Subcommittee on Long-Term Regional Planning Processes and Business Modeling

# Climate Adaptation Master Plan for Water Training Workshop

Item 5b

March 18, 2024

# Item 5b

Climate Adaptation Master Plan for Water – Training Workshop

## Subject

Climate Adaptation Master Plan for Water – Training Workshop

## Purpose

The Training Workshop's goal is to enhance understanding, confidence, and clarity in climate adaptation planning, incorporating scenario planning and adaptive management to optimize preparedness for Metropolitan.

The CAMP4W process will establish a methodology for evaluating options through a Climate Decision-Making Framework and will provide a roadmap for identifying solutions to mitigating the identified risks. It will be a living document that will be updated to identify changing conditions and to report those changes to the Board.

# Today's Agenda

Climate Adaptation Master Plan for Water

# Today's Objectives

CAMP4W
Climate Adaptation Master Plan for Water

## Objectives

1) Increase the Board and Member Agencies' understanding of the uncertainty associated with climate adaptation planning;
2) Increase the Board and Member Agencies' confidence in the CAMP4W process;
3) Provide a clear description of scenario planning and climate adaptation planning processes and application to CAMP4W; and
4) Demonstrate how adaptive management will inform Metropolitan to avoid overbuilding while maximizing preparedness

Climate Adaptation Master Plan for Water

# Today's Agenda

| Time | Topic | Speaker(s) |
|---|---|---|
| 9:00 AM | Welcome and Introductions Set Objectives for the Day | Chair Ortega; Task Force Chair Petersen |
| 9:15 AM | Session 1: Using Climate Science & Modeling | Dr. Alex Hall, UCLA |
| 10:00 AM | Q&A - Discussion | Dr. Alex Hall, Met Staff |
| 10:15 AM | Break | - |
| 10:30 AM | Thought Exercise | Dr. Kit Batten |
| 10:45 AM | Session 2: Scenario Planning | Dr. Robert Lempert, RAND |
| 11:30 AM | Q&A - Discussion | Dr. Robert Lempert, Met Staff |
| 11:45 PM | Lunch | - |
| 12:30 PM | Session 3: Climate Adaptation Planning | Dr. Juliette Finzi-Hart, Pathways Climate Inst. |
| 1:15 PM | Q&A - Discussion | Dr. Juliette Finzi-Hart, Met Staff |
| 1:45 PM | Climate Planning Exercise in Small Groups | Dr. Robert Lempert |
| 3:35 PM | Discussion / Reflection | Dr. Robert Lempert, Dr. Kit Batten, Liz Crosson |
| 4:15 PM | Session 4: Signposting and CAMP4W Adaptive Management | Met Staff |
| 5:00 PM | Adjourn | Task Force Chair Petersen |

# Session 1: Using Climate Science and Modeling
# Dr. Alex Hall, UCLA

# Climate Change Impacts on Water Resources in Southern California

Prepared for the Metropolitan Water District of Southern California

Alex Hall
Professor, Atmospheric and Oceanic Sciences Department
Director, UCLA Sustainable LA Grand Challenge

# Why is climate change occurring?

*At the most basic level:*

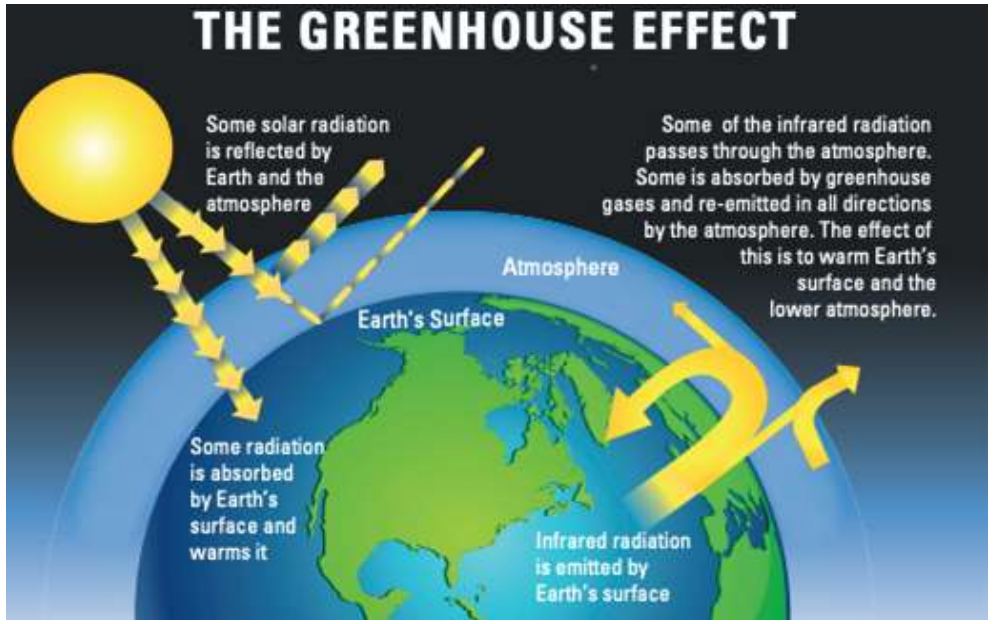
- To remain at the same temperature, objects need to maintain radiative balance:

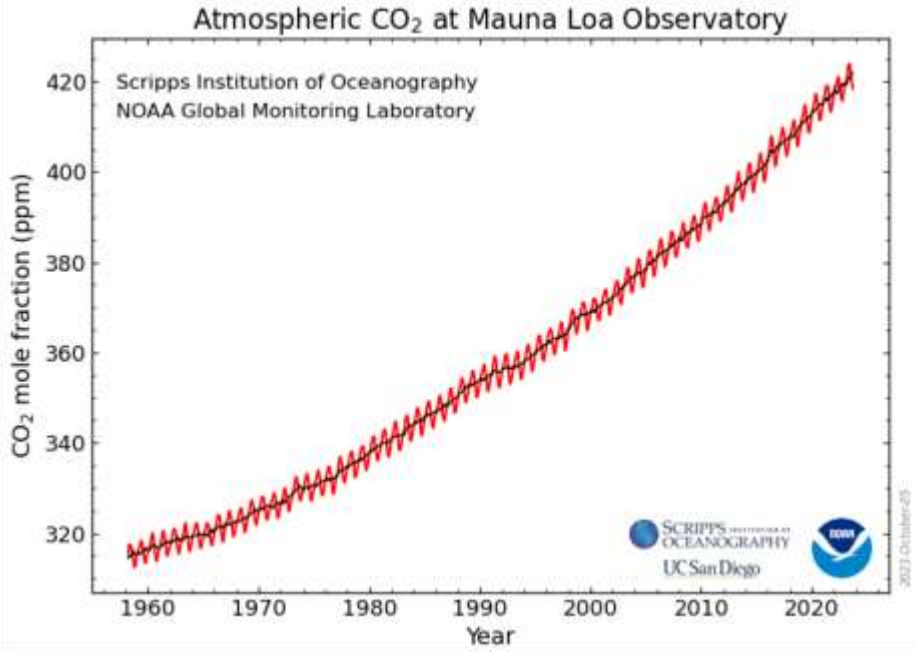
  *Energy coming in = Energy going out*

- Greenhouse gases disrupt the planet's energy balance by absorbing some of the outgoing energy and emitting it back to the surface

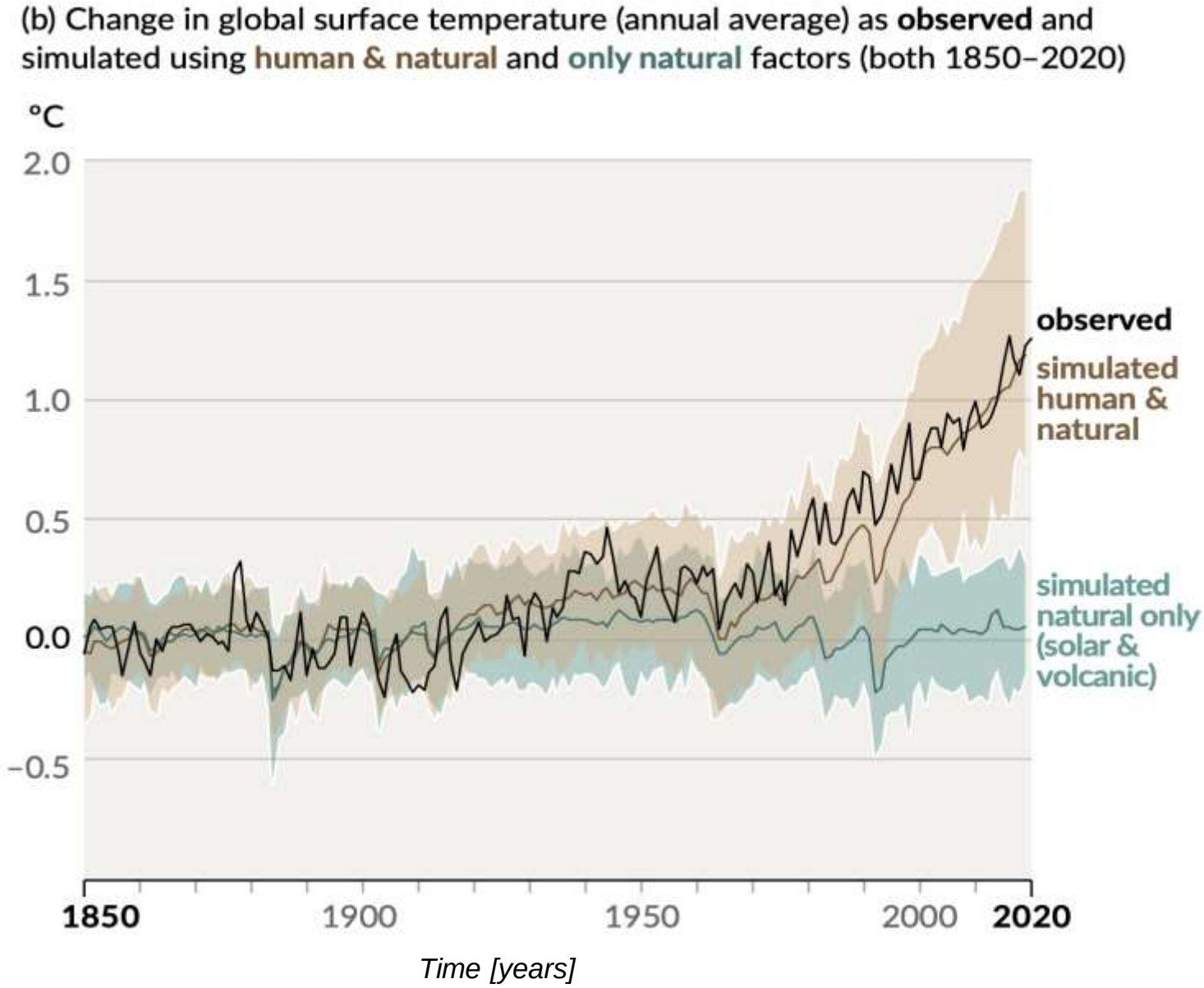
- Excess energy impacting the surface due to the greenhouse gases' downward emission causes surface temperatures to increase.

- This effect increases with increasing greenhouse gases

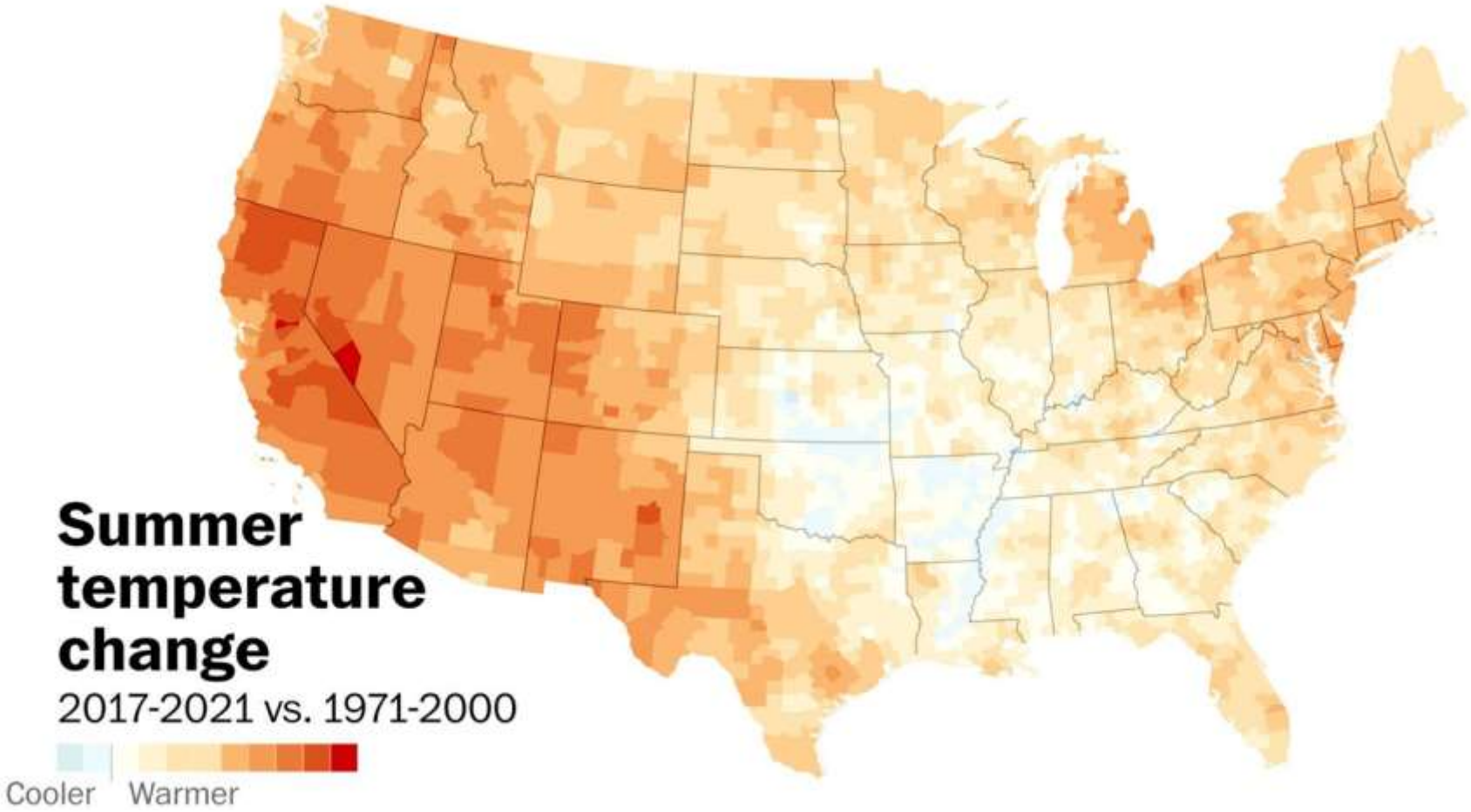


# How do we know climate change is caused by humans?

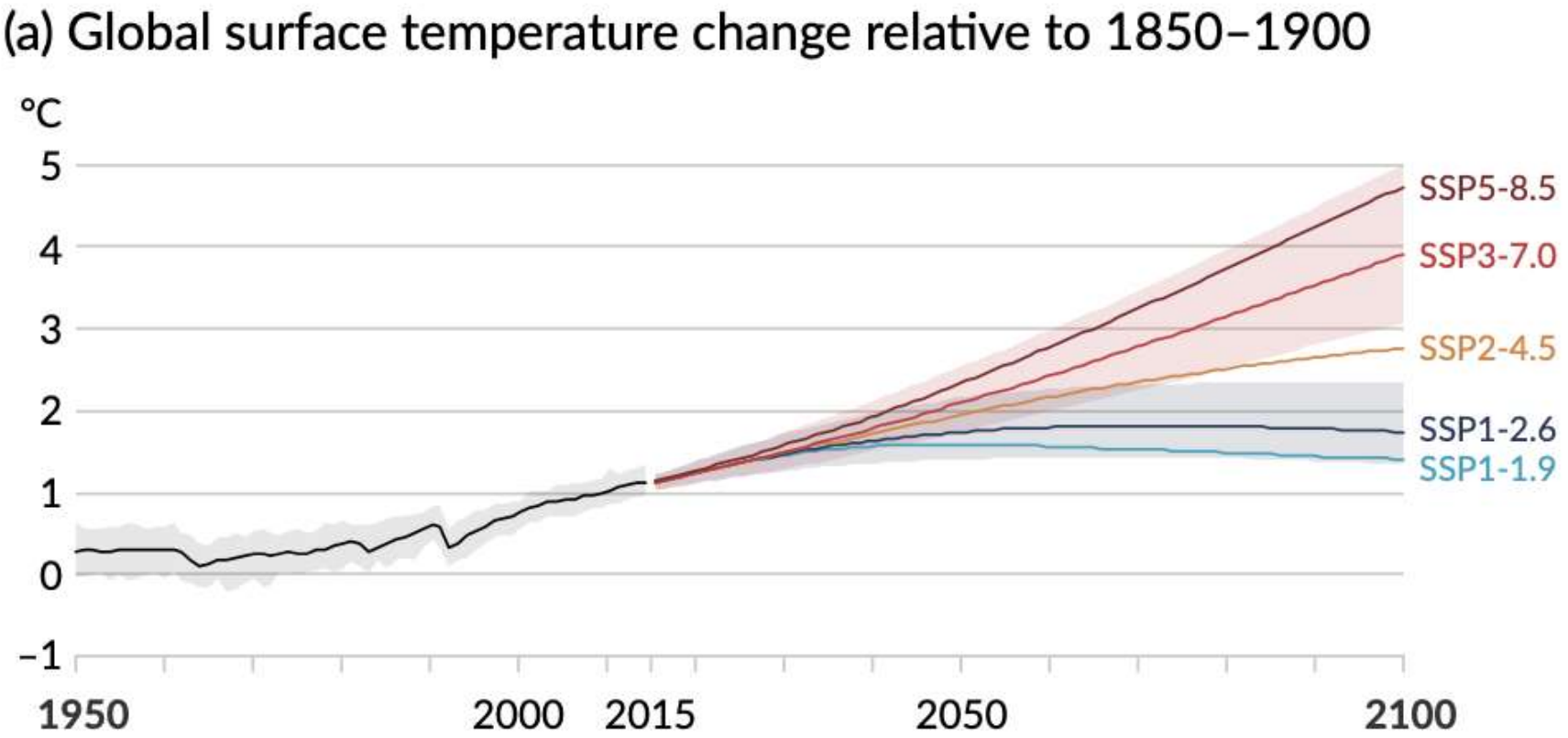


# Recent Temperatures in the U.S. Already Showing Warming



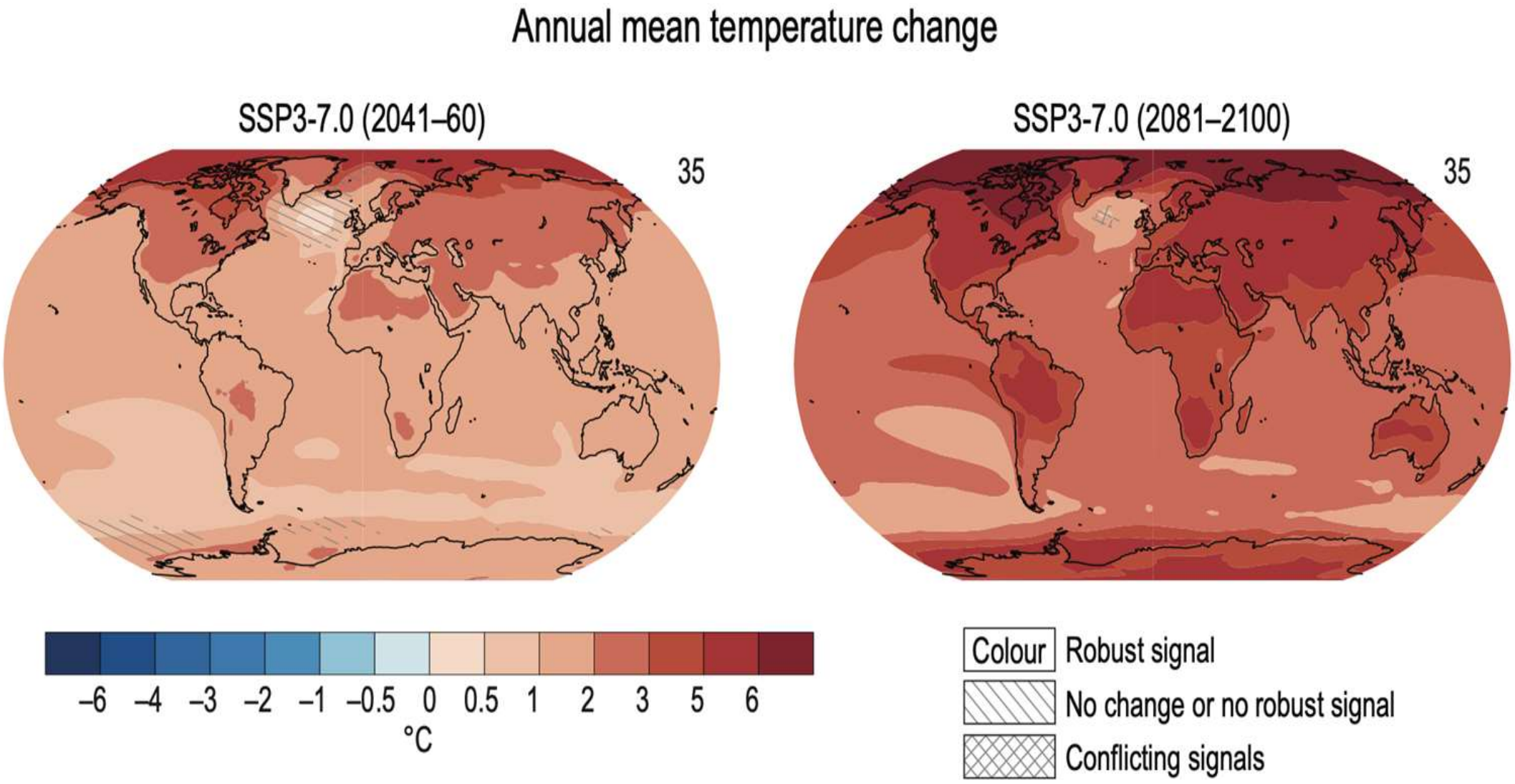
# Climate Projections: Global Climate Models

**Global Climate Models**
There are dozens of these, developed at centers around the world




Note “SSPs” are equivalent to “RCPs”

# Climate Projections: Global Climate Models



# Climate Projections: Uncertainty

There are three main types of uncertainty associated with climate projections:

1. ***Emission Scenario Uncertainty***
    - *Uncertainty due choice of emissions trajectory (i.e., economic estimate of future chemical emissions, RCPs, and now SSPs)*

2. ***Model Physics Uncertainty***
    - *Uncertainty due to the construction of the models themselves (i.e., "model physics"). Different models give different answers.*

3. ***Uncertainty due to Internal Variability***
    - *Uncertainty due to the natural phasing of climate variability (i.e., timing of El Niño)*

