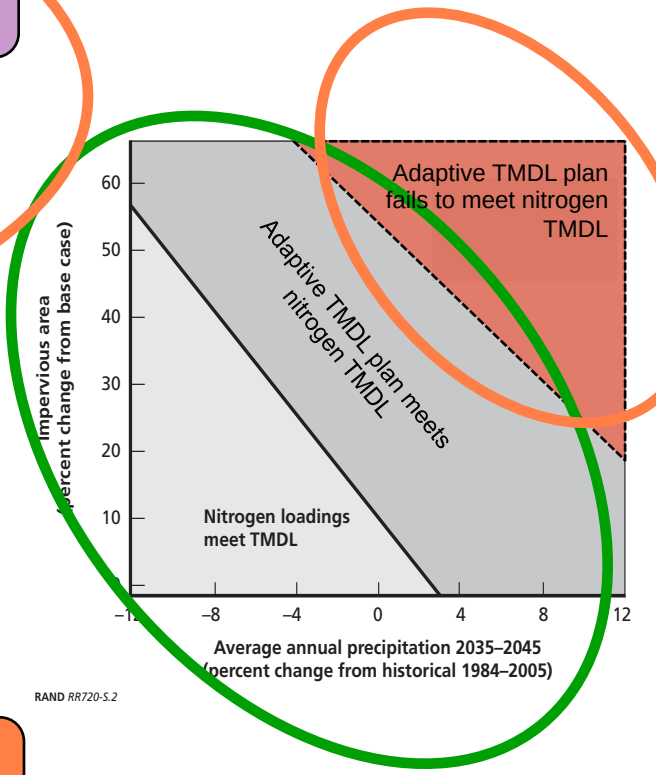
RDM Analytics Can Help Expand The Region Where "Adapt as Planned" Strategies Prove Successful



Analysis suggests signposts and actions appropriate for this region



In this region, adjusting as planned meets goal

Fischbach et. al. (2015)

Outline

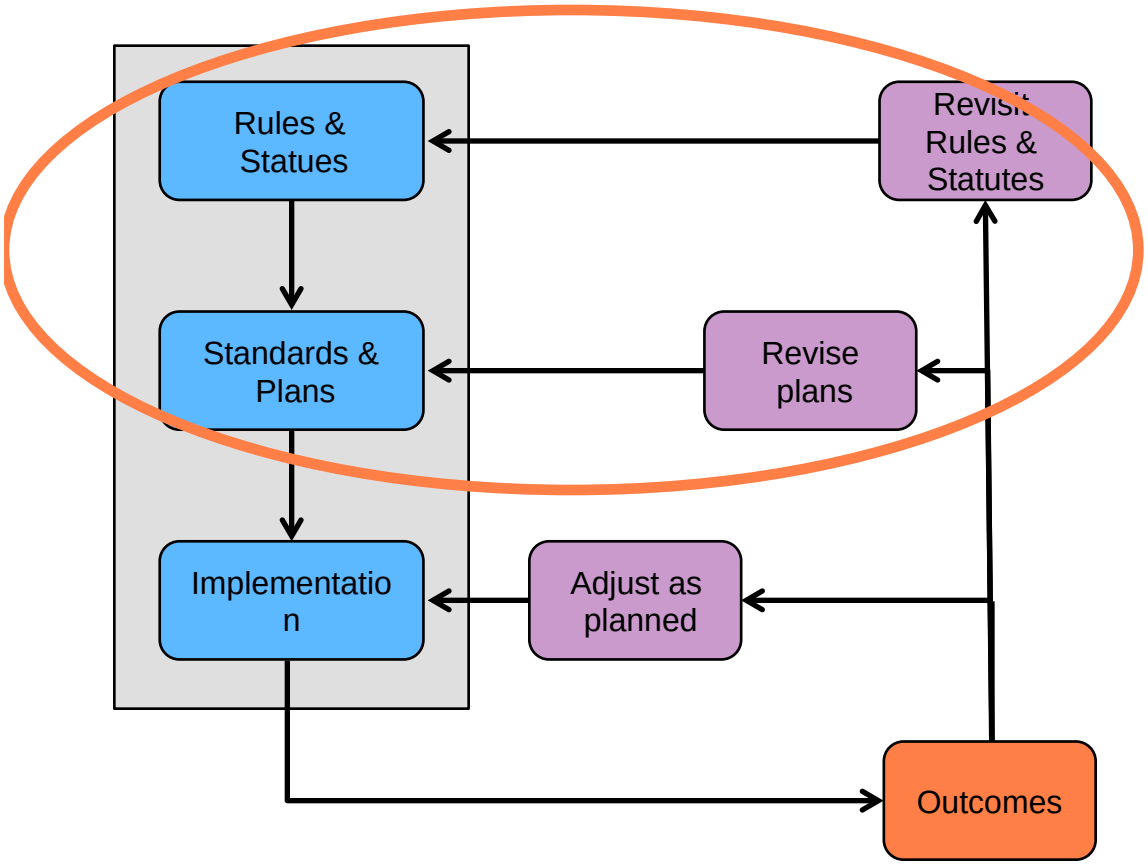
- Analytics for adaptive management
  - Water supply
  - Water quality (more regulatory)
- Observations on implementation
  - Thoughts on pacing problem

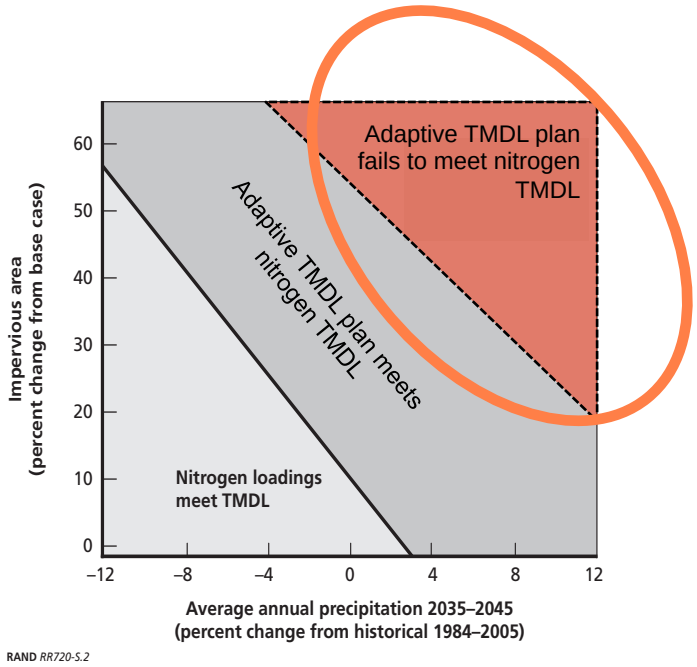
Observations on Implementation

- Decision makers find this analytic information useful
- Current legal framework allows willing groups to engage in adaptive water quality planning
- But contested legal action makes adaptive planning significantly more difficult
- Political constraints and expectations can hinder adaptive planning

Note: adaptive plans can introduce new vulnerabilities

Might Detailed Understanding of Where "Adapt as Planned" Fails Help Inform the Pacing Problem?





Can we expand our understanding of where "adapt as planned" fails by systematically looking for surprises?