The Metropolitan Water District of Southern California

The mission of the Metropolitan Water District of Southern California is to provide its service area with adequate and reliable supplies of high-quality water to meet present and future needs in an environmentally and economically responsible way.

Agenda

Board of Directors Workshop on Long-Term Planning Processes and Business Modeling - Final

March 18, 2024

9:00 AM

Monday, March 18, 2024 Meeting Schedule
09:00 a.m. BOD Wksp - LTRPPBM 10:15 a.m. Break 11:45 a.m. Lunch

Agendas, live streaming, meeting schedules, and other board materials are available here: https://mwdh2o.legistar.com/Calendar.aspx. If you have technical difficulties with the live streaming page, a listen-only phone line is available at 1-877-853-5257; enter meeting ID: 891 1613 4145. Members of the public may present their comments to the Board on matters within their jurisdiction as listed on the agenda via in-person or teleconference. To participate via teleconference 1-833-548-0276 and enter meeting ID: 815 2066 4276 or click https://us06web.zoom.us/j/81520664276pwd=a1RTQWh6V3h3ckFhNmdsUWpKR1c2Zz09

MWD Headquarters Building - 700 N. Alameda Street - Los Angeles, CA 90012
Teleconference Locations:
Borgo Santi Apostoli, 20 • Florence, Italy
525 Via La Selva • Redondo Beach, CA 90277
3024 Fairview Drive • Vista, CA 92084
City Hall • 303 W. Commonwealth Ave. • Fullerton, CA 92832
17853 Santiago Blvd., #107 • Villa Park, CA 92861
710 S Arroyo Blvd., • Pasadena, CA 91105
Princess Cruise / Emerald Princess • 3721 S.W. 30th Avenue, Fort Lauderdale, FL 33312

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1. Call to Order

a. Pledge of Allegiance: Vice Chair of the Board S. Gail Goldberg, San Diego County Water Authority

2. Roll Call

3. Determination of a Quorum

4. Opportunity for members of the public to address the Board limited to the items listed on the agenda. (As required by Gov. Code §54954.3(a))

5. SUBCOMMITTEE ITEMS - CAMP4W TASK FORCE

a. Member Agency Managers Task Force Members **21-3156**

Cesar Barrera, City of Santa Ana
Nina Jazmadarian, Foothill Municipal Water District
Shivaji Deshmukh, Inland Empire Utilities Agency
Dave Pedersen, Las Virgenes Municipal Water District
Anatole Falagan, Long Beach Water Department
Anselmo Collins, Los Angeles Department of Water and Power
Harvey De La Torre, Municipal Water District of Orange County
Dan Denham, San Diego County Water Authority
Kristine McCaffrey, Calleguas Municipal Water District
Tom Love, Upper San Gabriel Valley Municipal Water District
Craig Miller, Western Municipal Water District
Joe Mouawad, Eastern Municipal Water District
Stacie Takeguchi, Pasadena Water and Power

b. Training Workshop on Climate Adaptation and Scenario Planning **21-3157**

Session 1: Using Climate Science and Modeling
- Question and Answer
- Thought Exercise

Session 2: Scenario Planning
- Question and Answer

Session 3: Climate Adaptation Planning
- Question and Answer
- Introduce Climate Planning Exercise and Breakout Session 1
(Breakout into small groups: less than quorum)

Attachments: 03182024 LTRPPBM 5b Speaker Bios
03182024 LTRPPBM 5b and 7d Presentation
03182024 LTRPPBM 5b2 Presentation

6. ADJOURN TO 2:35 p.m., AFTER COMPLETION OF BREAKOUT SESSION 1

c. Reconvene for Discussion / Reflection on Breakout exercises **21-3158**
- Climate Planning Exercise and Breakout Session 2 (Breakout into small groups: less than quorum)