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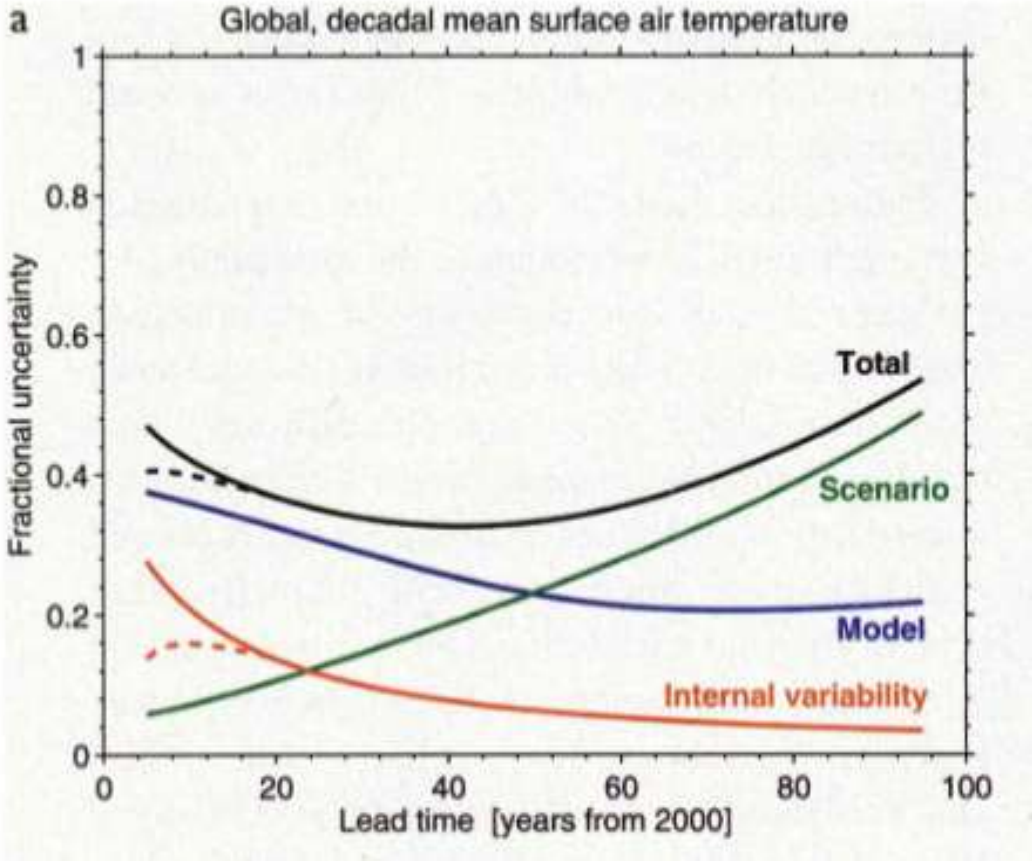
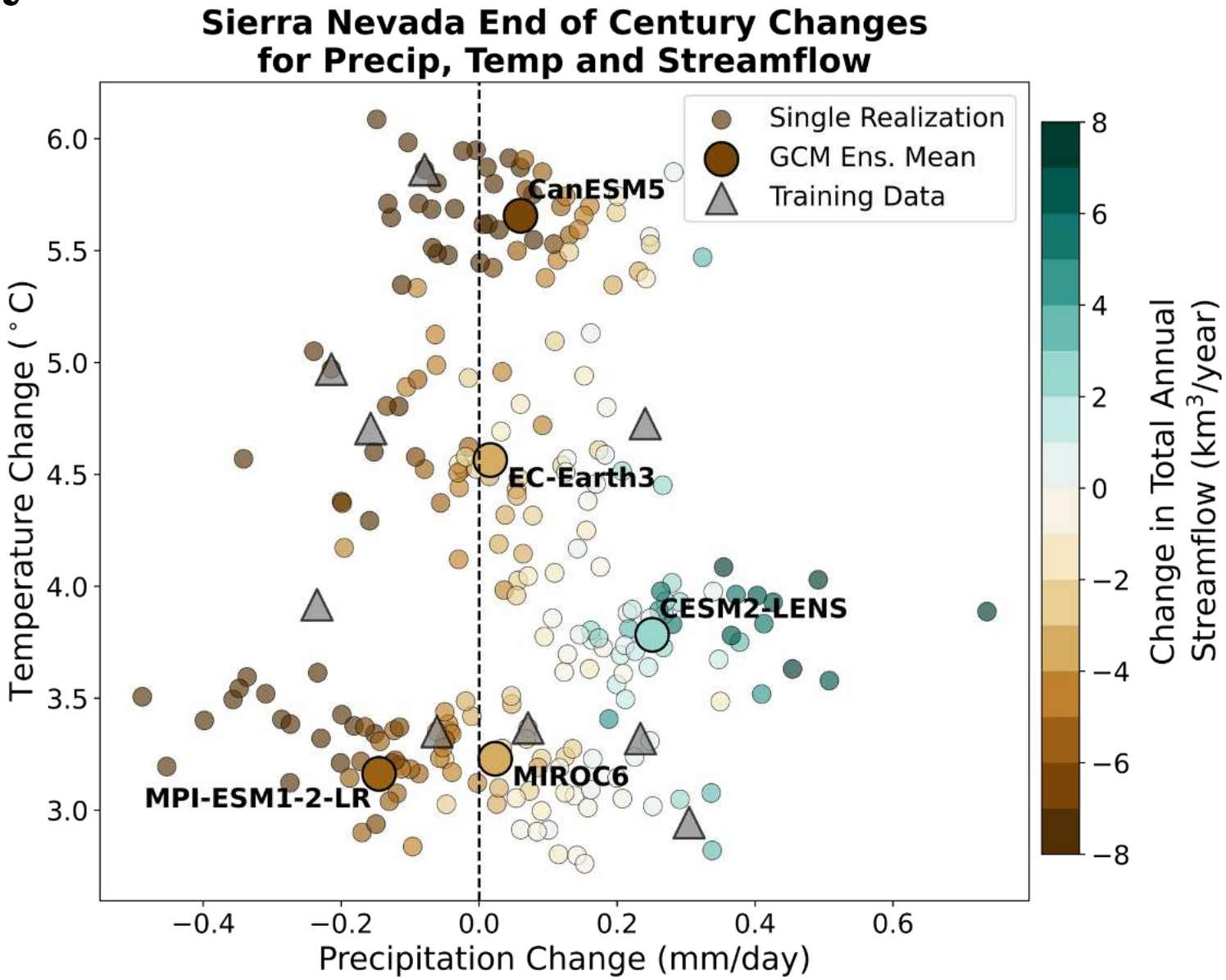
**The uncertainty sources vary with forecast lead time**

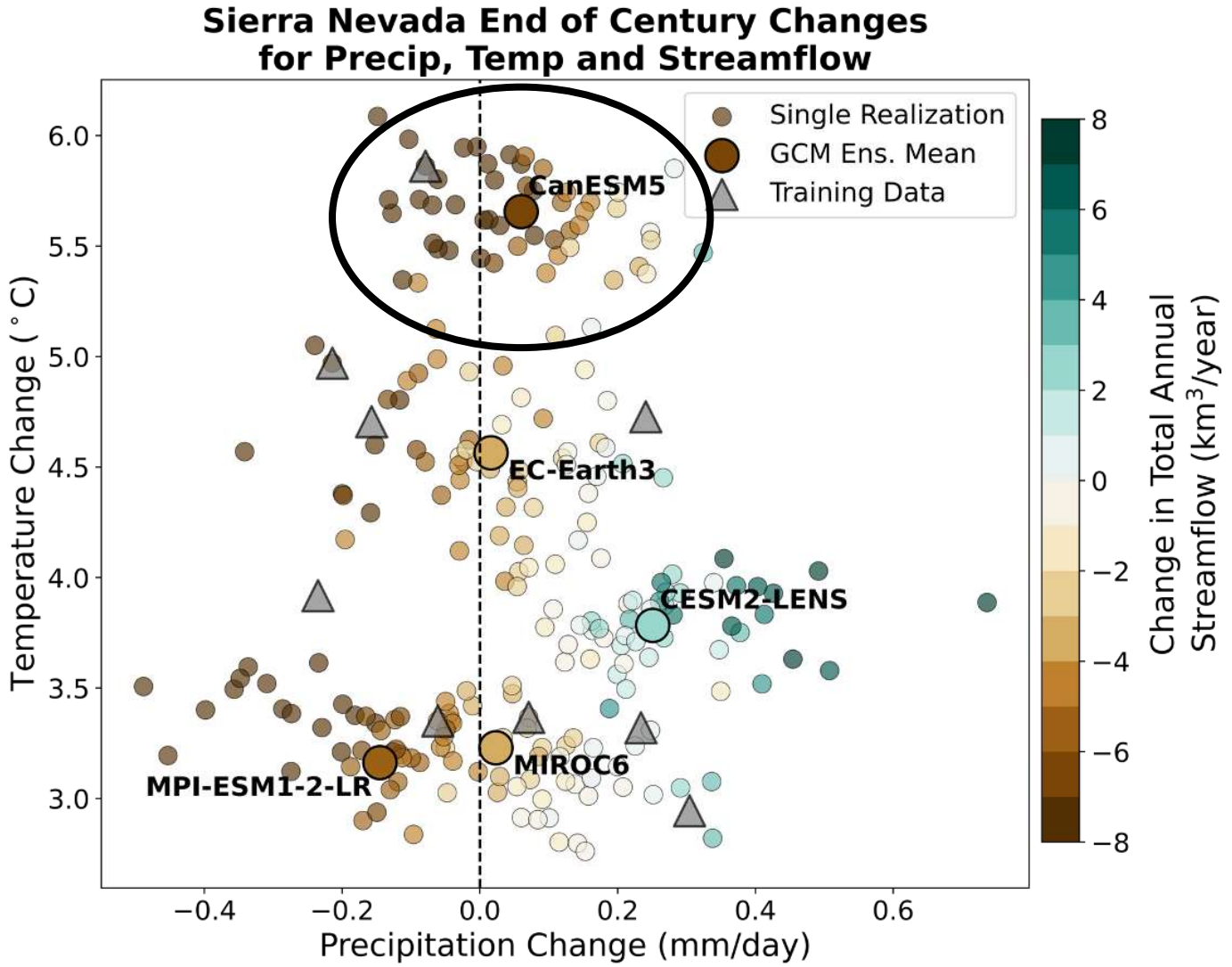


# Effect of Internal Variability



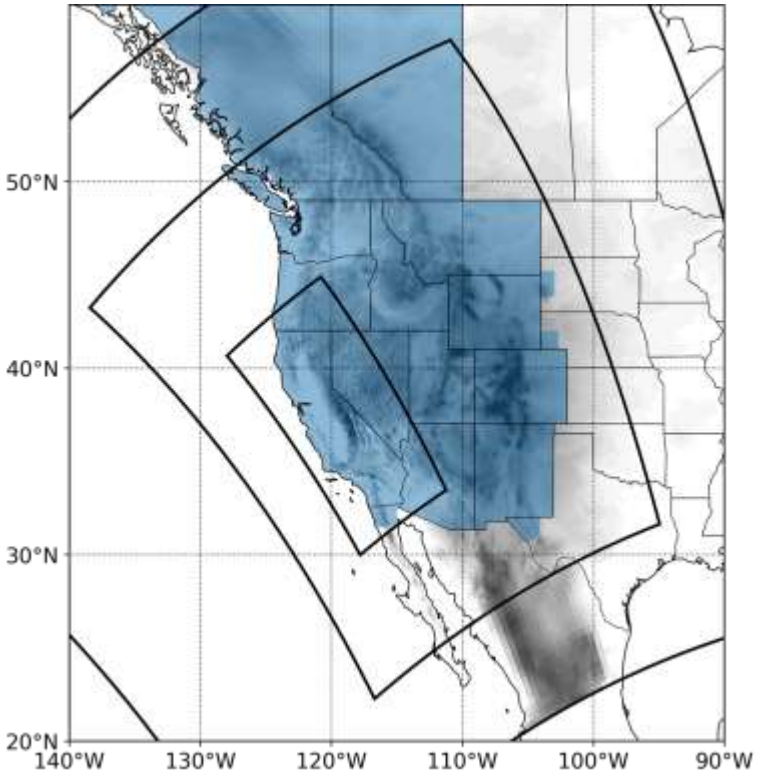

Downscaled data, same emissions scenario (SSP3-7.0)

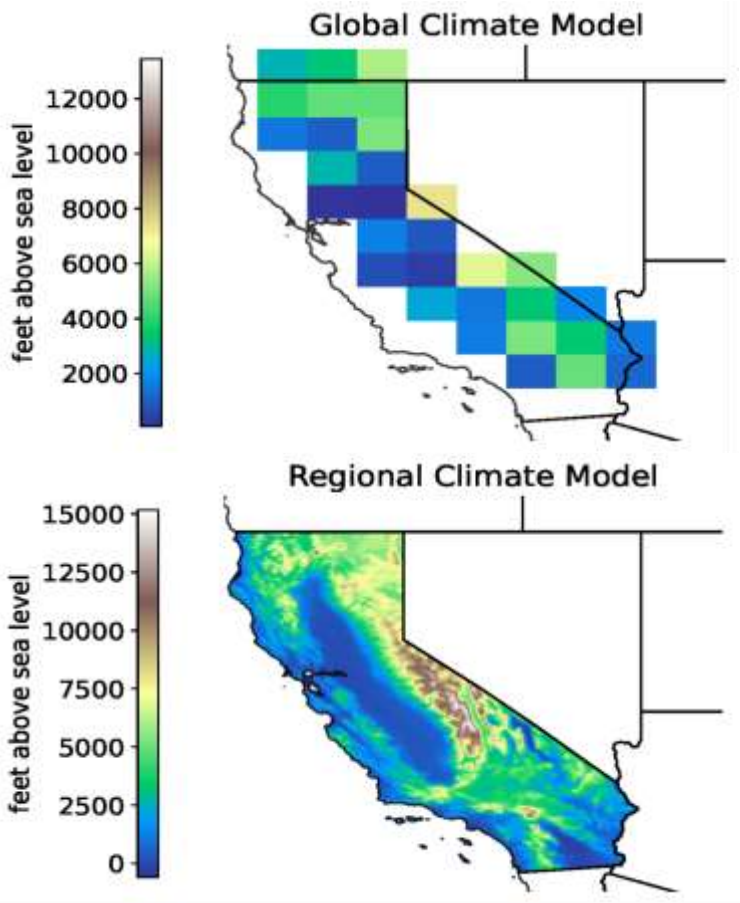
# Effect of Internal Variability




Downscaled data, same emissions scenario (SSP3-7.0)

# Climate Projections: Downscaling




**Global Climate Model**

**Regional Climate Model**

**High-Resolution Downscaled Solution**

# California's Projected (Downscaled) Future: Maximum Temperature

RCP4.5
emissions scenario

Figure 1

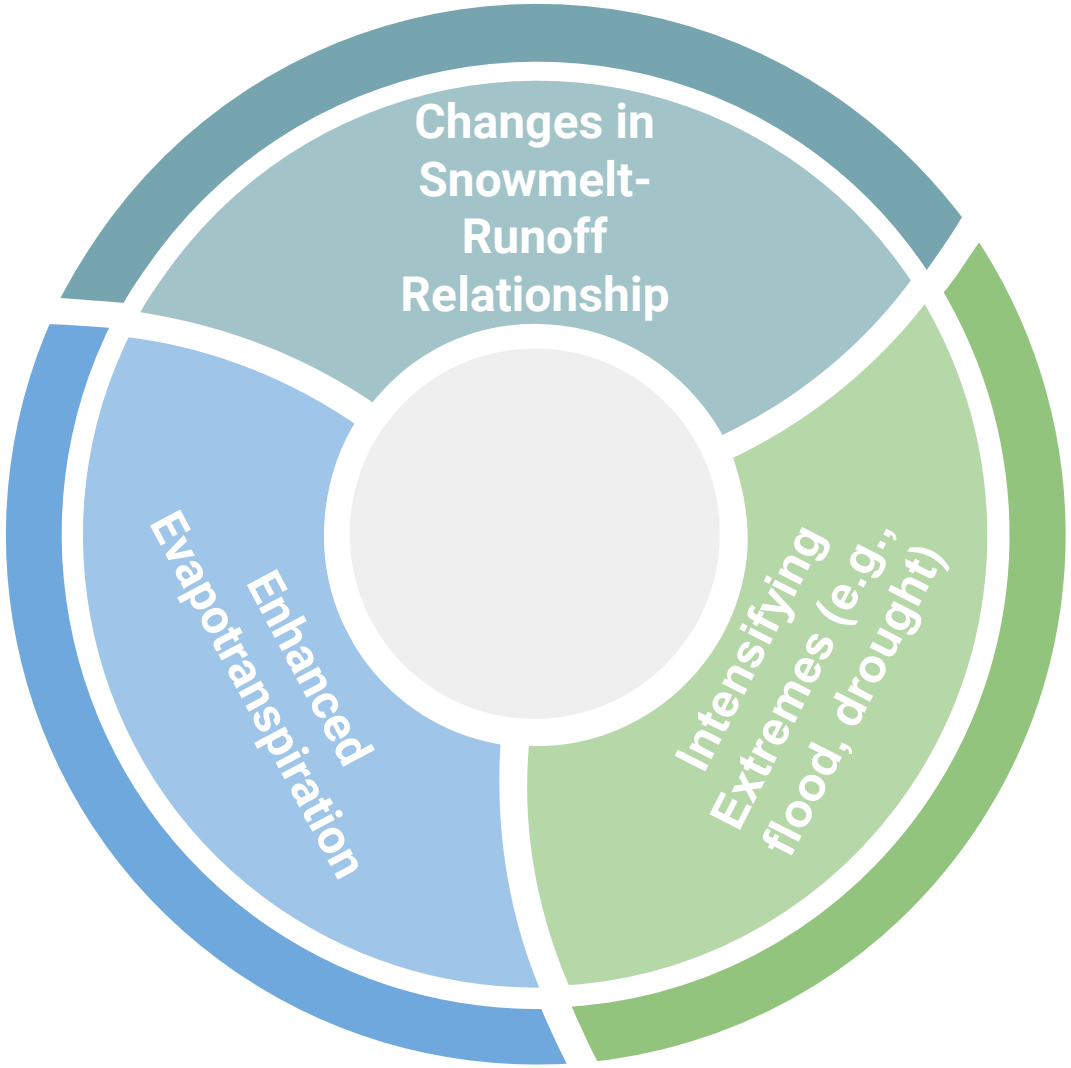
**Projected Increases in Average Maximum Temperatures Are Greatest in Inland and Southern California**


Reflects changes from historical baseline 30-year average maximum temperatures (1961-1990). These estimates assume the moderate climate change scenario of "RCP 4.5," in which international practices result in the rate of worldwide greenhouse gas emissions slowly declining in the coming decades.

Data from www.Cal-Adapt.org

LAO

# Aspects of the WUS Water Cycle that Respond to Climate



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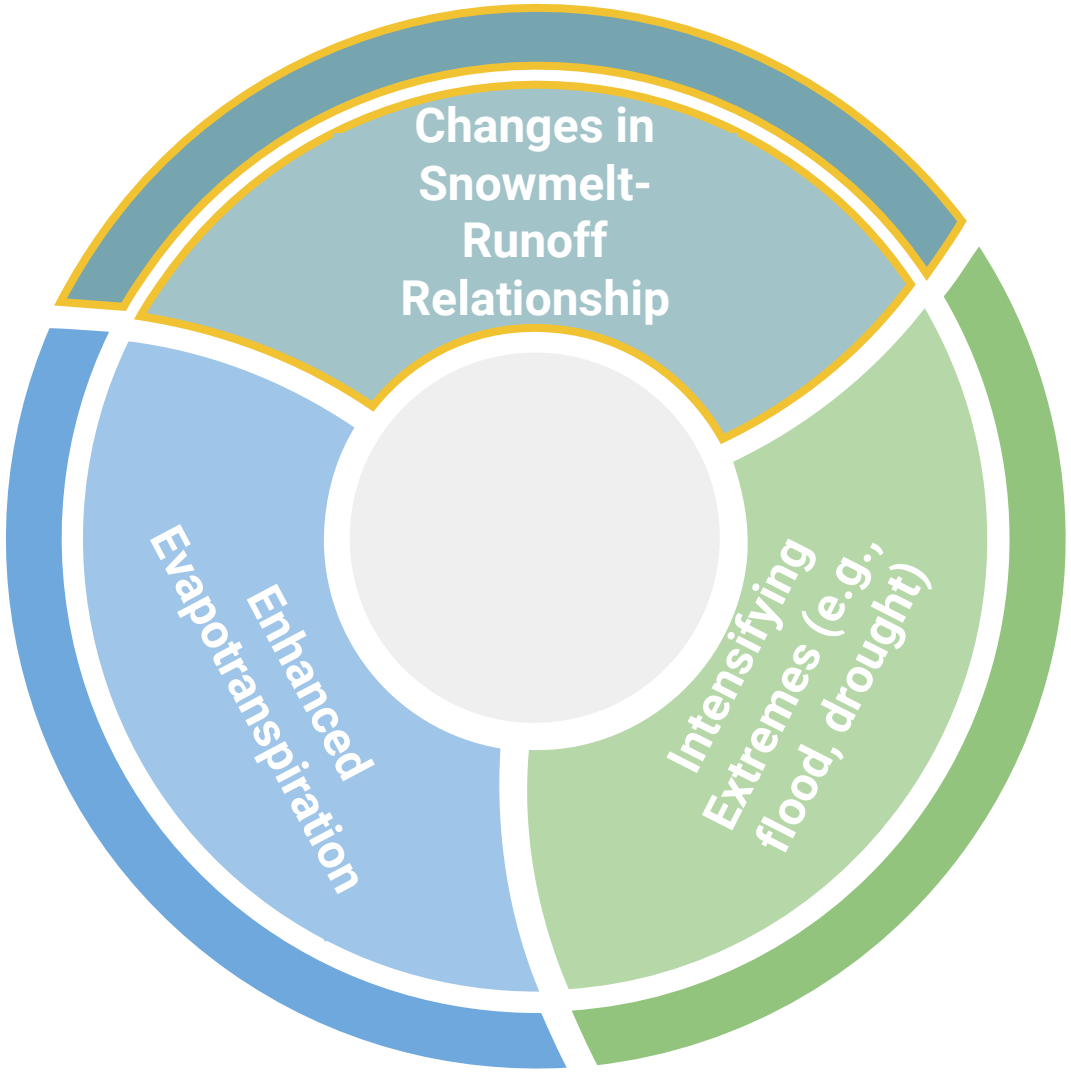
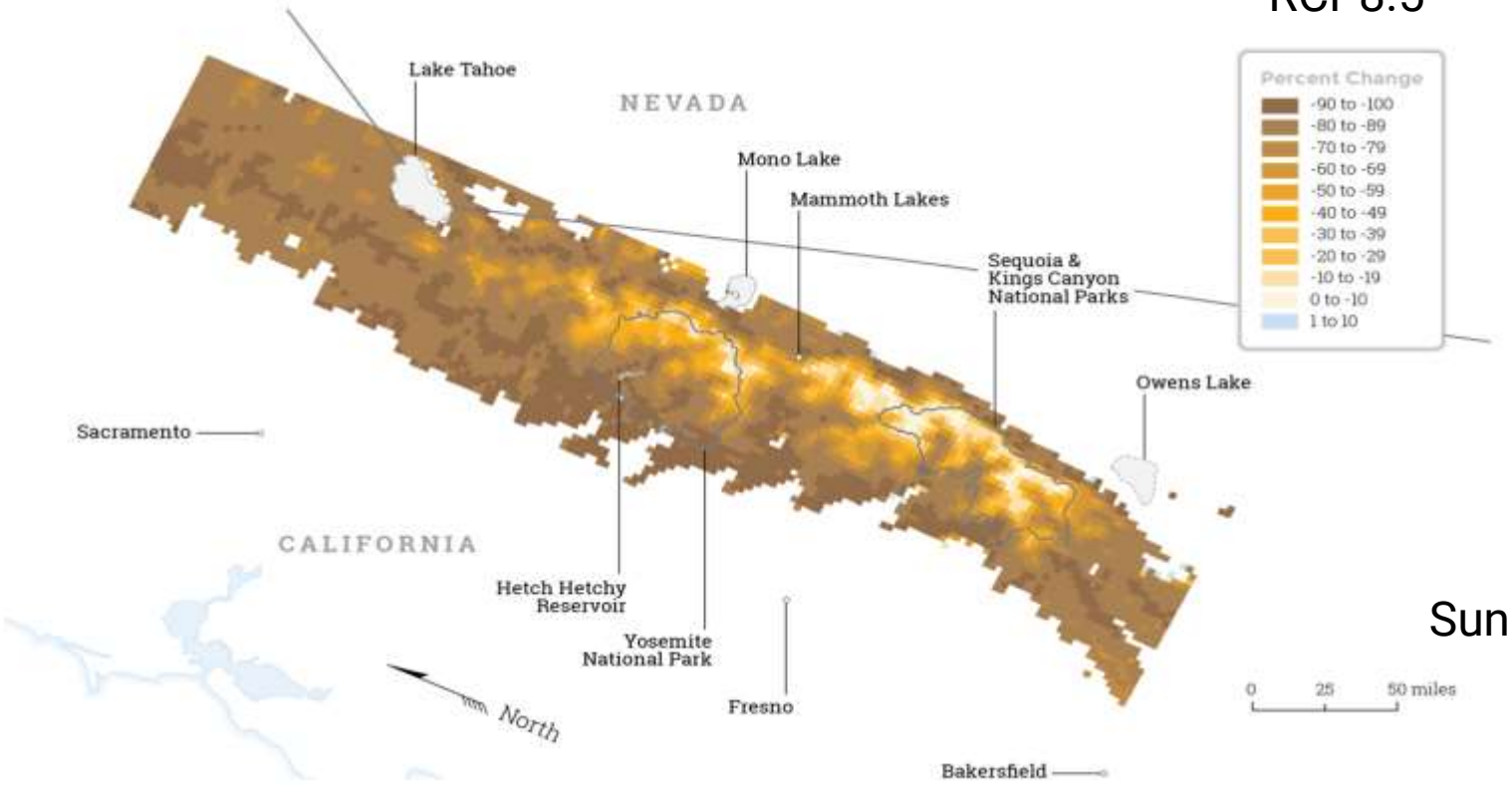


# Climate Warming is Projected to Cause a Reduction in Sierra Snowpack

Sierra Nevada Mountains

**Change in Snow Water Equivalent, April 1**

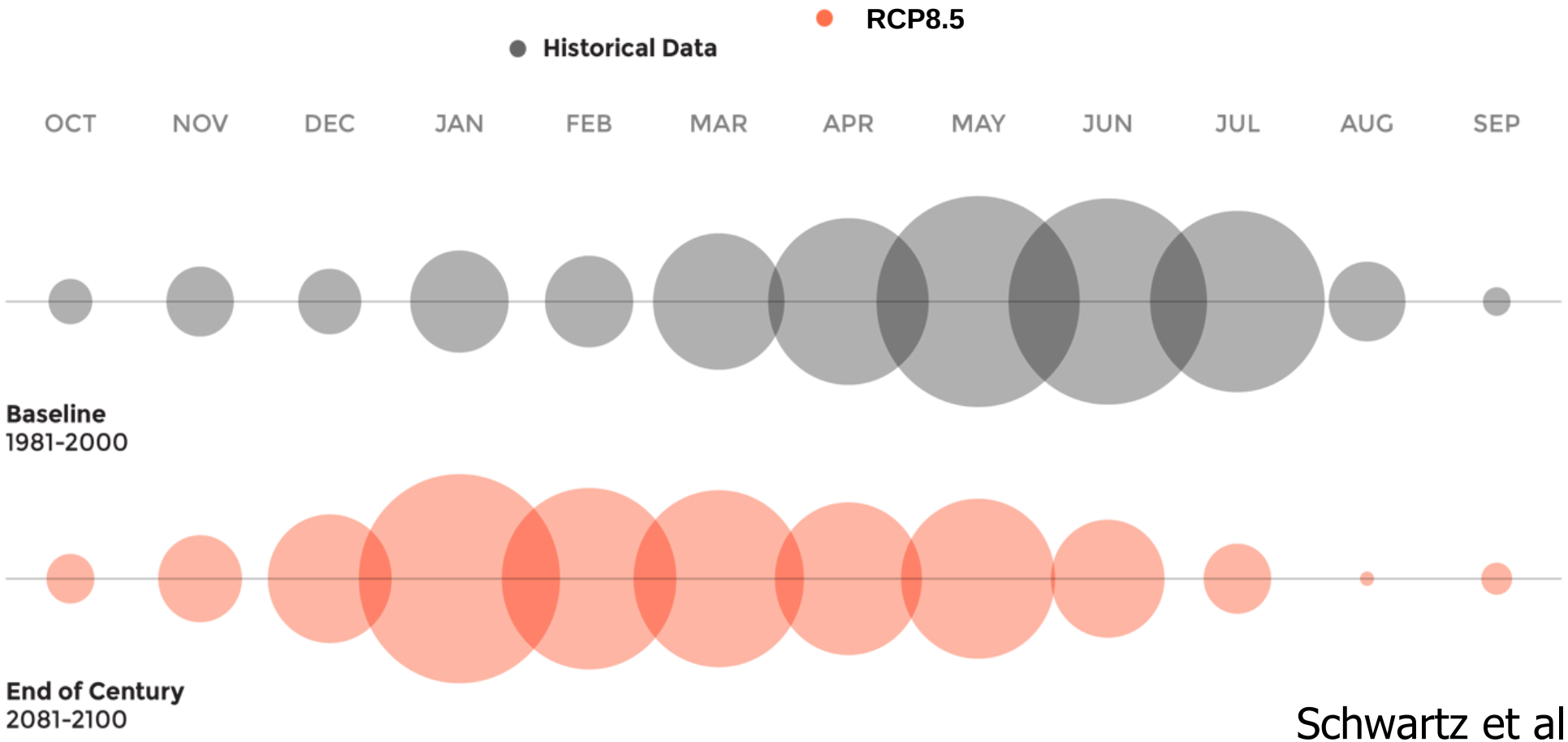
2081–2100
RCP8.5




Sun et al 2019

Downscaled Data, RCP8.5

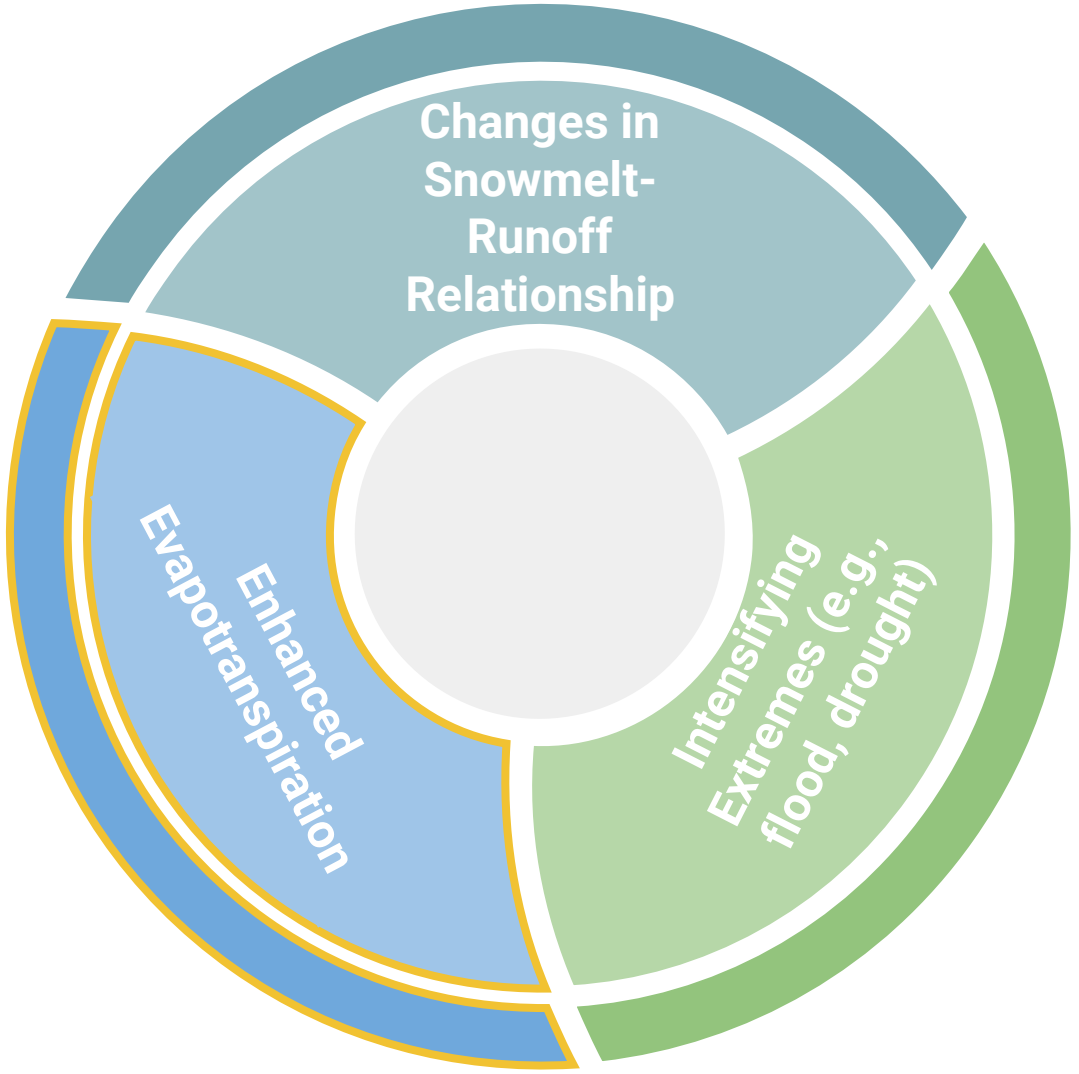
# The loss of snow is associated with a change in the timing of Sierra Runoff




Schwartz et al. 2017

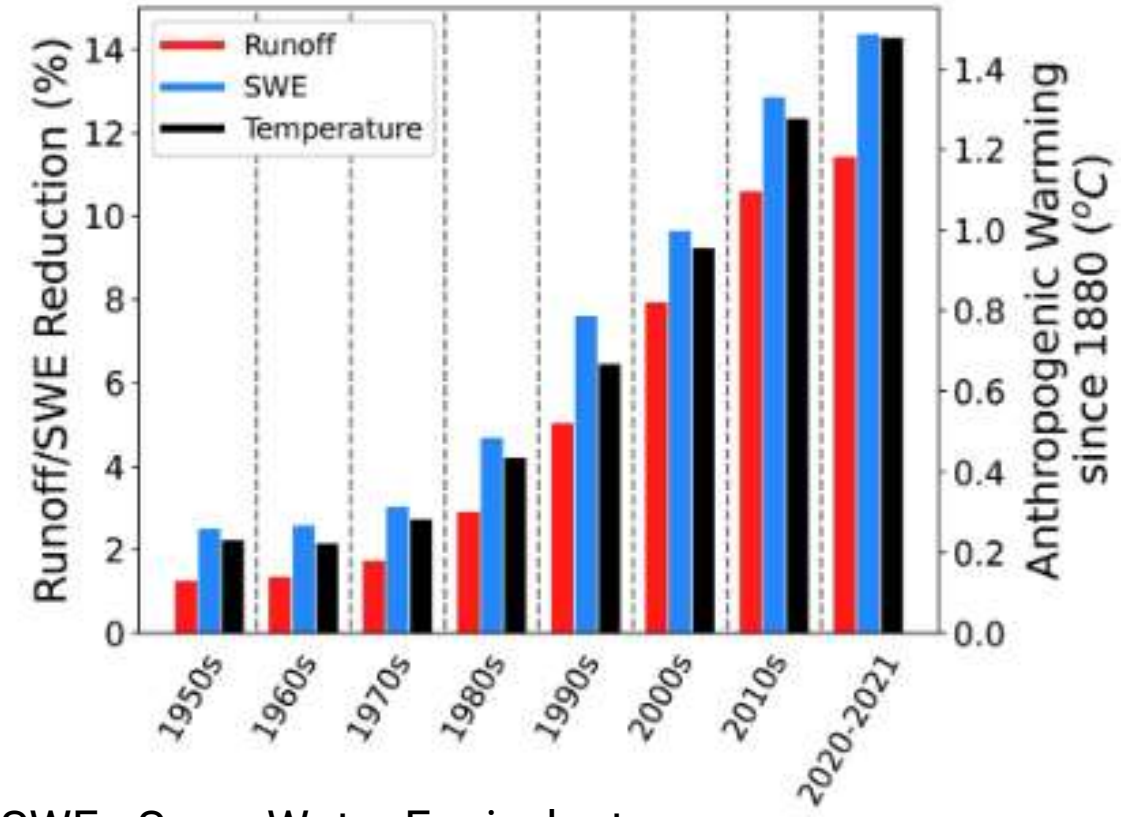
Downscaled Data

# Aspects of the WUS Water Cycle that Respond to Climate



# Warming that's already occurred has led to a reduction in streamflow

**Colorado River Basin**




SWE= Snow Water Equivalent

**Figure 7.** Reductions in runoff and peak integrated SWE, based on the overall impact of warming and $CO_2$, and how these reductions relate to anthropogenic warming.

Downscaled Reanalysis Data

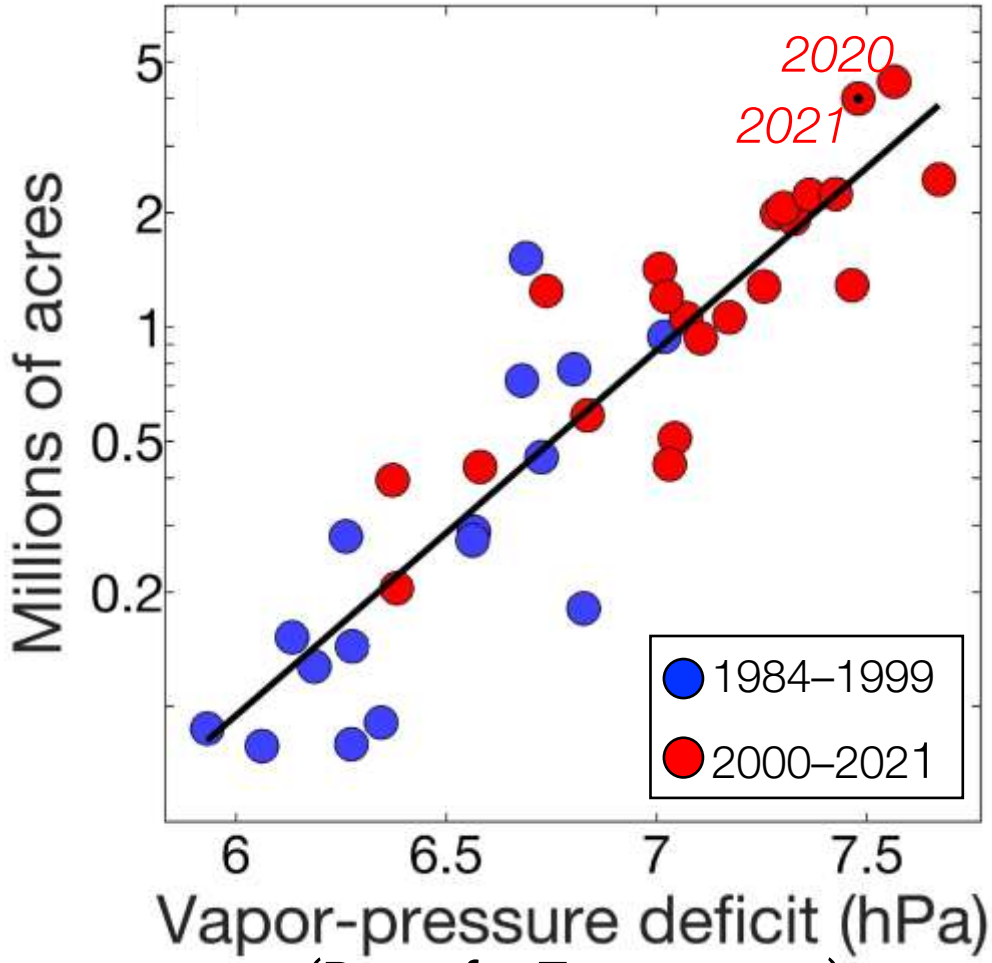
Bass et al 2023

# Temperature increases wildfire breadth and intensity

- As temperature increases so does the *Vapor Pressure Deficit (VPD)*, a metric for how dry the air is. VPS scales with warming.
- Drier air leads to drier fuels for wildfires
- It has been shown that increases in VPD leads to increases in millions of acres burned

Observed Data

## Fire in forests

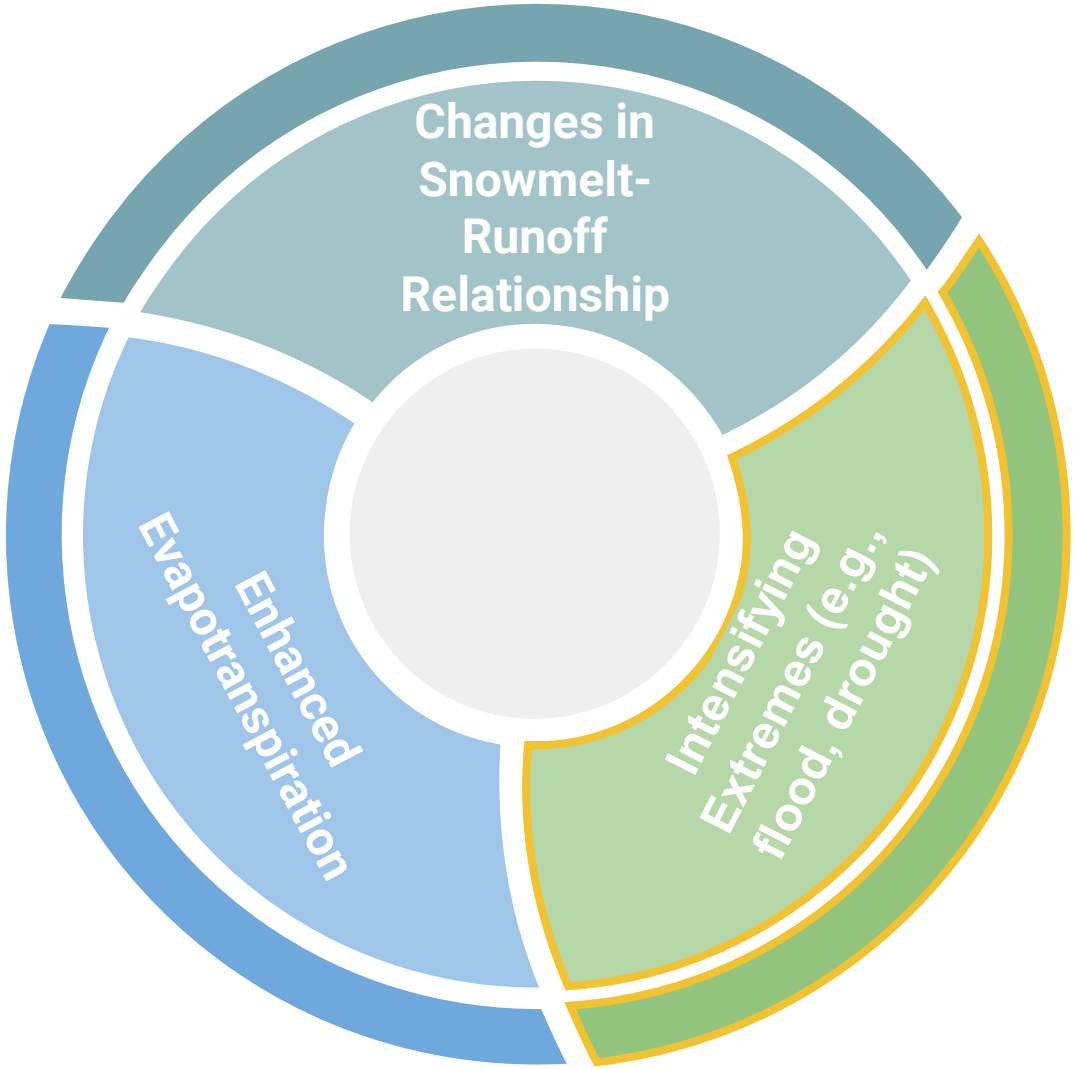



(Proxy for Temperature)
(adapted from Juang et al 2022)

# Wildfires lead to sediment runoff, which can affect reservoirs

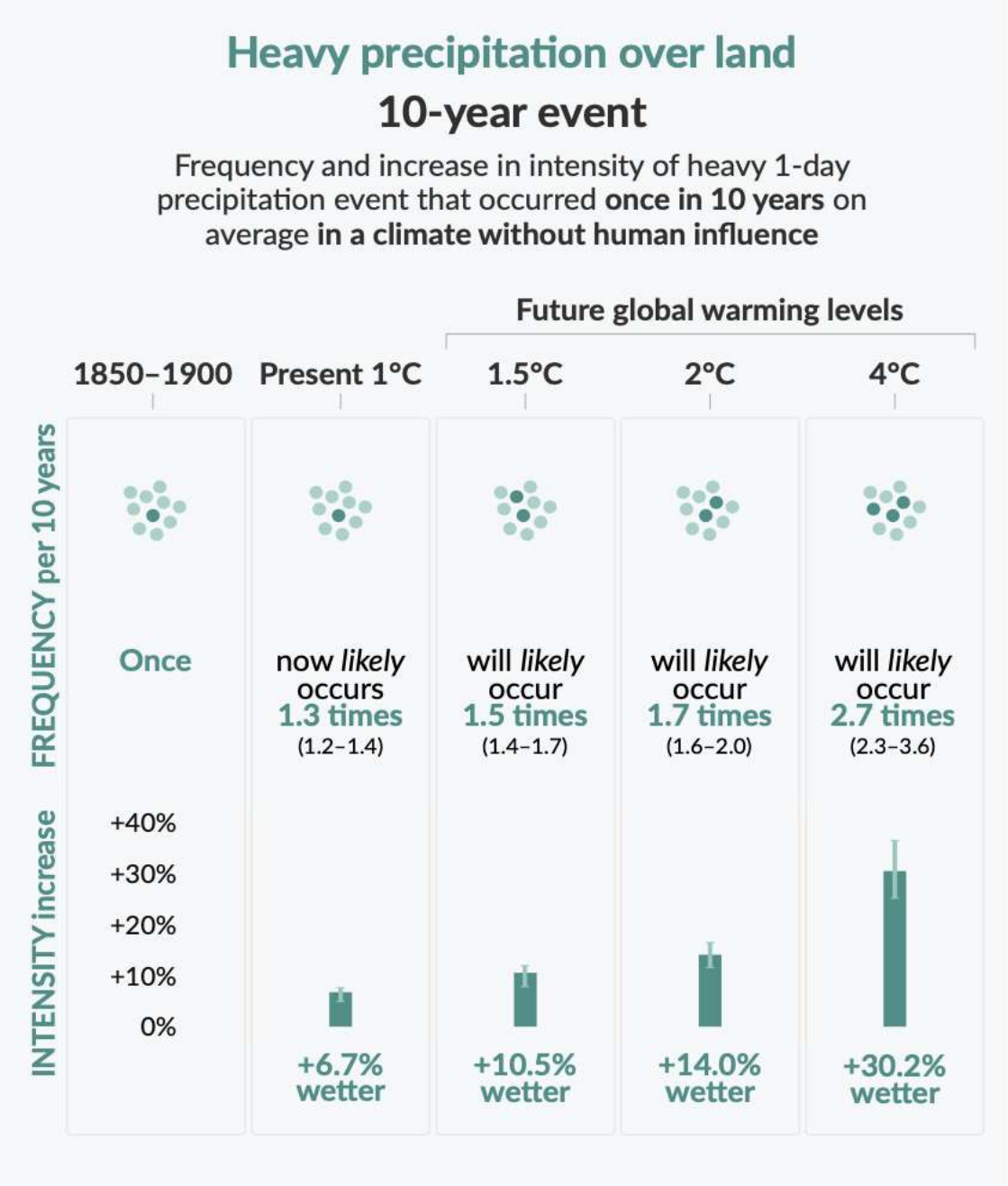
There has been so much sedimentation at the Paonia Reservoir in Gunnison County, Colorado, that the bottom of the lake is now above the outlet. (Jeffrey Beall / Flickr)

# Aspects of the WUS Water Cycle that Respond to Climate



# Future of the Flooding

Extreme precipitation increases in intensity with every degree of climate warming