7. ADJOURN TO 3:35 p.m., AFTER COMPLETION OF BREAKOUT SESSION 2

d. Reconvene for Discussion / Reflection on Breakout exercises **21-3159**

Session 4: Signposting and CAMP4W Adaptive Management
- Question and Answer

8. FOLLOW-UP ITEMS

NONE

9. FUTURE AGENDA ITEMS

10. ADJOURNMENT

NOTE: Each agenda item with a committee designation will be considered and a recommendation may be made by one or more committees prior to consideration and final action by the full Board of Directors. The committee designation appears in parenthesis at the end of the description of the agenda item, e.g. (EOT). Board agendas may be obtained on Metropolitan's Web site https://mwdh2o.legistar.com/Calendar.aspx

Writings relating to open session agenda items distributed to Directors less than 72 hours prior to a regular meeting are available for public inspection at Metropolitan's Headquarters Building and on Metropolitan's Web site https://mwdh2o.legistar.com/Calendar.aspx.

Requests for a disability-related modification or accommodation, including auxiliary aids or services, in order to attend or participate in a meeting should be made to the Board Executive Secretary in advance of the meeting to ensure availability of the requested service or accommodation.

Subcommittee on Long-Term Regional Planning Processes and Business Modeling
Climate Adaptation Master Plan for Water Task Force

Training Workshop

March 18, 2024

Speaker Bios

Dr. Alex Hall is a professor in the Department of Atmospheric and Oceanic Sciences at UCLA, Director of the Center for Climate Science at the UCLA Institute of the Environment and Sustainability, and interim Director of the UCLA Sustainable LA Grand Challenge. His research is aimed at predicting and understanding climate change impacts at scales relevant to decision-makers, especially in the State of California. Alex and his team are currently studying the future of wildfire in California and are working with water management agencies in the Los Angeles region to ensure sustainability of water resources under climate change.

Alex co-founded the Climate & Wildfire Institute, a non-profit org, to tackle the rapidly-emerging threat of megafire in the Western U.S. He is a contributing author on the Fifth U.S. National Climate Assessment and was also a Lead Author of the Intergovernmental Panel on Climate Change 5th Assessment Report's chapter on regional climate change, a Contributing Author to its chapter on climate model evaluation and Coordinating Lead Author of the Los Angeles Region Report, part of California's Fourth Climate Change Assessment. In 2022, Alex received the UCLA Public Impact Research Award, and in 2019, he was awarded the American Geophysical Union (AGU) Future Horizons in Climate Science Turco Lectureship.

Dr. Robert Lempert is a principal researcher at the RAND Corporation and Director of the Frederick S. Pardee Center for Longer Range Global Policy and the Future Human Condition. His research focuses on climate risk management and decision-making under uncertainty. Dr. Lempert was a coordinating lead author for Working Group II of the United Nation's Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report and the inaugural president of the Society for Decision Making Under Deep Uncertainty (http://www.deepuncertainty.org). A Professor of Policy Analysis in the Pardee RAND Graduate School, Dr. Lempert is an author of the book Shaping the Next One Hundred Years: New Methods for Quantitative, Longer-Term Policy Analysis.

Dr. Juliette Finzi Hart is the Director of Science Policy and Engagement, at Pathways Climate Institute, a SF-based consulting firm that focuses on climate adaptation science and planning. Pathways works with entities, such as Caltrans, to the Port and Public Utilities Commission of San Francisco to communities of all sizes throughout California, to develop cutting edge climate science and climate adaptation plans. Prior to joining Pathways, Dr. Finzi Hart worked at the Governor's Office of Planning and Research and lead the Climate Services Program for the Integrated Climate Adaptation and Resiliency Program, the state's only dedicated climate adaptation program. There she helped write the 2021 CA Climate Adaptation Strategy. She was an Oceanographer at USGS, working with the team that developed the Coastal Storm Modeling Systems. She got her start at the University of Southern California, where she received her Ph.D. in Ocean Sciences in 2007 and served as research faculty and Marine and Climate Science Specialist for the USC Sea Grant Program for a decade. She is an author on both the Fourth and Fifth National Climate Assessments, as well as leading studies

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

UCLA Sustainable LA Grand Challenge

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Why is climate change occurring?