Global Data

# Future of the Flooding

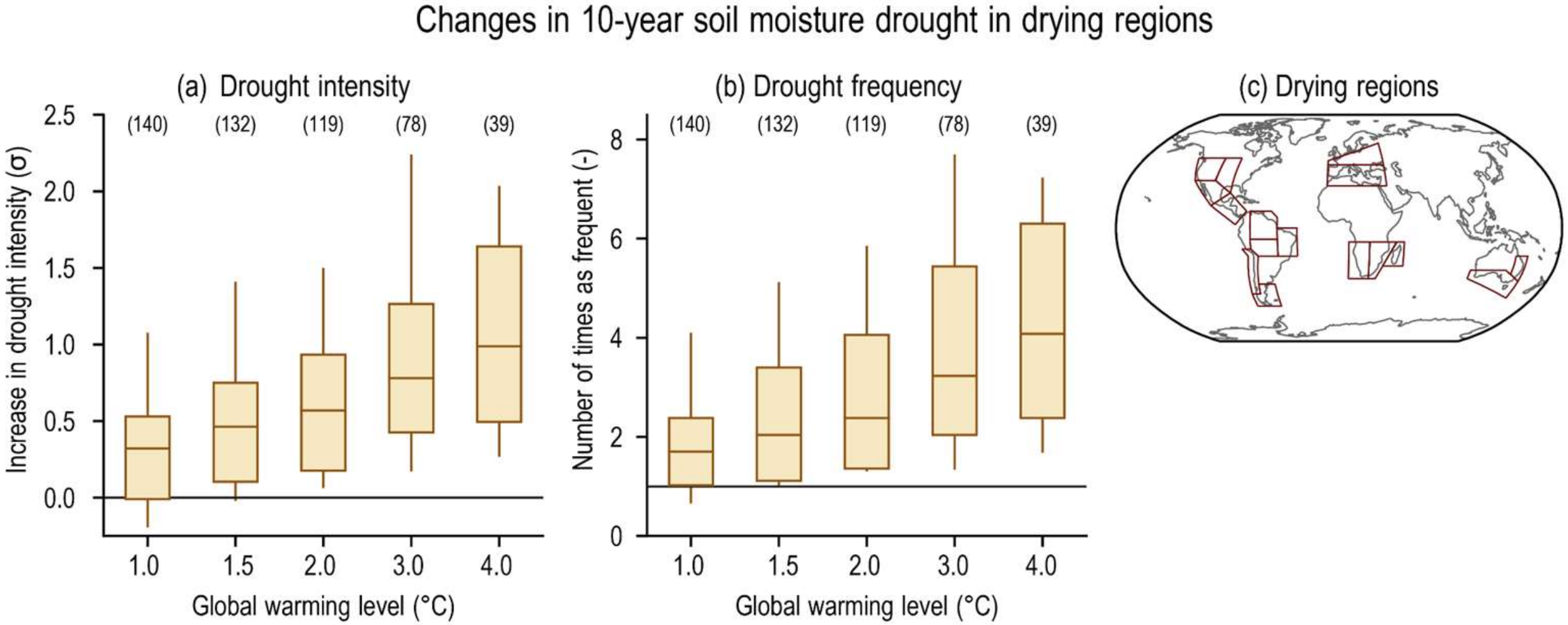
Huang et al. 2020

Large change in snow and surface runoff during large atmospheric rivers by the end of the century.
ARs produce more precipitation, but more falls as rain than snow → huge increase in streamflow


Downscaled Data

# Future of the Drought

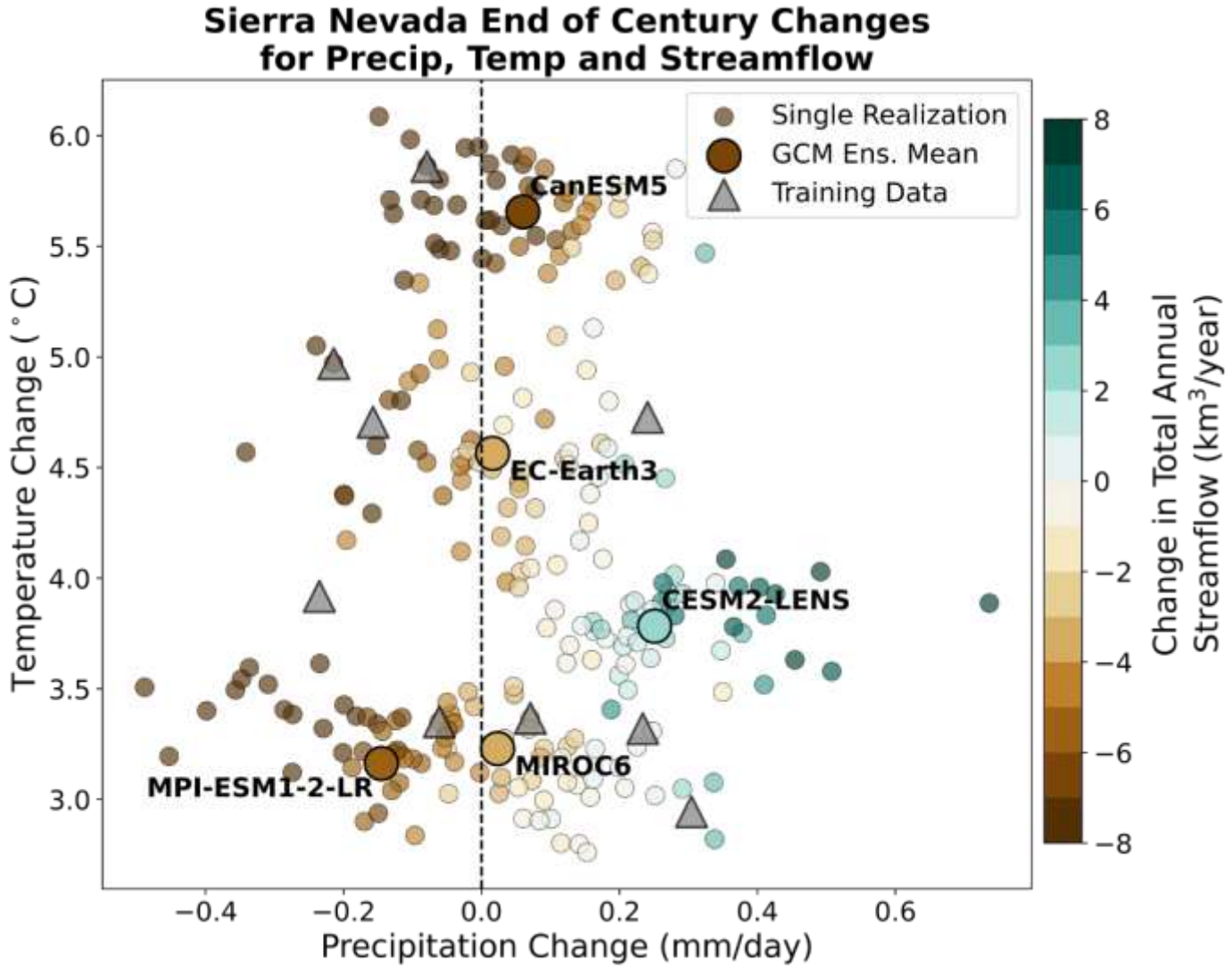
## Drought frequency increases globally with climate warming




Global Model Data

IPCC 6th Assessment Report

# Future of the Drought

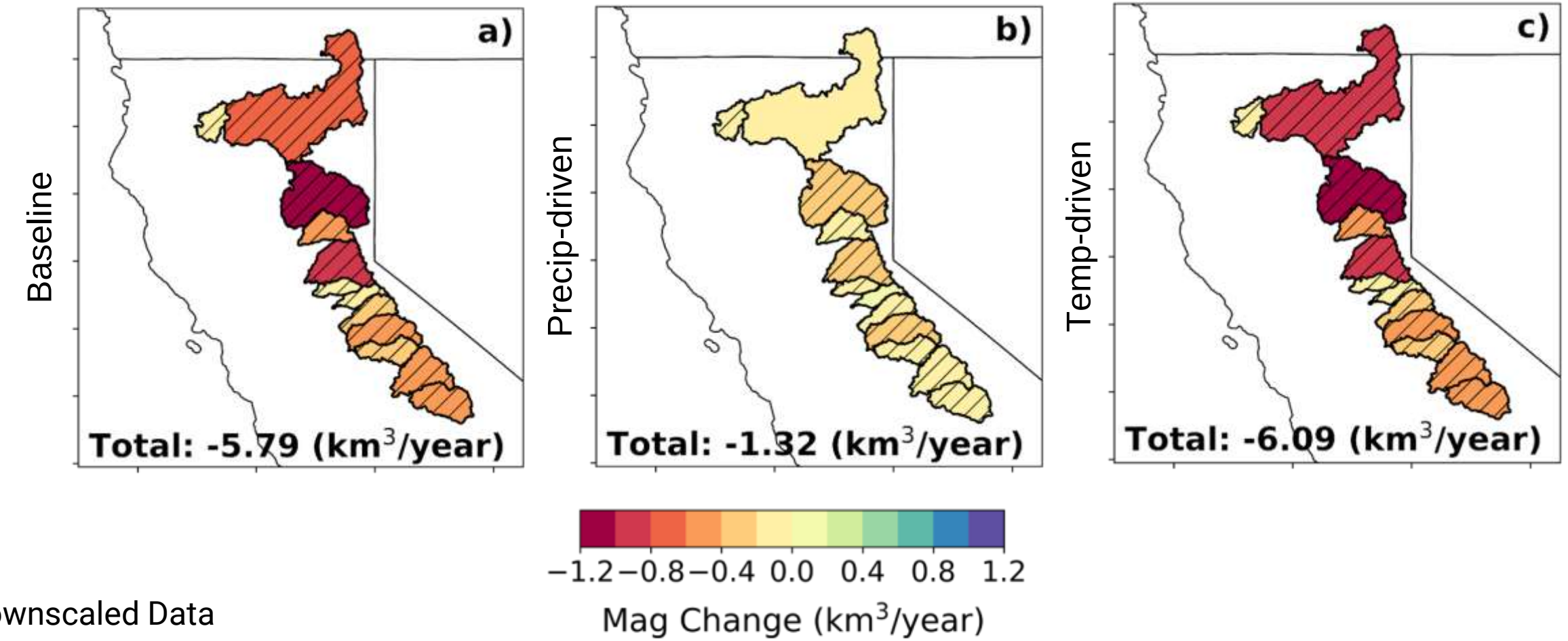



Temperature increases hydrologic (streamflow) drought severity

Downscaled Data, same Emissions scenario (SSP3-7.0)

# Future of the Drought

Temperature determines the extent and intensity of streamflow drought more so than precipitation in the Sierra Nevada Mountains




Downscaled Data

# Tying is all Together

We can integrate the high resolution climate data with modeling of water resource infrastructure to assess policy choices under climate change

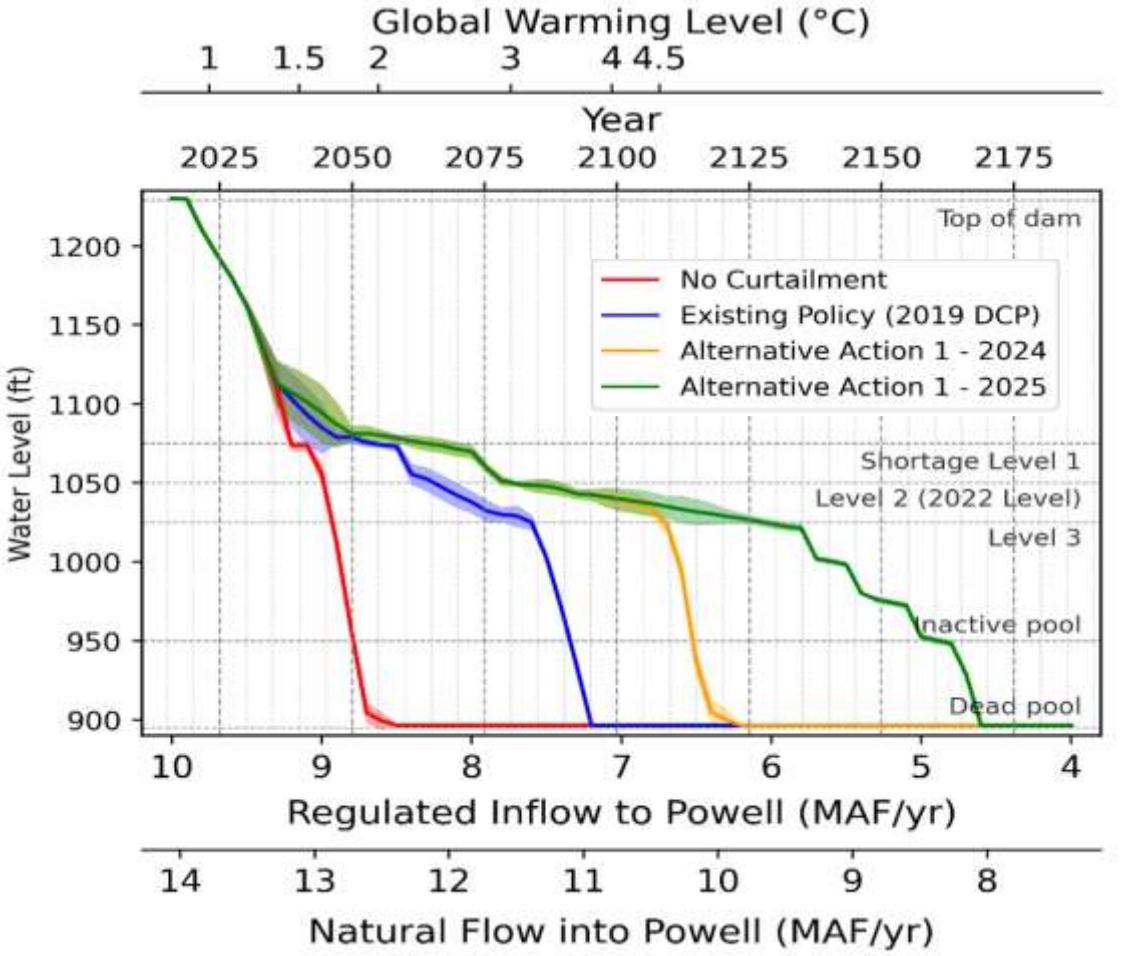
***Colorado River Example:***

*This projected utilized:*

- *10 high-resolution GCMs, SSP3-7.0 scenario*
- *A calibrated hydrological model*
- *Lake level models (for Lake Powell and Lake Mead)*
- *A Decision-Making Under Deep Uncertainty framework*

*We were able to evaluate current and proposed policy to manage the Colorado River Basin, showing that the business-as-usual policy would result in sustained dead pool conditions.*

**Most likely future Lake Mead water levels under various policy scenarios**



# Key Takeaways/Conclusions

- Projected climate data includes quantifiable uncertainty (emissions scenario, models, internal variability)
- Regional climate studies usually require high-resolution data (necessitating downscaling procedures)
- Using climate model data we have shown examples describing the regional climate change response:
  - snowpack decreases significantly,
  - evaporation increases
  - hydrological extremes become more frequent
- Lastly, we can couple climate data and water infrastructure models, enabling targeted analysis of policy choices (e.g., the CO River Example)

# Thank you.

# Session 1: Q&A and Discussion

# BREAK

# Thought Exercise

Consider the following questions:

1) On a scale of 1-10, what is your level of understanding on the concept and source of uncertainty in climate planning?
2) How do you think Climate Adaptation Planning differs from other planning processes that you've engaged in?
3) Why do you think adaptive management is important in the CAMP4W process?

# Session 2: Scenario Planning
# Dr. Robert Lempert, RAND

*Planning is indispensable*
*But the future is sure to surprise us*

# Water Managers Have Long Addressed Uncertainty, But Today Face New Challenges

In California water managers have long addressed extreme hydrologic variability via:

- Diverse supplies
- Safety factors
- Adjusting plans and operational rules over time

New challenges include:

- Increased climate variability and change
  "End of stationarity"
- Increased need and opportunities for collaboration
- Changing technologies and economies
- More financial, environmental, and other constraints

# Today We'll Discuss

- Scenario Planning
- Scenarios and Time-Bound Targets

# Three Approaches Can Support Water Agency Planning

1. Classic Decision Analysis
   - Plan to the most likely future

2. Scenario Planning
   - Consider a wide range of plausible futures
   - Use storylines to help understand and communicate scenarios
   - Identify plans robust over many scenarios

3. Robust decision making
   - Use thousands of simulation model runs to
     - Help identify most policy-relevant scenarios
     - Stress test proposed plans
     - Inform the development of more robust plans

Mearns et. al. 2010

# Three Approaches Can Support Water Agency Planning

1. Classic Decision Analysis
   - Plan to the most likely future

*Optimizing for a best-estimate future sometimes yields effective plans*

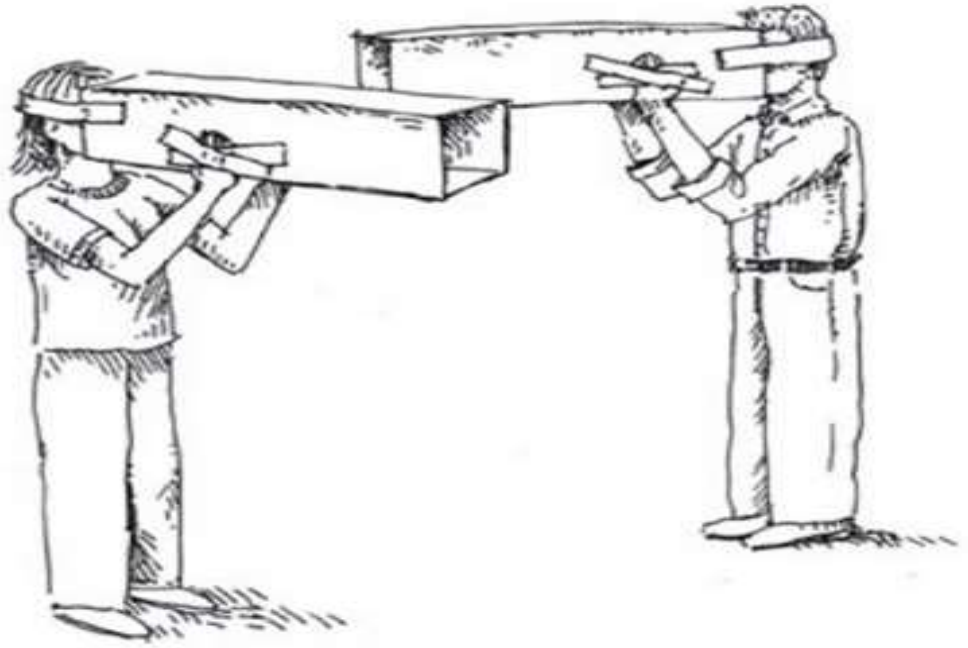
# Three Approaches Can Support Water Agency Planning

1. Classic Decision Analysis
   - Plan to the most likely future

*But what happens when we are wrong about the future?*

*"The most likely scenario isn't"*

*Herman Kahn*



Source: http://www.hockscqc.com/articles/tunnelvision/tunnel-vision.jpg

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Mearns et. al. 2010

# What Are Scenarios?

*Scenarios are focused descriptions of fundamentally different futures, often presented in a coherent script-like or narrative fashion*

*Schoemaker (1993)*

*A scenario is a plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts, but are used to provide a view of the implications of developments and actions.*

*IPCC Sixth Assessment Report, Glossary (2022)*

# Humans Are Avid Scenario Builders

We:

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

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

*Suddendorf (2013)*

# There Exist Different Types of Scenarios

**Explorative**
What might happen?

Used to help ensure decision options reach goals no matter what the future brings

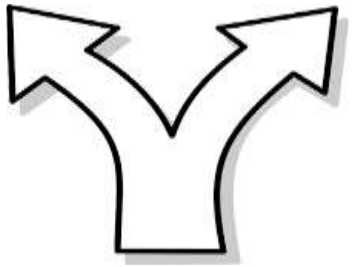
**Normative**
How can we reach our goals?

Used to describe alternative decision options

# Scenarios Provide Benefits for Decision Makers

Scenarios can help:

Reduce over-confidence



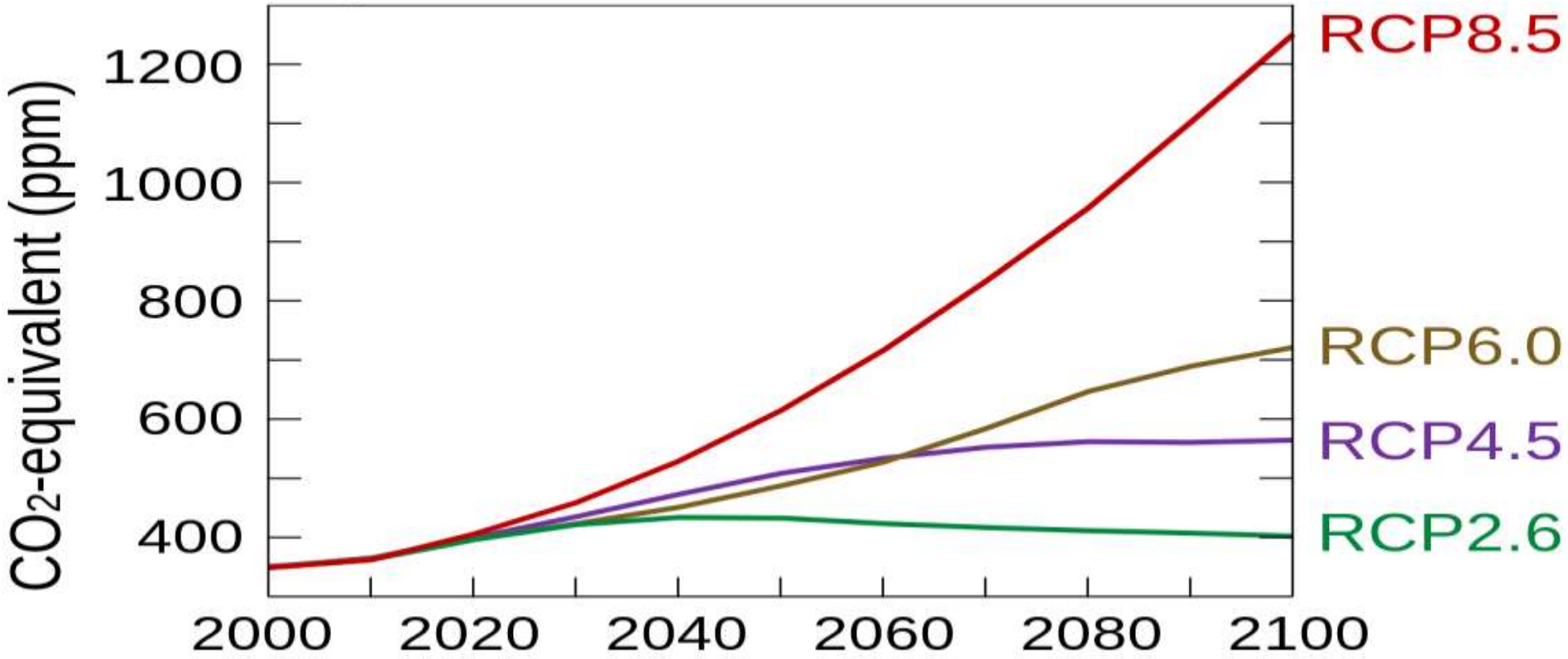
Expand the range of options considered

Facilitate collaboration among people who disagree on expectations and values

*Lempert (2013)*

# IPCC Employs Scenarios to Explore a Range of 21st Century Greenhouse Gas Concentrations

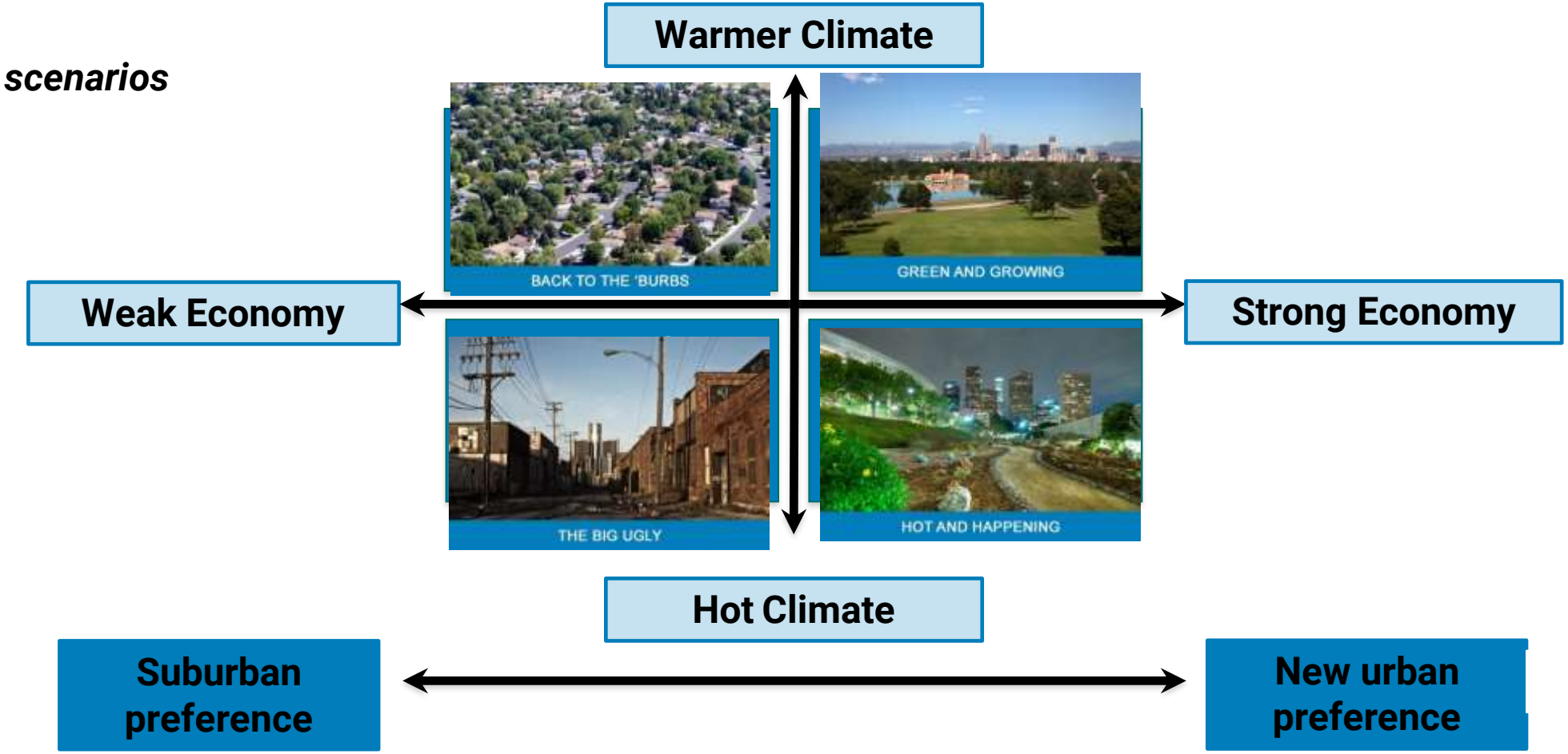
Representative Concentration Pathways developed for Intergovernmental Panel on Climate Change (IPCC)



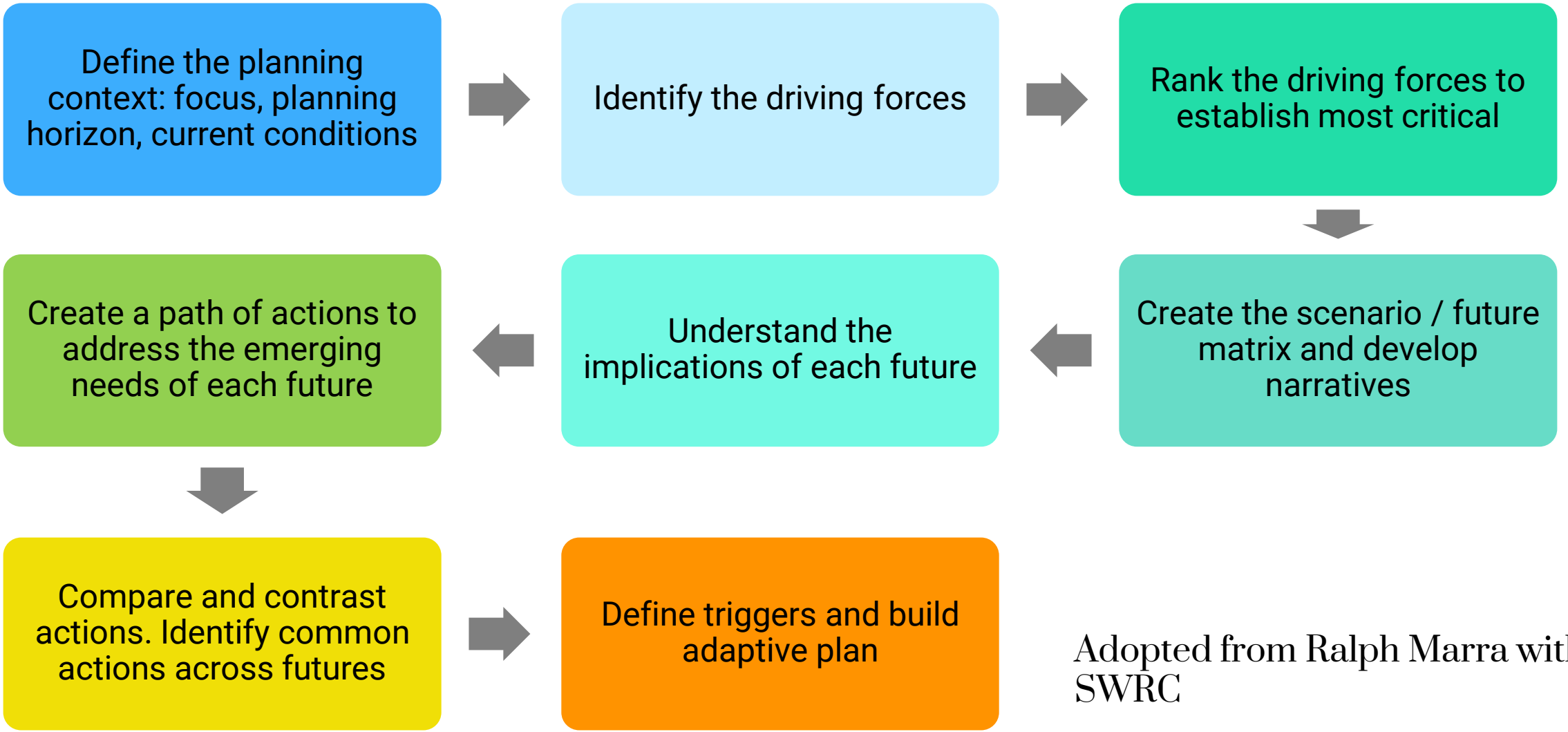

*RCP number indicates radiative forcing in the year 2100 in W/m²*

# Water Agencies Often Use Scenarios

***Example scenarios***

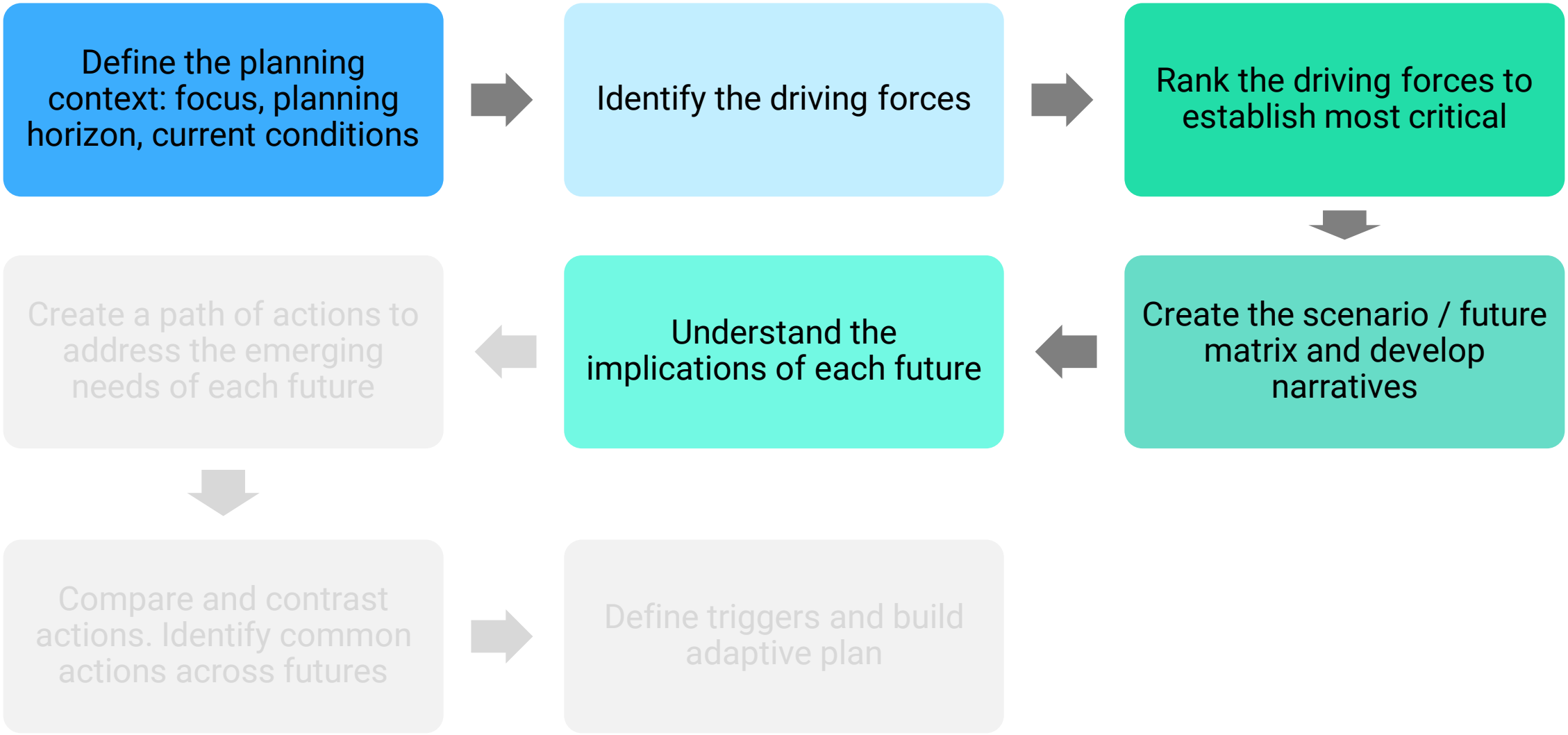


# Scenario Planning Process Moves From Context to Plans

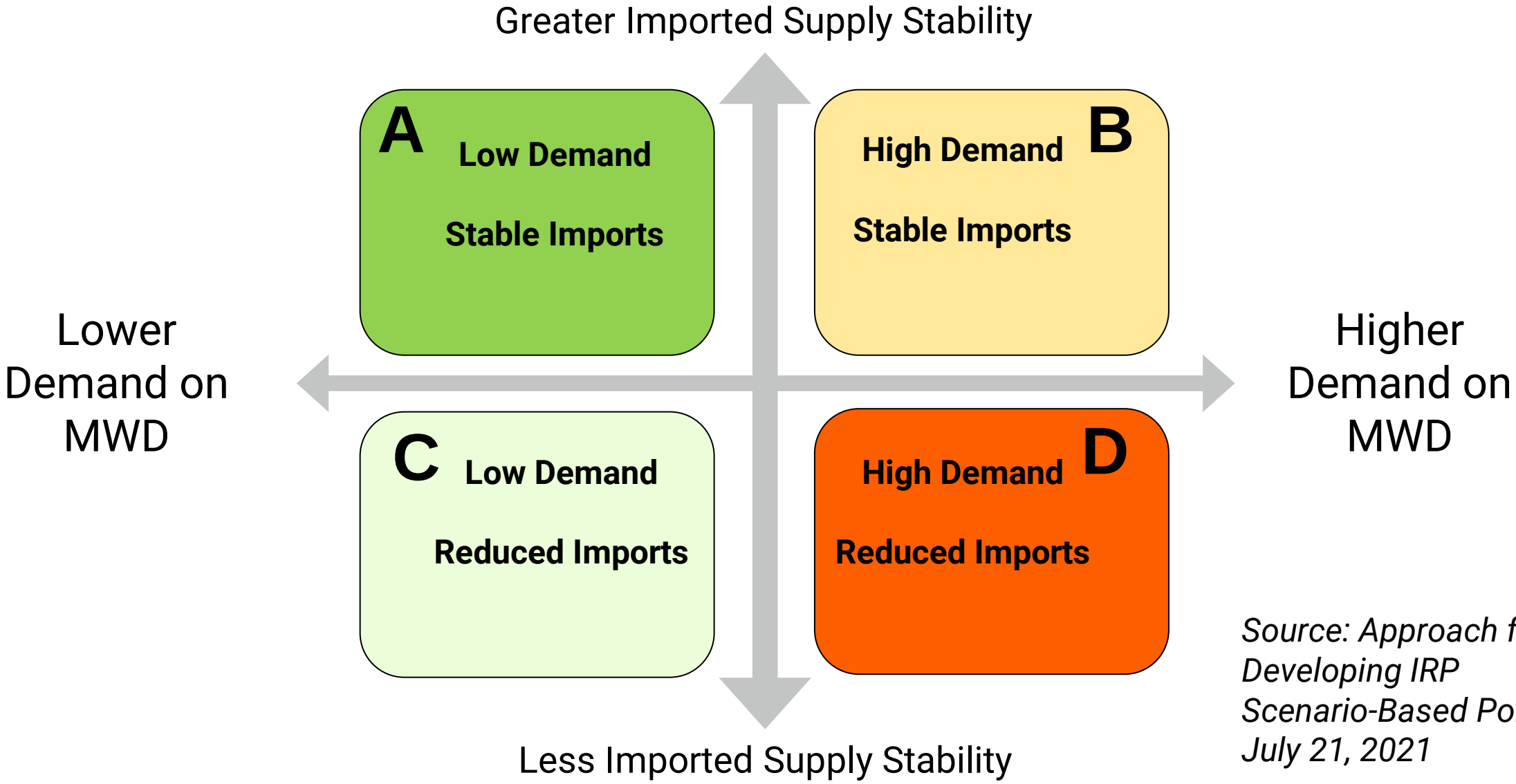



Adopted from Ralph Marra with SWRC

# Work Often Proceeds in Stages

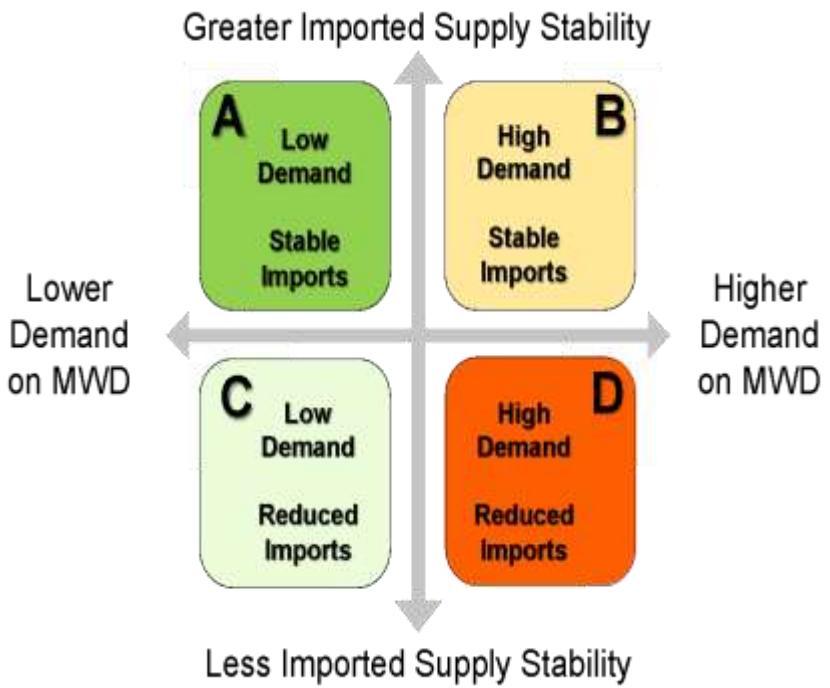


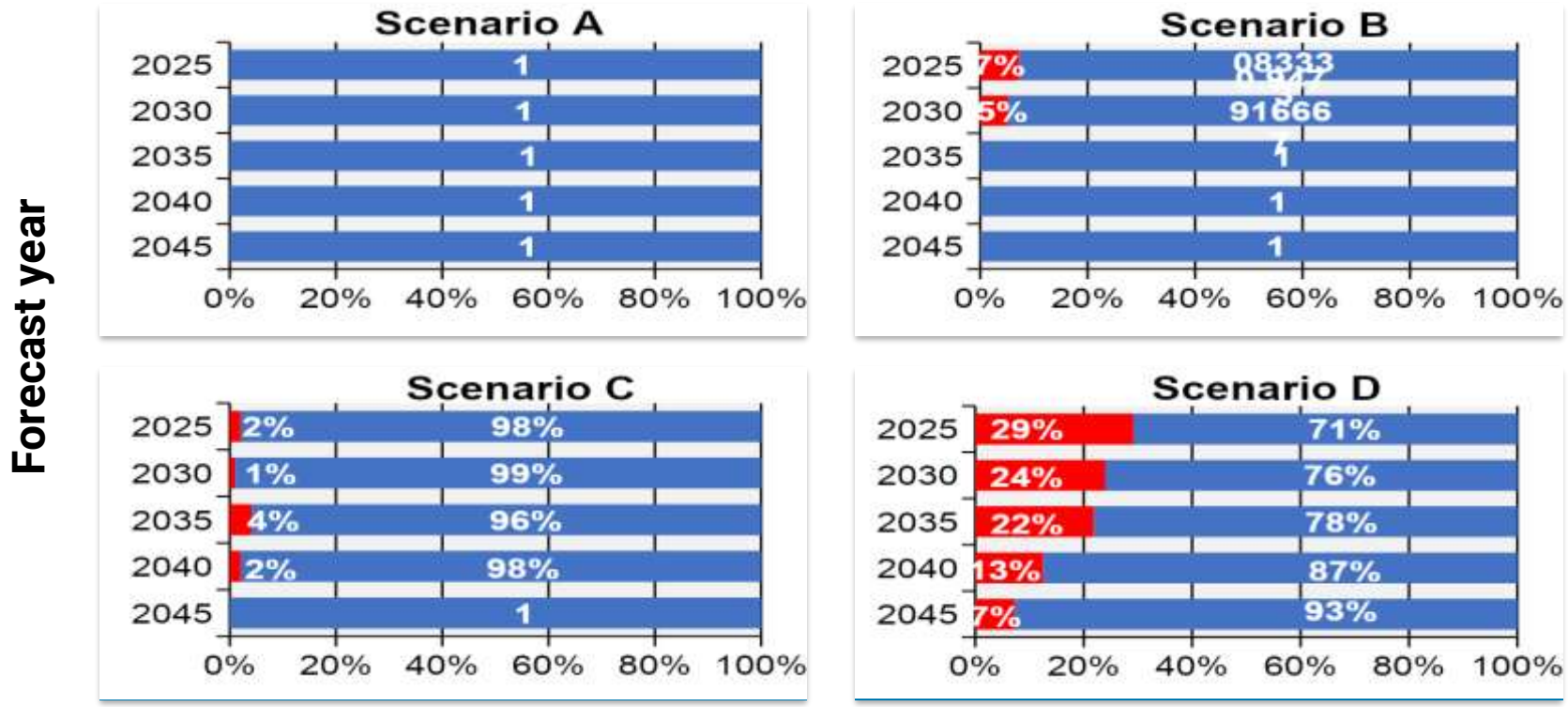
# Metropolitan Has Developed Scenarios




*Source: Approach for Developing IRP Scenario-Based Portfolios, July 21, 2021*

# Supply Gap Varies Over Scenarios

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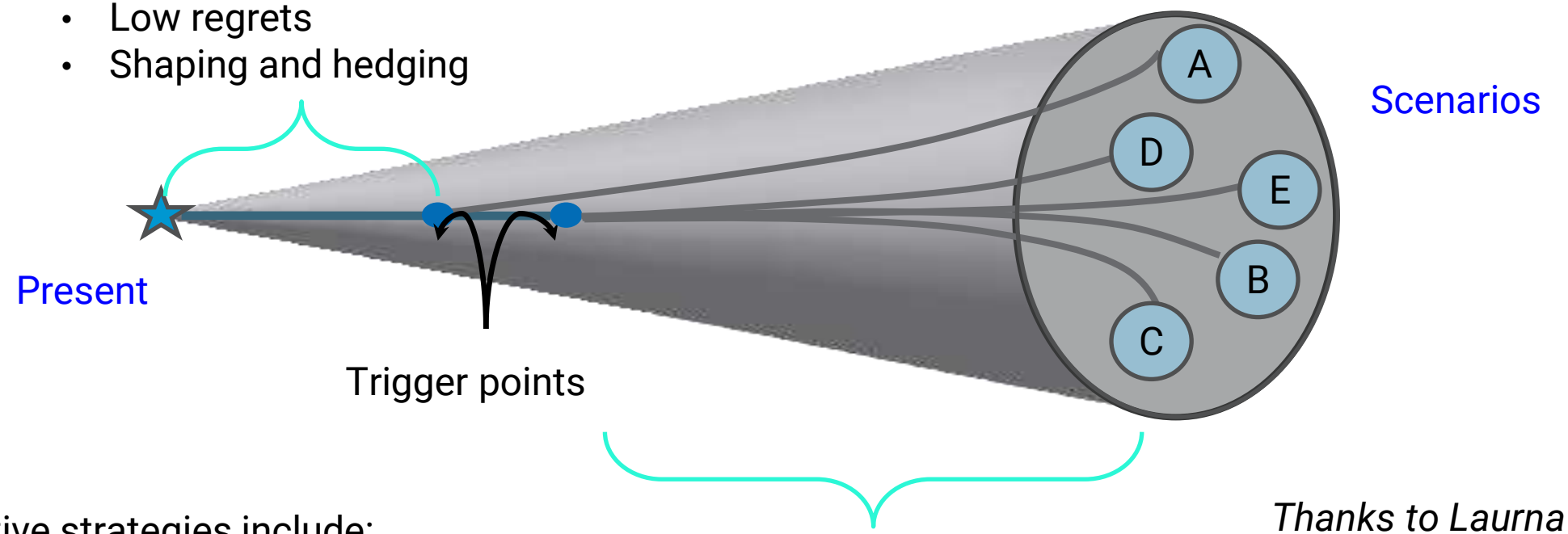
# Today We'll Discuss

- **Scenario Planning**
- **Scenarios and Time-Bound Targets**

# Water Agencies Can Use Scenarios to Inform Plans That Adjust Over Time to New Information

Near-term actions
- Low regrets
- Shaping and hedging

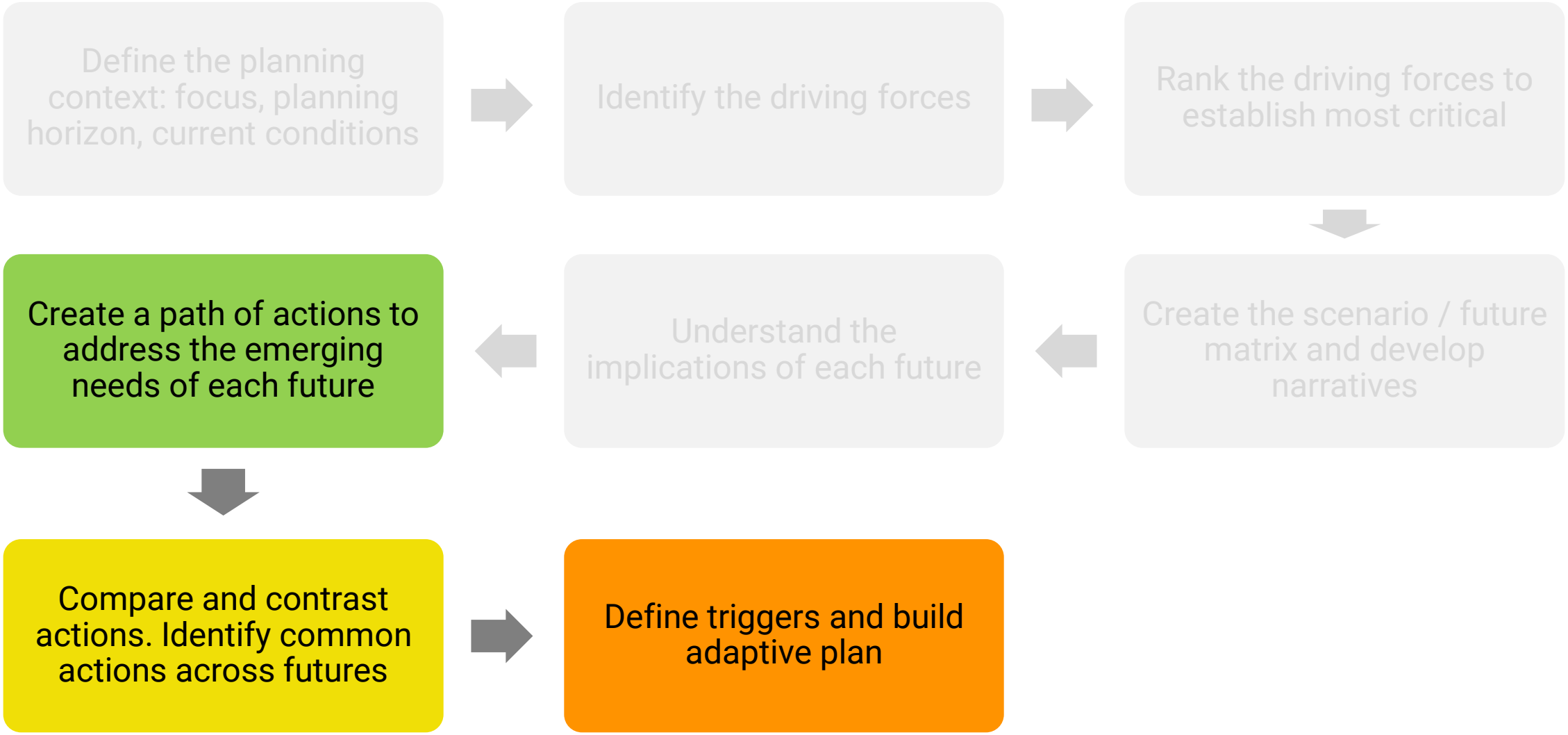



*Thanks to Laurna Kaatz*

Adaptive strategies include:
- Near-term actions
- Trigger points
- Contingent actions

*Haasnoot et. al. (2013) Dynamic Adaptive Policy Pathways: A New Method for Crafting Robust Decisions for a Deeply Uncertain World. Global Environmental Change*

# Adaptive Plans Emerge From Latter Parts of Scenario Planning Process



# Simple Example of Scenarios and Time-Bound Target

Example based on South Florida Water Management District

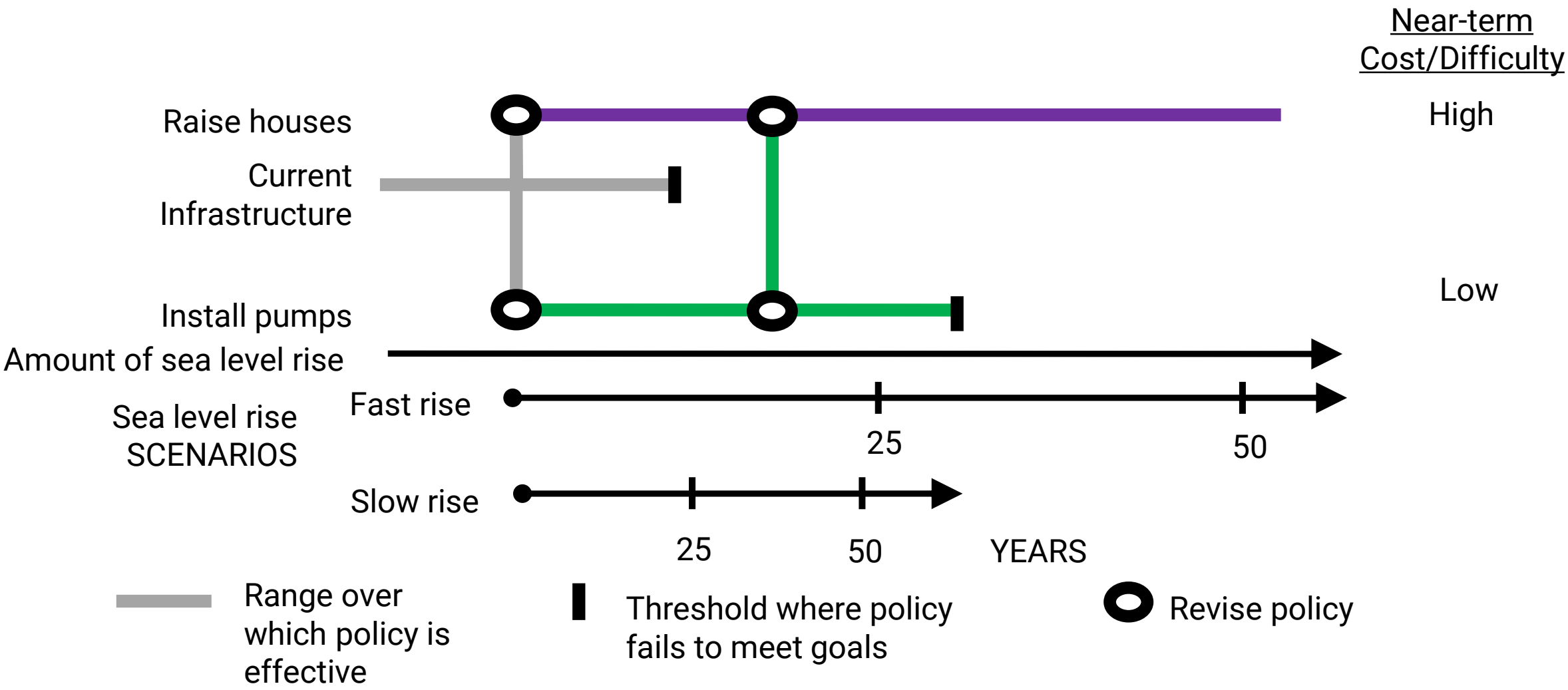
- Challenge:
  - Extensive infrastructure exists to drain residential neighborhoods in South Florida, but rising sea levels increase flood risk
- Overall Goal:
  - Hold flood risk constant at current levels
- Options include
  1. Retain current infrastructure
  2. Install new pumps over next two years
  3. Raise all houses by 6 feet over next thirty years
- Scenarios
  A. Rapid sea level rise
  B. Slow sea level rise

House by C-7 canal

Coastal gate for C-7 canal

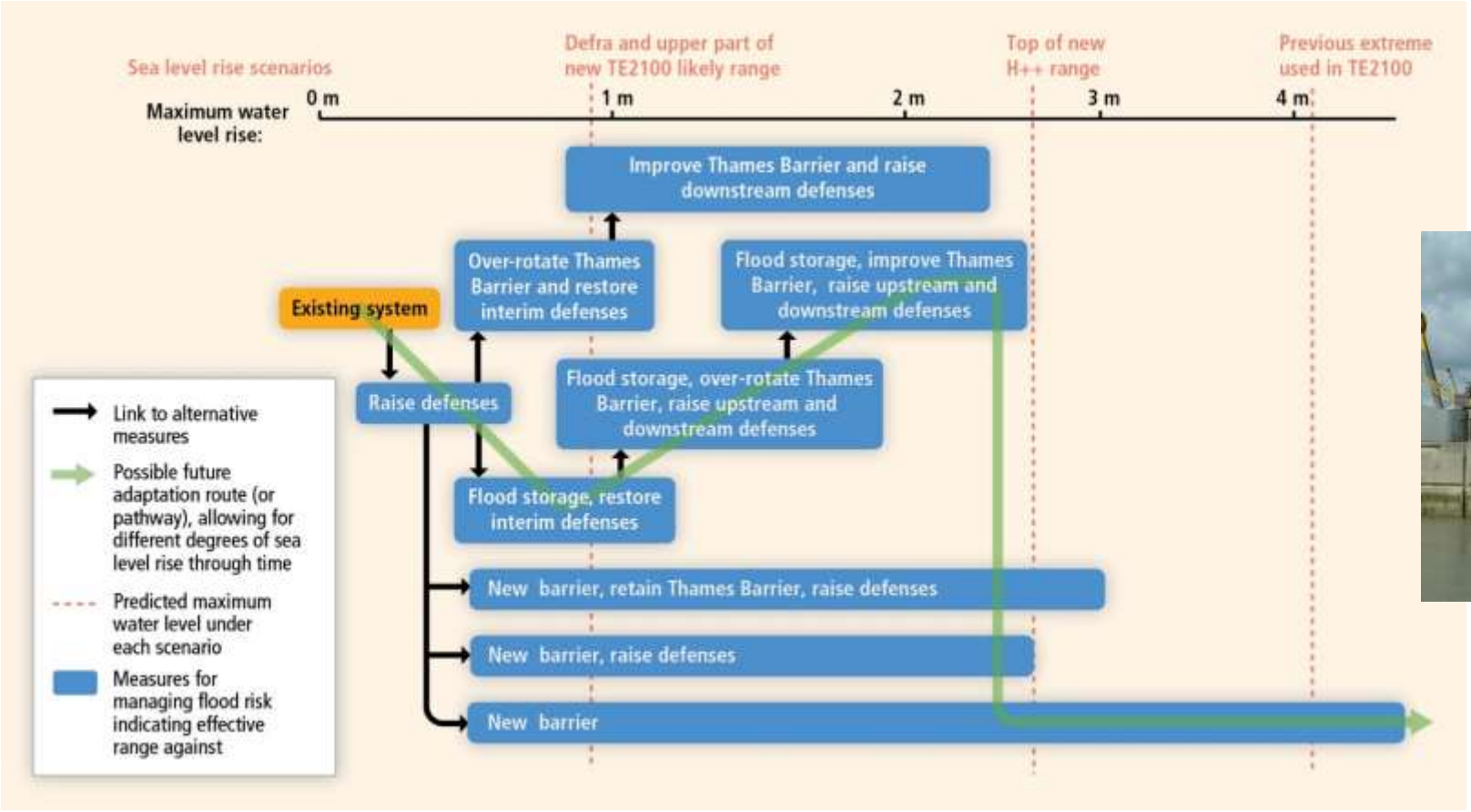
Bouwer, Haasnoot, Wagenaar, Roscoe (2018) Assessment of alternative flood mitigation strategies for the C-7 Basin in Miami, Florida Deltares

# Adaptive Pathways "Subway Maps" Help Organize Thresholds and Actions Over Time



# Adaptive Pathways Inform Significant Investments

**Adaptive Pathway Map for Thames River Estuary**




http://blogs.worldbank.org/sustainablecities/go-flow-adaptive-management-urban-flood-risk, Accessed May 22, 2023

# Scenario Planning

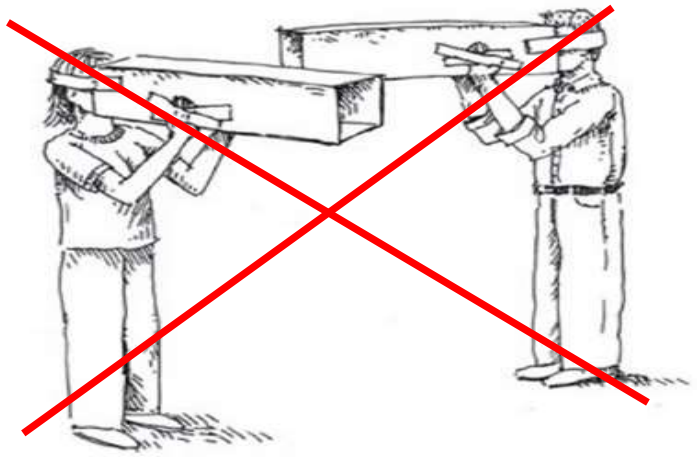
- Scenario Planning IS about being prepared for whatever happens in the future

- Scenario Planning is NOT about envisioning what we want to happen in the future or predicting what will happen in the future

# Scenarios Help People Make Better Decisions, Not Better Predictions

Basic principles

1. Consider multiple futures, not one single future, in your planning. Choose these futures to stress test your organization's plans
2. Seek robust plans that perform well over many futures, not optimal plans designed for a single, best-estimate future
3. Make your plans flexible and adaptive, which often makes them more robust



*Plan over multiple futures*

Scenarios:

- Identify plans robust and resilient over many futures
- Facilitate engagement and consensus among diverse stakeholders

# Thank you!

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

www.rand.org/water

RAND

**Pardee Center**

THE SOCIETY FOR Decision Making under Deep Uncertainty

http://www.deepuncertainty.org

# Session 2: Q&A and Discussion

# LUNCH

# Session 3: Climate Adaptation Planning Dr. Juliette Finzi-Hart, Pathways Climate Institute

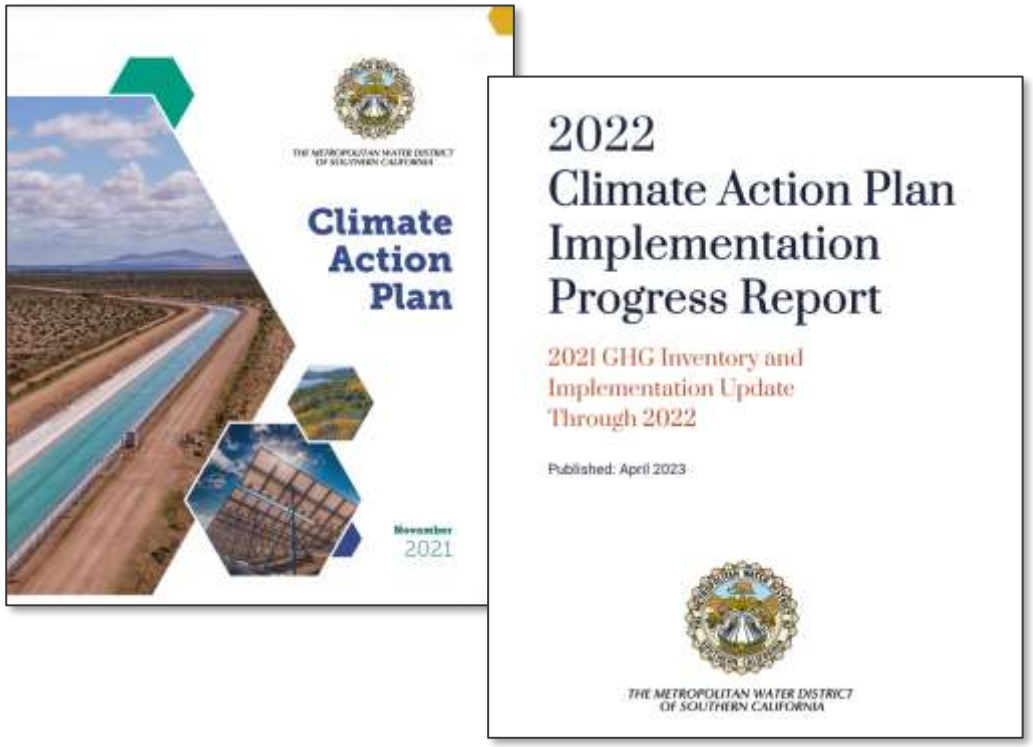
# Adaptation Planning and Adaptation Pathways

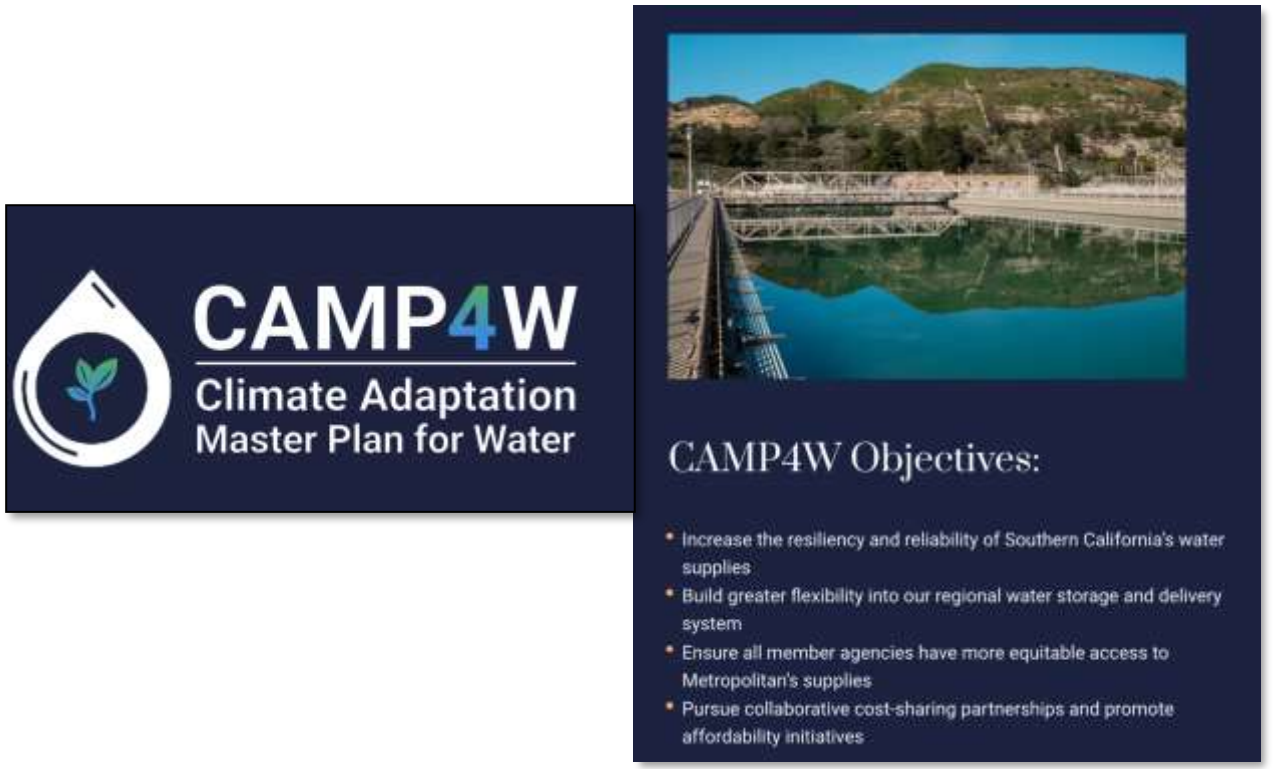
Juliette Finzi Hart, Ph.D.
Pathways Climate Institute
March 18, 2024

# Climate Action Terminology

**Climate change mitigation** refers to actions limiting the magnitude and rate of future climate change by reducing greenhouse gas emissions.

**Climate change adaptation or climate adaptation** means taking action to prepare for and adjust to both the current and projected impacts of climate change.



# Climate *Adaptation* Terminology

**Climate resilience** can be generally defined as the capacity of a system to maintain function in the face of stresses imposed by climate change and to adapt the system to be better prepared for future climate impacts.

**Climate Mitigation**

**Climate Adaptation**

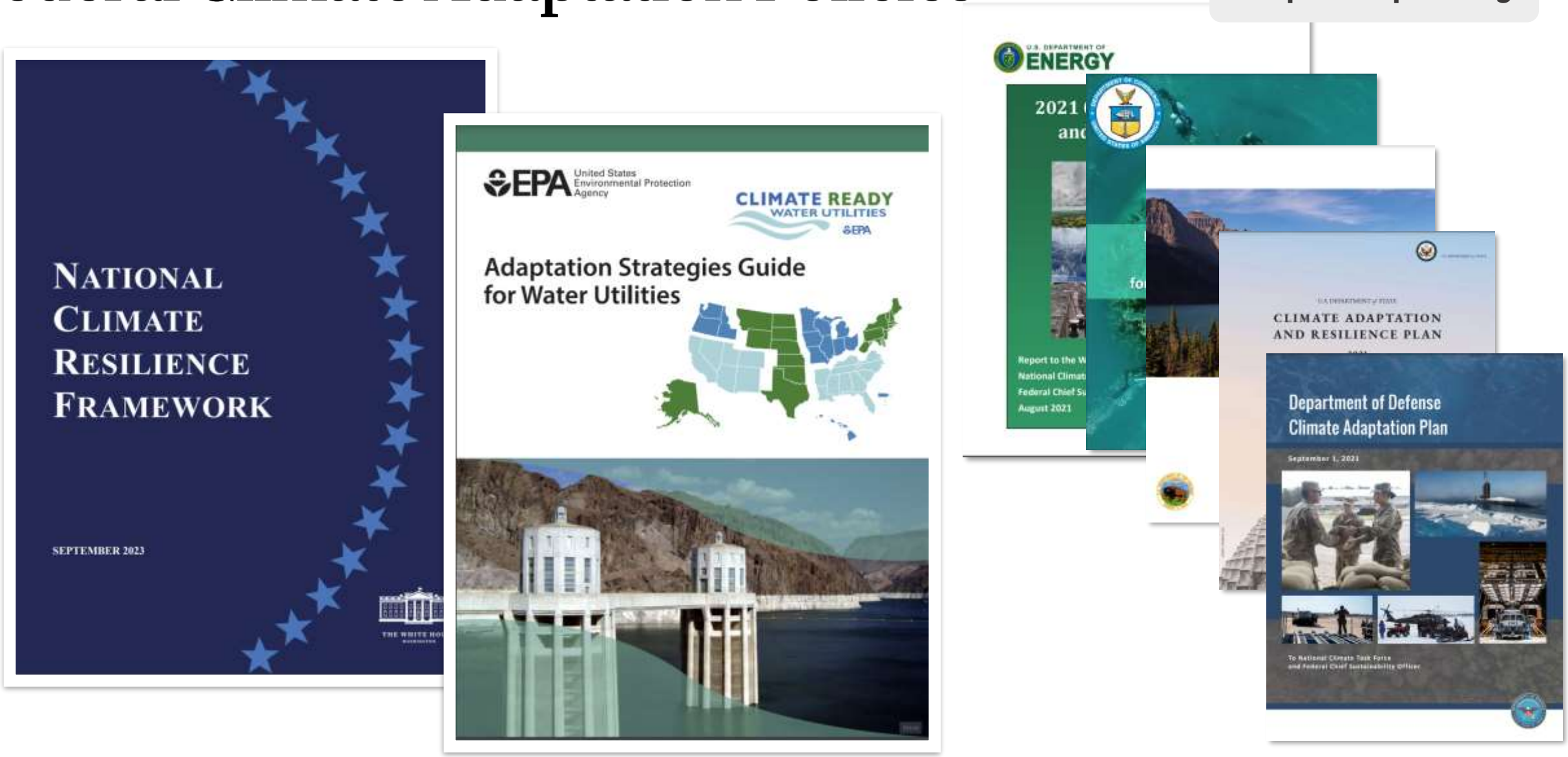
**Adaptation pathways** is an approach that allows decision makers to build adaptive capacity, prioritize strategies, stagger investment, and maintain flexibility.

**Adaptive capacity** is the ability of a human or natural system to adjust to climate change by moderating potential damages, taking advantage of opportunities, or coping with the consequences.

**Climate-adaptive design** aims to create infrastructure that can adapt to changing conditions, reducing vulnerability and increasing sustainability.

# Federal Climate Adaptation Policies

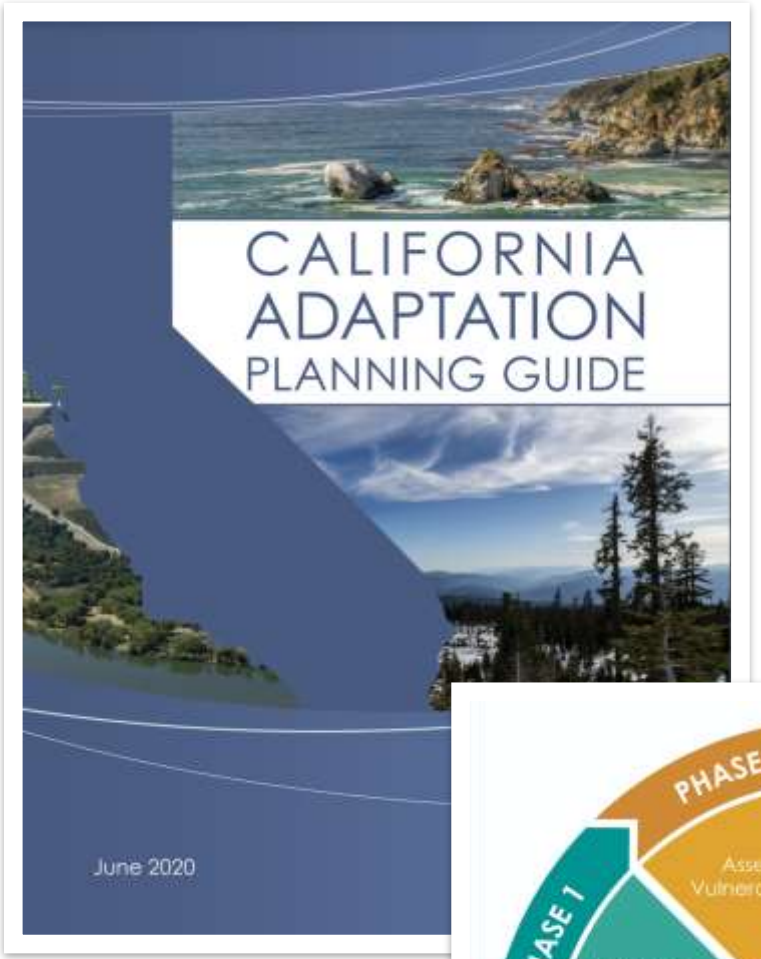
adaptation planning

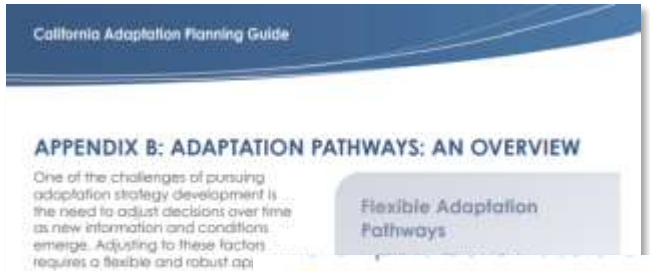


# California Climate Adaptation Policies

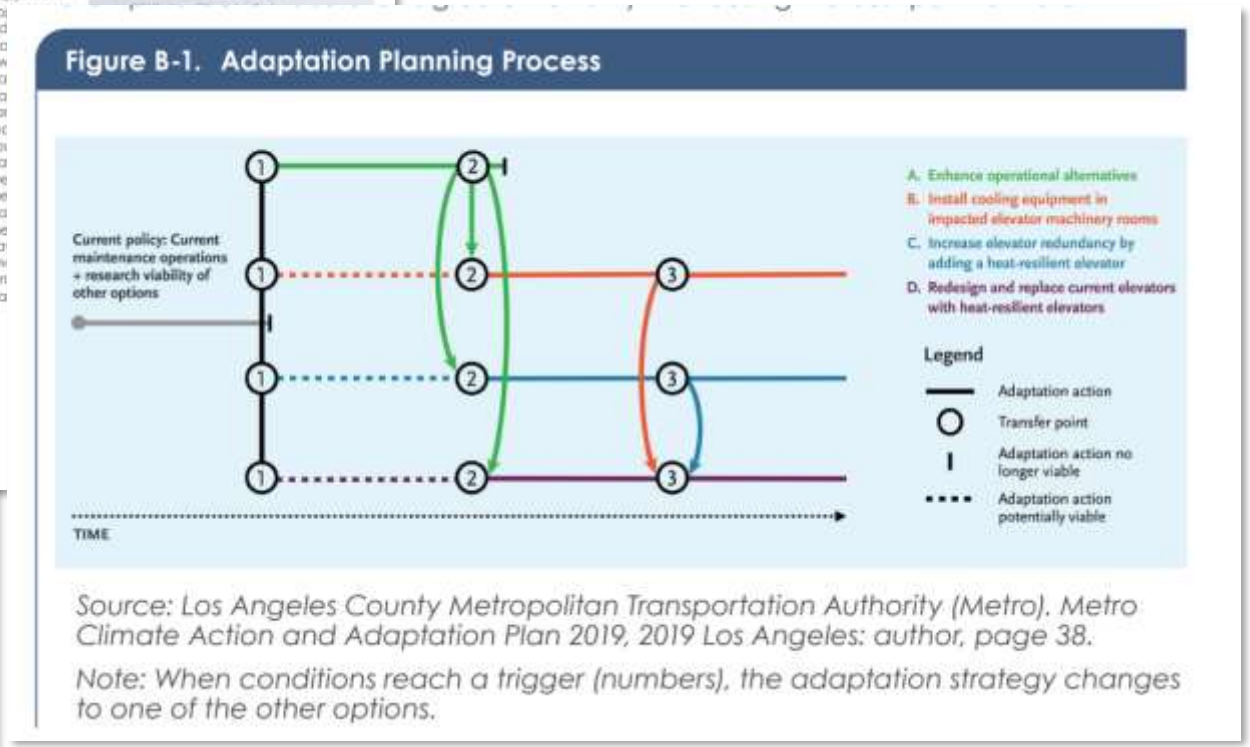
adaptation planning

adaptation pathways







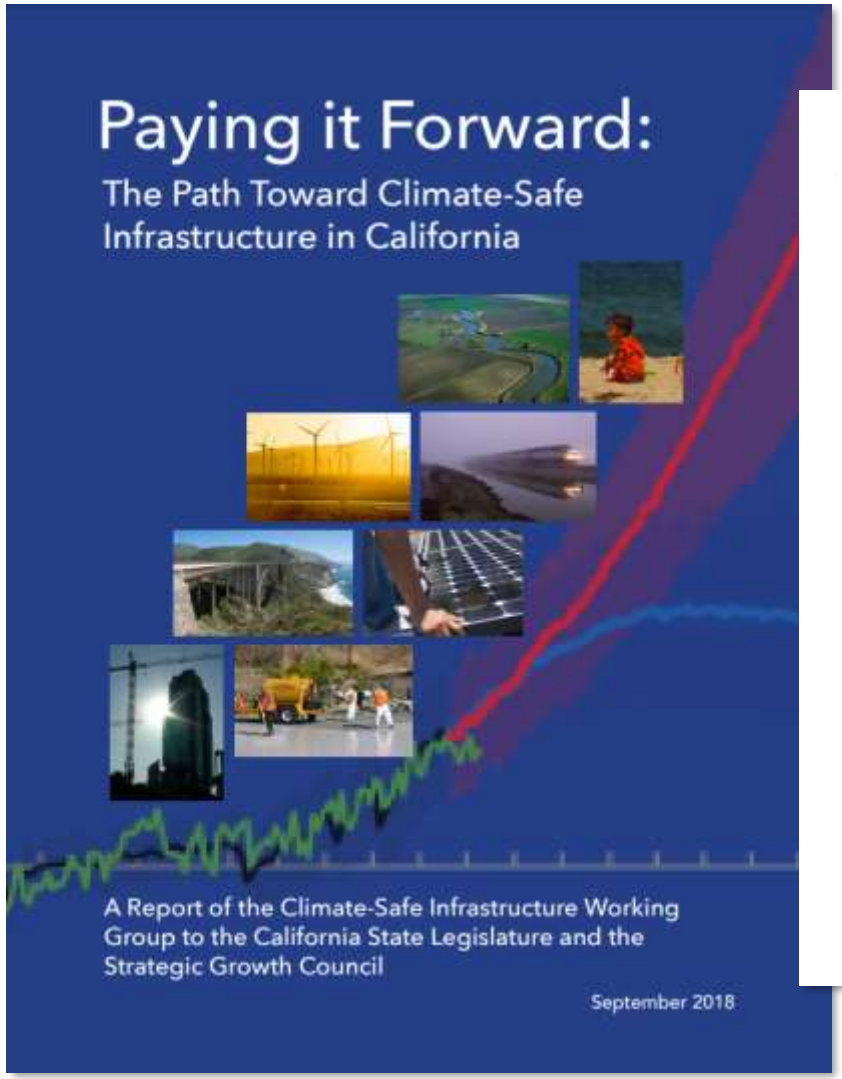

*Source: Los Angeles County Metropolitan Transportation Authority (Metro). Metro Climate Action and Adaptation Plan 2019, 2019 Los Angeles: author, page 38.*

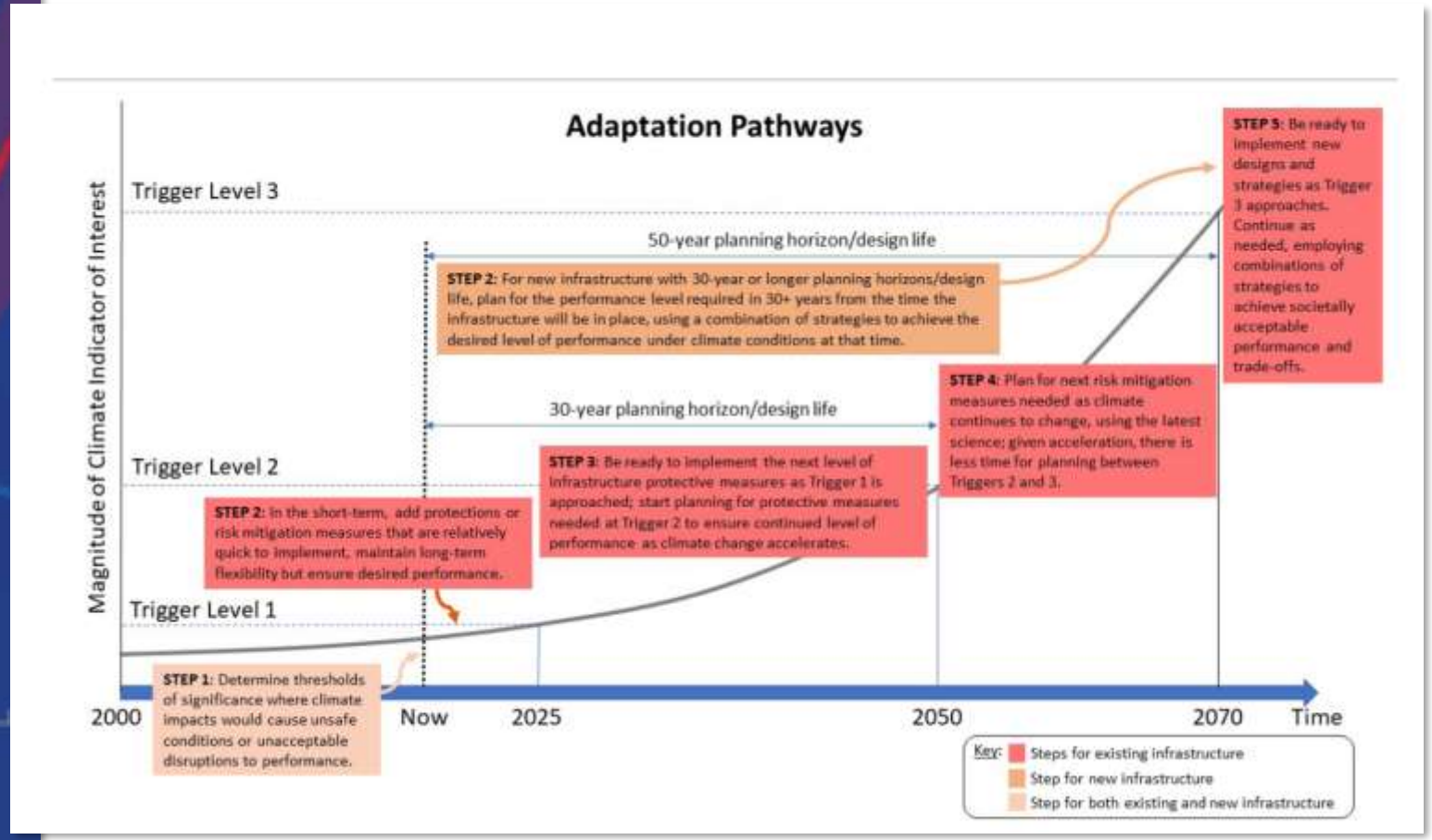
*Note: When conditions reach a trigger (numbers), the adaptation strategy changes to one of the other options.*

https://resilientca.org/apg/

# CA Climate-Safe Infrastructure

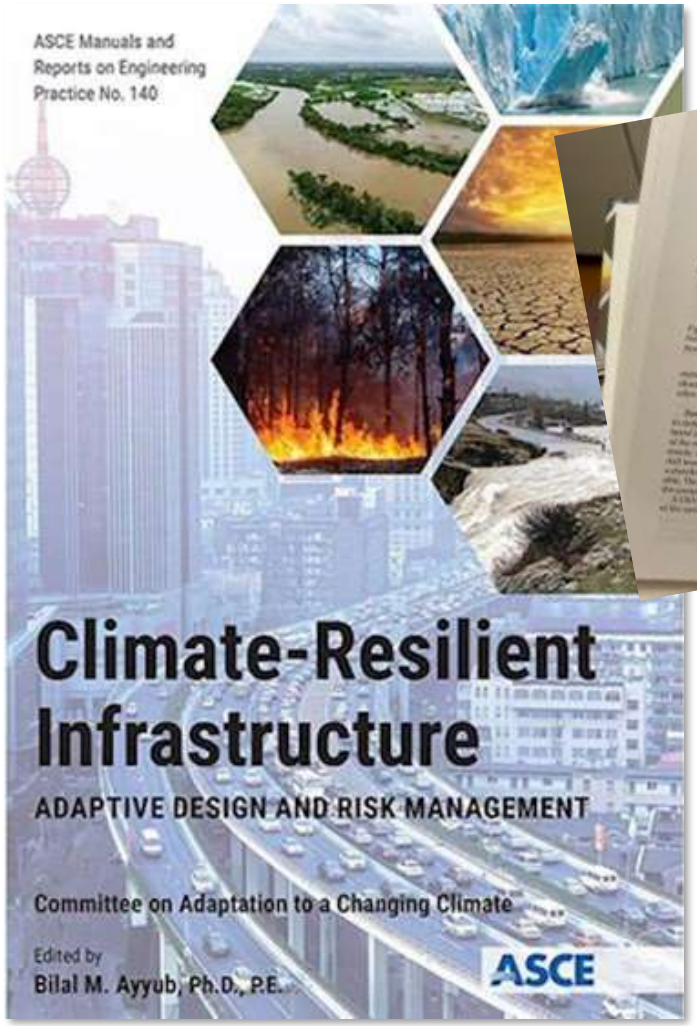
**adaptation pathways**

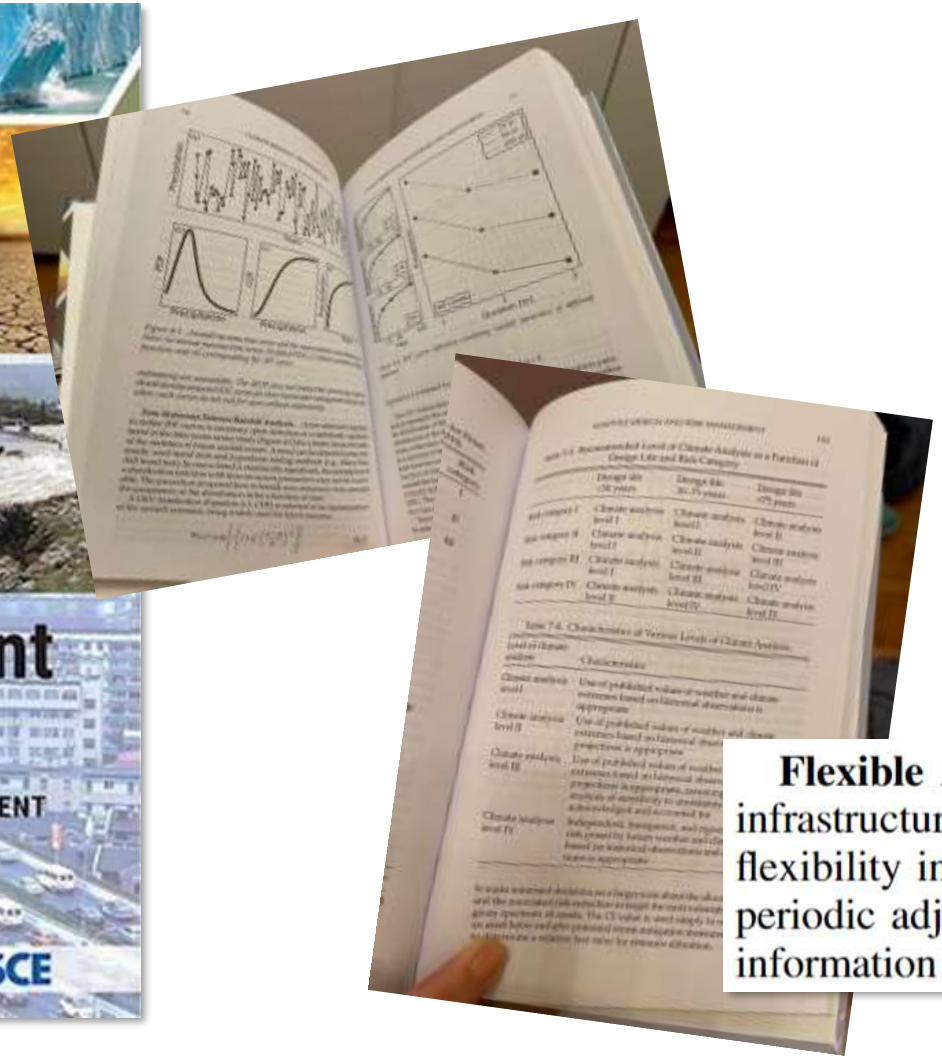


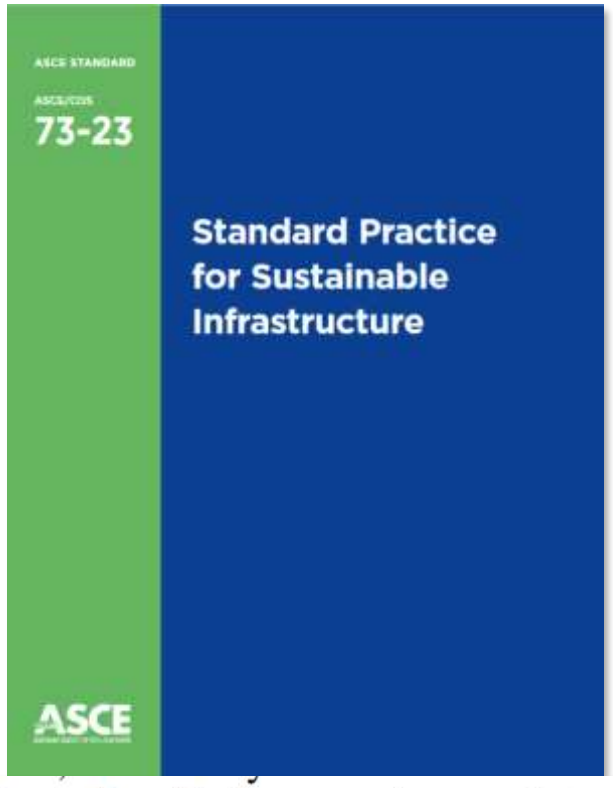



# Even Water Engineers Do it

adaptation pathways






**Flexible Adaptation Pathways:** Approach to implementing infrastructure solutions with a long-time horizon by building flexibility into the overall adaptation strategy, which allows for periodic adjustment of adaptation strategies in response to new information and changing circumstances.

# Why Adaptive Management?

nature communications

Article

**Increasing global to anthropogenic**

Received: 3 August 2022

Accepted: 4 May 2023

Xuezhi
Simin D

May 26, 2021

**Profiles in Education | Joyce Jones: "Role Model and Advocate" at Princeton High School for 51 Years**


OPINION

FARHAD MANJOO

**What Will 'Weather Whiplash' Mean for California?**

Jan. 20, 2023

# Sea Level Rise Adaptation Pathways – City of Santa Cruz

adaptation pathways

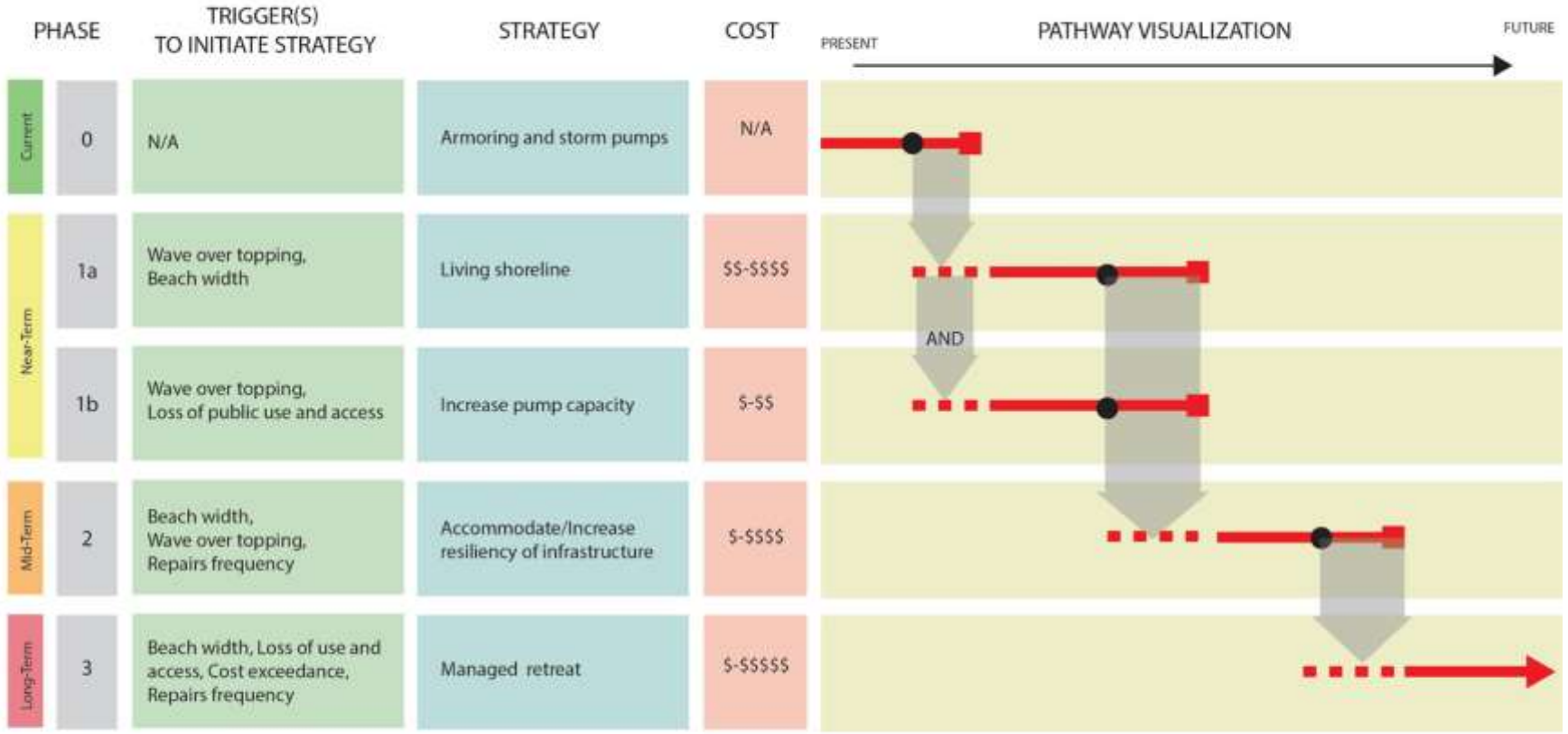
CITY OF SANTA CRUZ

Resilient Coast Santa Cruz

https://www.cityofsantacruz.com/government/city-departments/city-manager/climate-action-program/resilient-coast-santa-cruz

## Main and Cowell Beaches: Accommodate then Retreat

| | PHASE | TRIGGER(S) TO INITIATE STRATEGY | STRATEGY | COST |
|---|---|---|---|---|
| Current | 0 | N/A | Armoring and storm pumps | N/A |
| Near-Term | 1a | Wave over topping, Beach width | Living shoreline | $$-$$$$ |
| Near-Term | 1b | Wave over topping, Loss of public use and access | Increase pump capacity | $-$$ |
| Mid-Term | 2 | Beach width, Wave over topping, Repairs frequency | Accommodate/Increase resiliency of infrastructure | $-$$$$ |
| Long-Term | 3 | Beach width, Loss of use and access, Cost exceedance, Repairs frequency | Managed retreat | $-$$$$$ |



# Sea Level Rise Pathways – Port of San Francisco

**adaptation pathways**

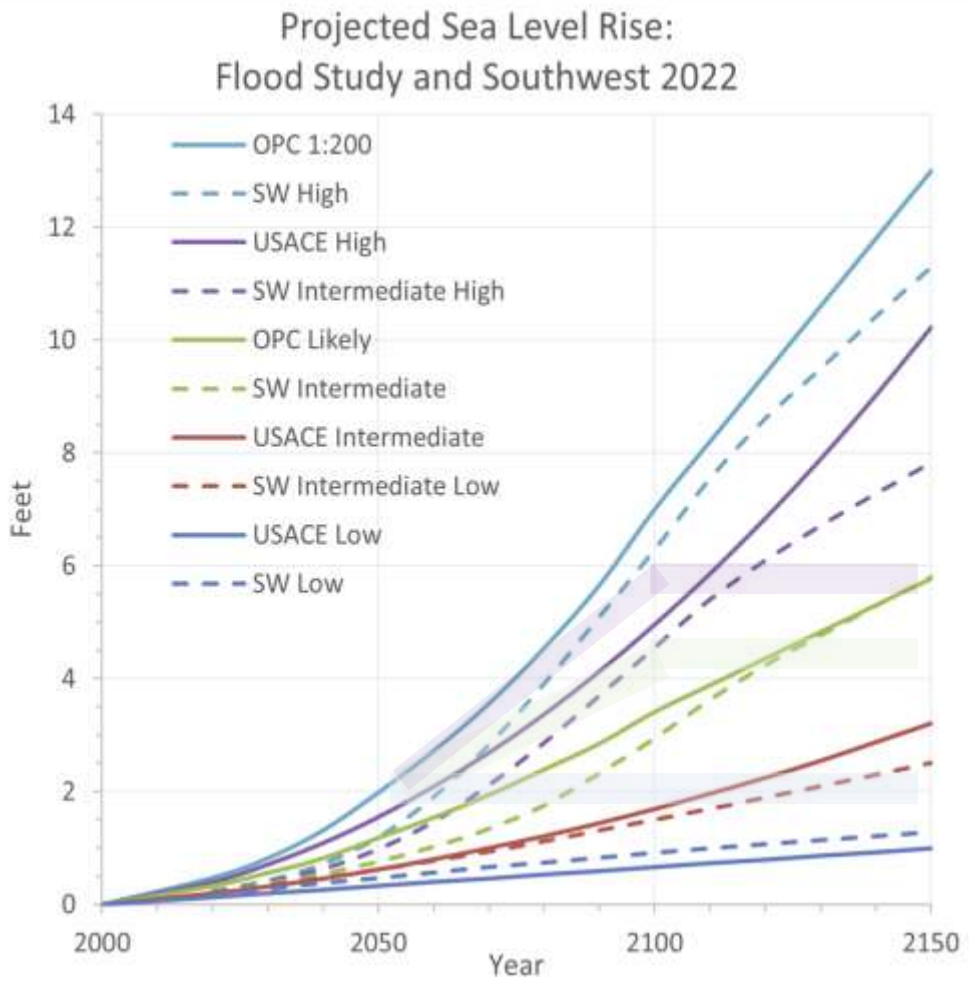

BAY AREA // SAN FRANCISCO

## How S.F.'s Embarcadero could be transformed by this $13.5 billion proposal

By John King
Jan 26, 2024

# Sea Level Rise Pathways – Port of San Francisco

**adaptation pathways**




San Francisco Waterfront Coastal Flood Study

PORT OF SAN FRANCISCO

**The Draft Plan**

**Early Projects**
*Now until 2030*
Addresses highest risk areas through Proposition A General Obligation Bond

**First Actions**
*~2030 and beyond*
Defends against 1.5 to 3.5 feet of sea level rise, actions prioritized and phased

**Monitoring**
(Sea Level Rise, Climate Indicators)

**Subsequent Actions**
*Timing driven by monitoring*
Defends against 3.5 to 7 feet of sea level rise

*Federal Actions*

**Future Adaptation**

# Sea Level Rise Pathways – Port of San Francisco

adaptation pathways

San Francisco Chronicle e-Edition Account

BAY AREA // SAN FRANCISCO

## How S.F.'s Embarcadero could be transformed by this $13.5 billion proposal

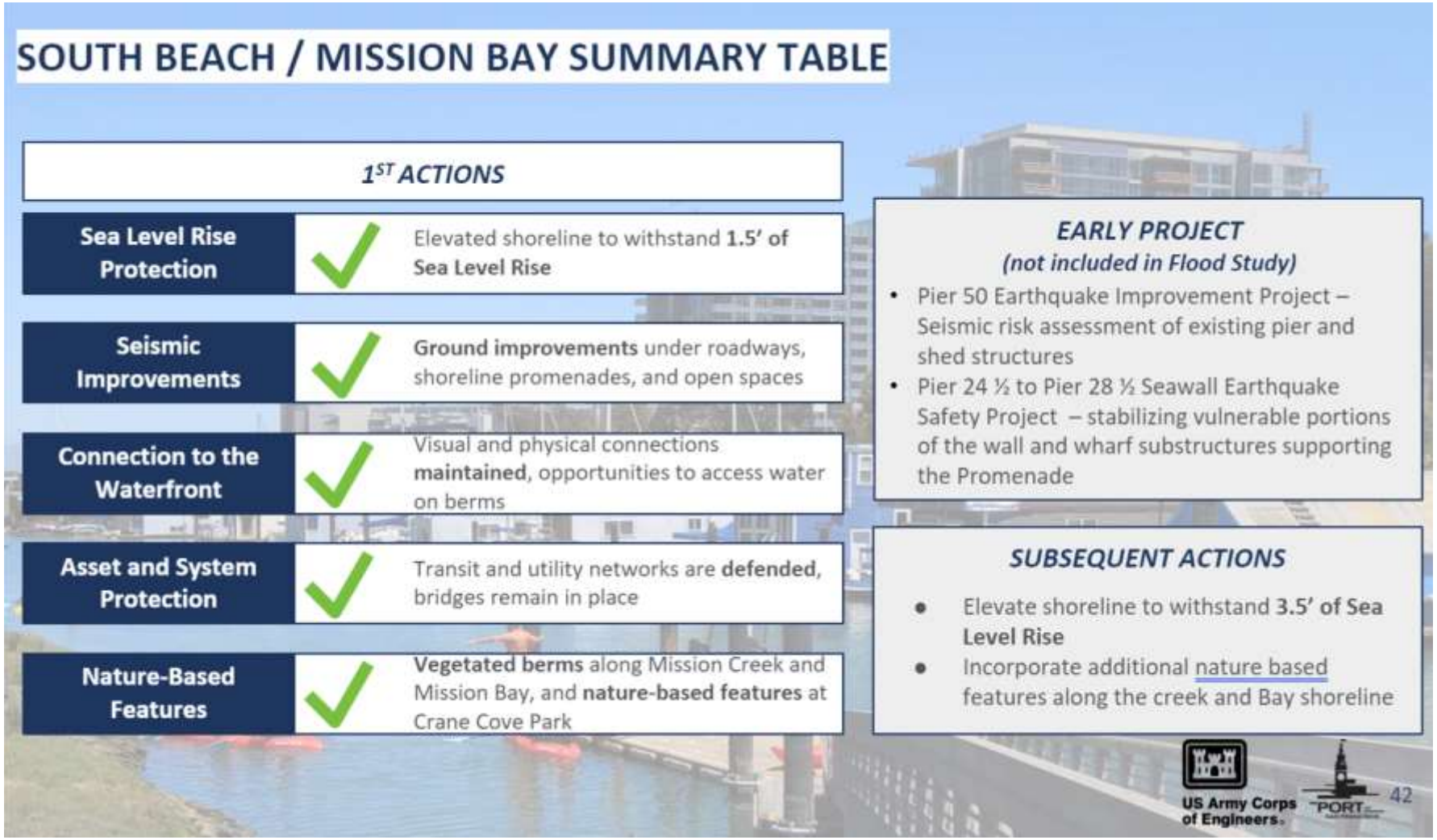
By John King
Jan 26, 2024

Gift Article

"Putting things in place now, that will allow us to reach our (future) goals. I like that," said Brian Harper, civil works director of the Corps' Regional Planning and Environmental Center. "Let's use time as our friend, not an enemy."

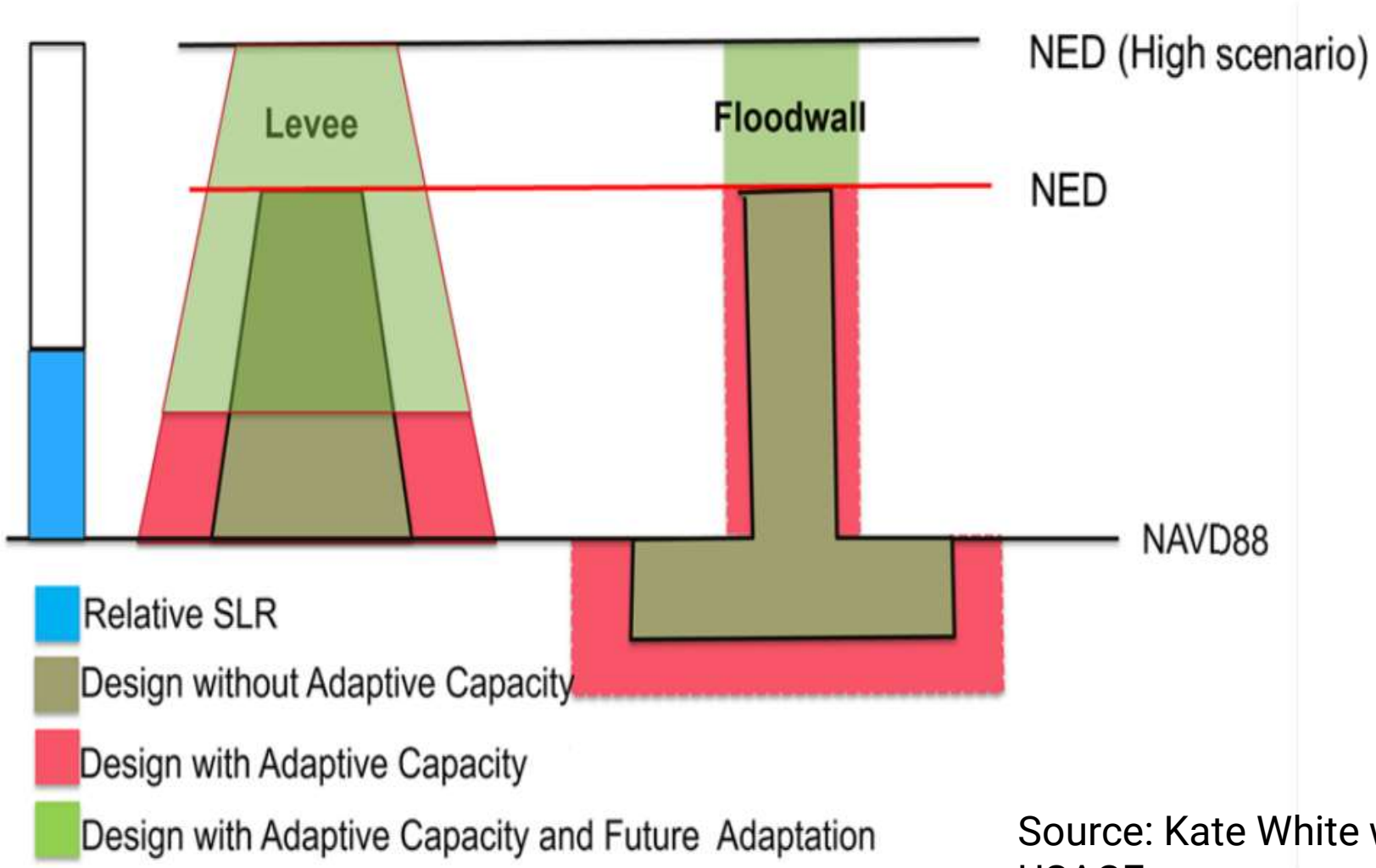
# Sea Level Rise Pathways – Port of San Francisco

adaptation pathways



# USACE Adaptive Capacity Analysis

adaptive design




Source: Kate White webinar 2018, USACE

# North Atlantic Right Whales

adaptation pathways


Plankton net towed from the stern; orange colored plankton caught in sample bottle.

# North Atlantic Right Whales

adaptation pathways

National Fisherman Since 1946

June 14, 2022

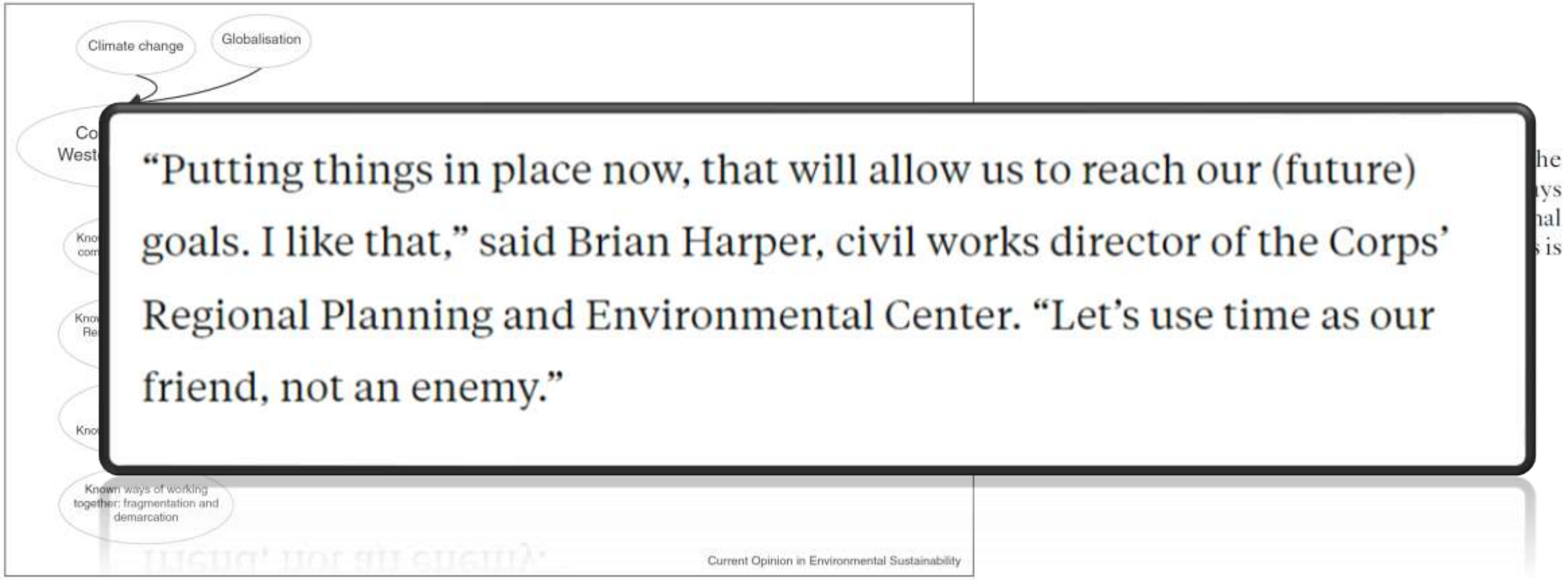
## Study says whales adapting to climate change; so too must mariners and fishermen

by Kirk Moore in Northeast, News

SHARE

*Three North Atlantic right whales feeding at the water surface in Cape Cod Bay. Brigid McKenna/Center for Coastal Studies photo, under NOAA research permit #19315-01.*


# Adaptive Management & Policy




"Putting things in place now, that will allow us to reach our (future) goals. I like that," said Brian Harper, civil works director of the Corps' Regional Planning and Environmental Center. "Let's use time as our friend, not an enemy."

**Climate change and water security: challenges for adaptive water management**

Catherine Allan[1], Jun Xia[2] and Claudia Pahl-Wostl[3]

# Session 3: Q&A and Discussion

# Climate Planning Exercise in Small Groups

# Decisions for the Decade: A Serious Game on Long-Term Decision Making

Dr. Robert Lempert, RAND

# Discussion/Reflection

# Session 4: Signposting and CAMP4W Adaptive Management

Subcommittee on Long-Term Regional Planning Processes and Business Modeling

# Signposting and Adaptive Management

Item 7d

March 18, 2024

# Item 7d

## Signposting and Adaptive Management

## Subject

Overview of Signposting and Adaptive Management

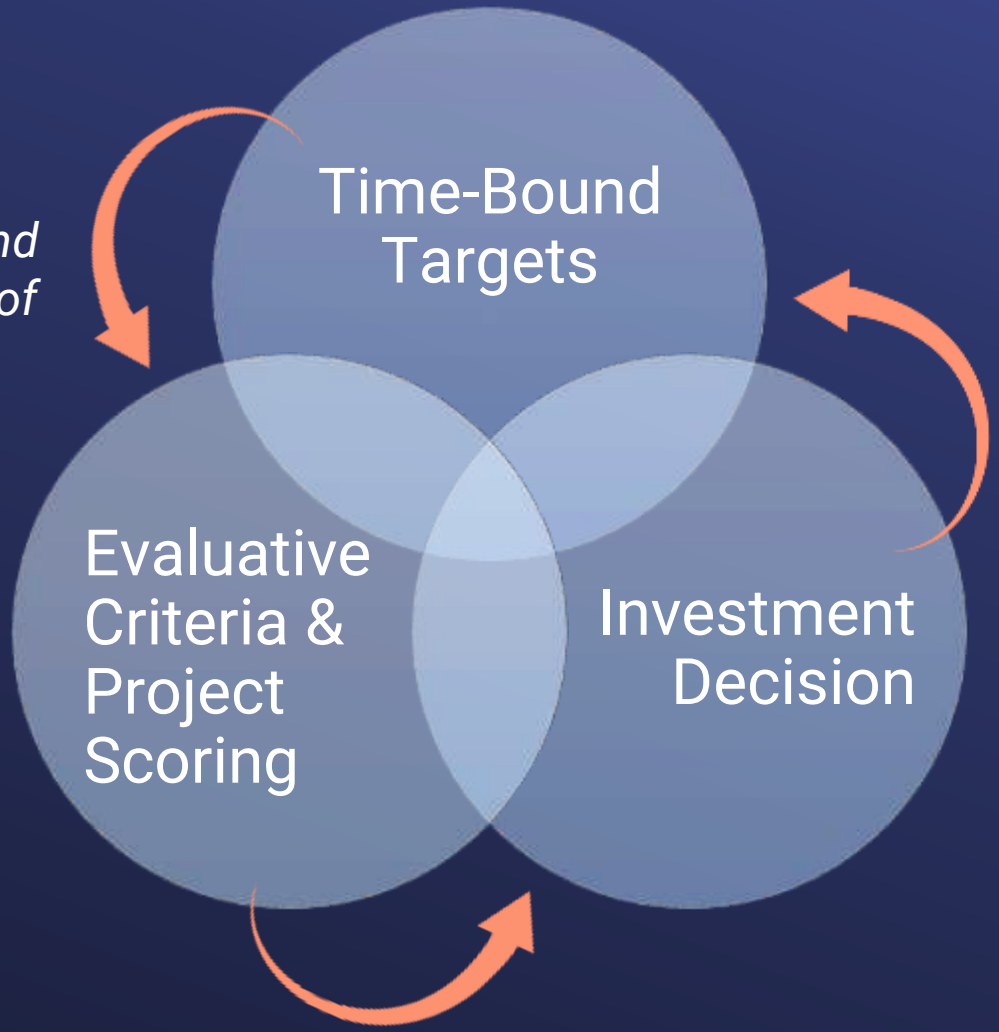
## Purpose

The CAMP4W process will establish a methodology for evaluating options through a Climate Decision-Making Framework and will provide a roadmap for identifying solutions to mitigating the identified risks. It will be a living document that will be updated to identify changing conditions and to report those changes to the Board.

This Committee Item focuses on the concept of adaptive management and the development and use of signposts to inform the process.

# Adaptive Management Supports Informed Decision-Making

*Time-Bound Targets guide project development and inform scoring of projects*



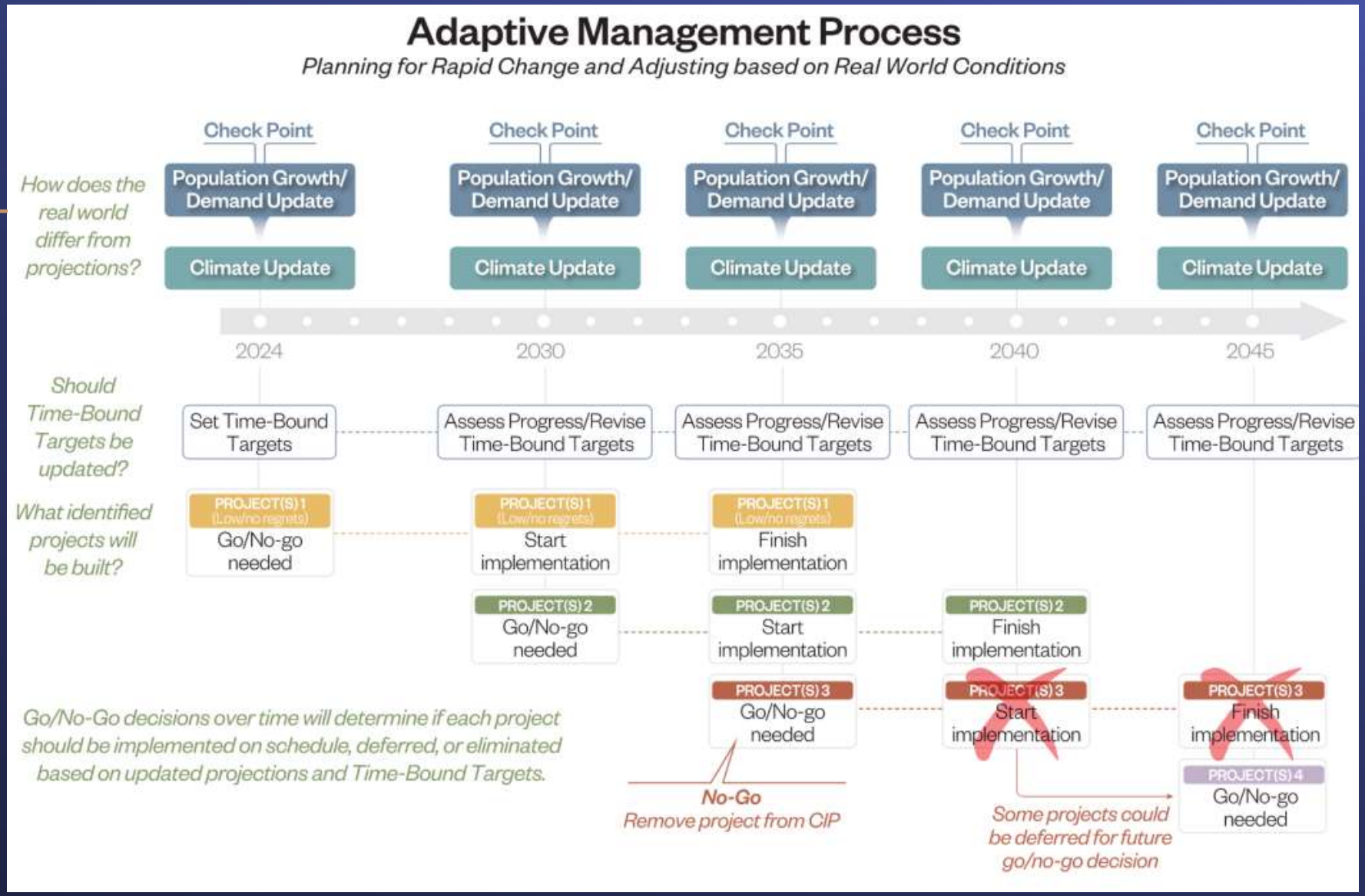

***Adaptive Management:***
*1.Provides a framework for decision support through time*
*2.Iterative process over time to balance the risk of shortage and overinvesting*
*3. Updates resource development needs and **Time-Bound Targets** based on updated projections and **Signposts***

***Signposts** inform how conditions are changing*

*Scores and Time-Bound Targets inform decision-making*

# Signposts Facilitate Adaptive Management

***Signposts** inform through regularly tracking real-world conditions*



# Potential Examples of Signposts

*Signposts should be measurable, updatable, readily available*

## DEMAND

### Population
- Population projections
- Net migration

### Economy
- Employment
- Housing permits

### Local Agency Supply
- Maintained existing supply (AF)
- New supply (AF)

### Demand Management
- Structural conservation progress (installations/rebates/code compliance)
- Reported reduction in agricultural irrigation

### Regulations
- State Water Board water use efficiency standards
- Non-functional turf / AB 1572 compliance (SF of turf replaced)

## SUPPLY

### Climate Change Indicators
- Carbon loading trends
- Average annual temperature

### Regulations
- Listed species
- Constituents of concern

### Storage
- Volume (AF)

# Adjourn


THE METROPOLITAN WATER DISTRICT OF
SOUTHERN CALIFORNIA
1928