At the most basic level:

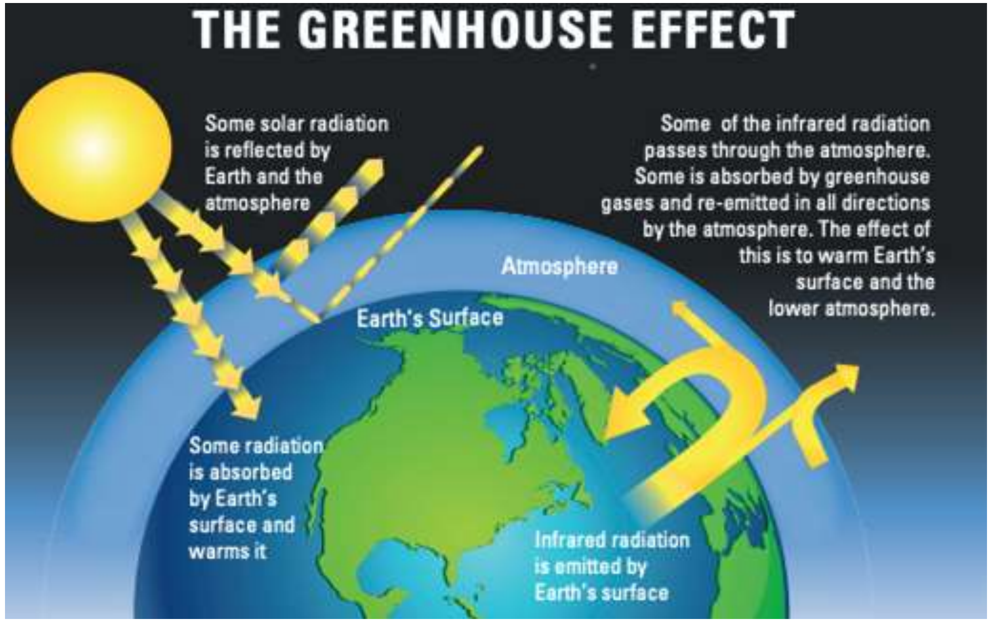
➤ To remain at the same temperature, objects need to maintain radiative balance:

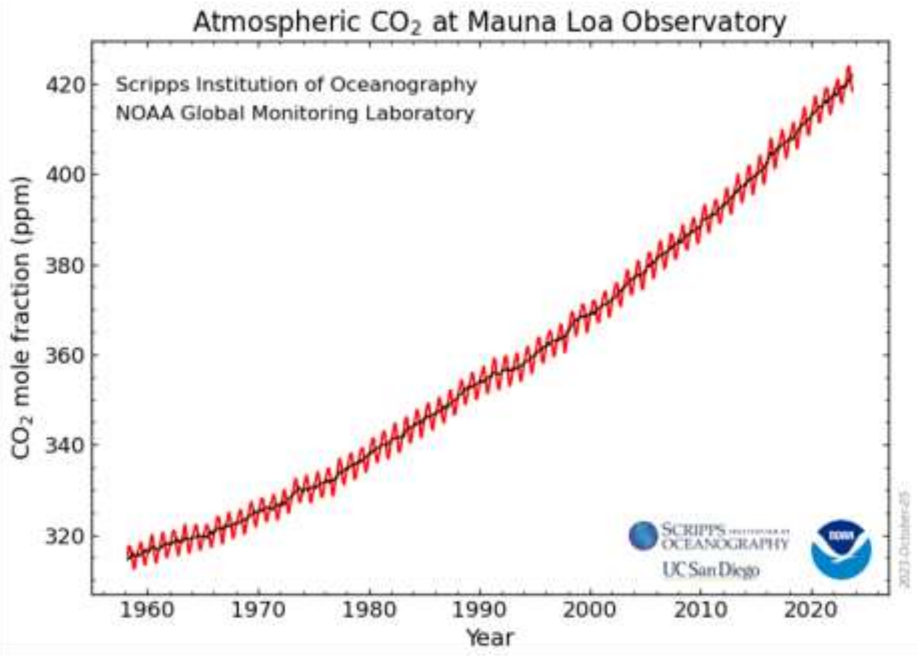
Energy coming in = Energy going out

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

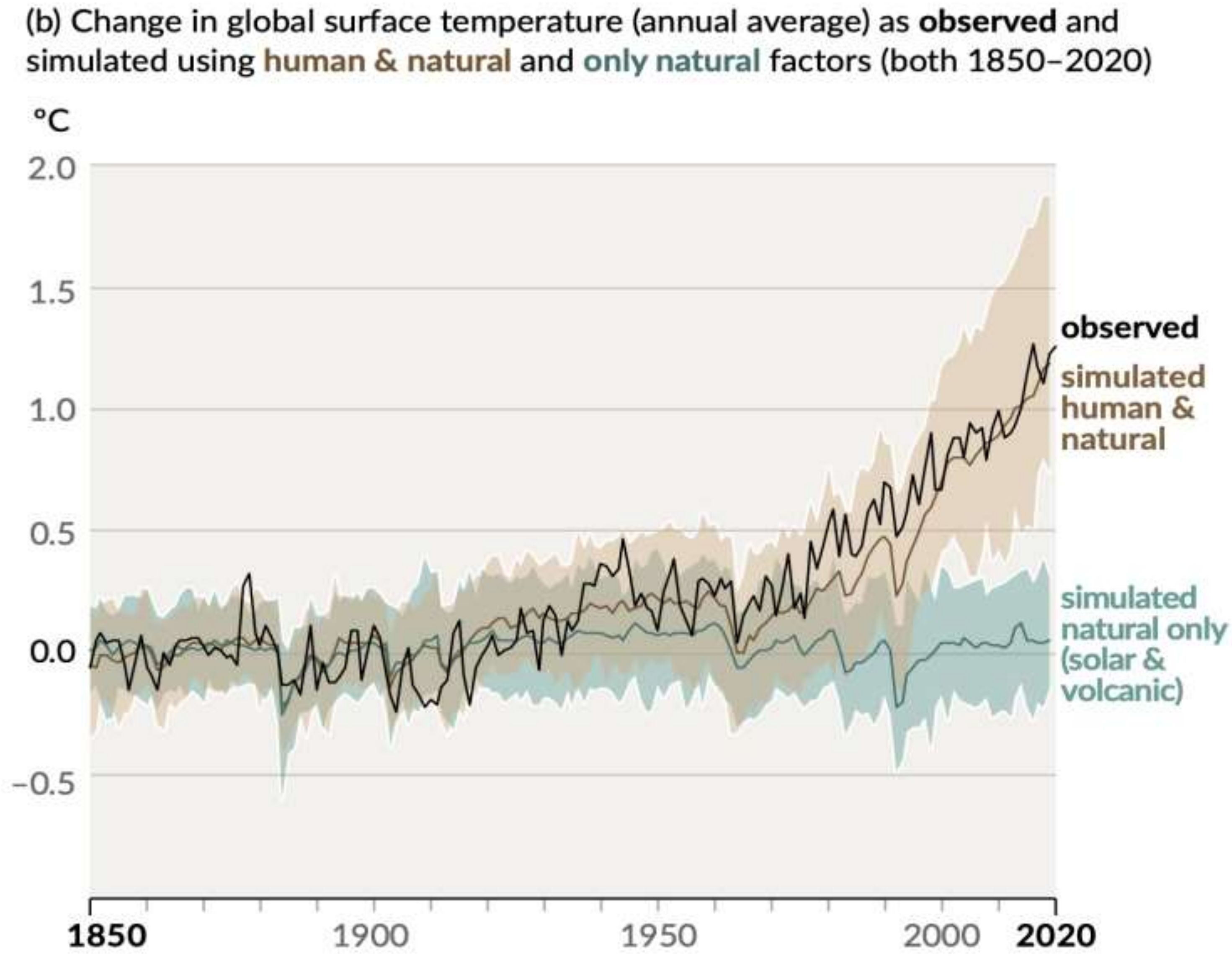
➤ Excess energy impacting the surface due to the greenhouse gases' downward emission causes surface temperatures to increase.

➤ This effect increases with increasing greenhouse gases





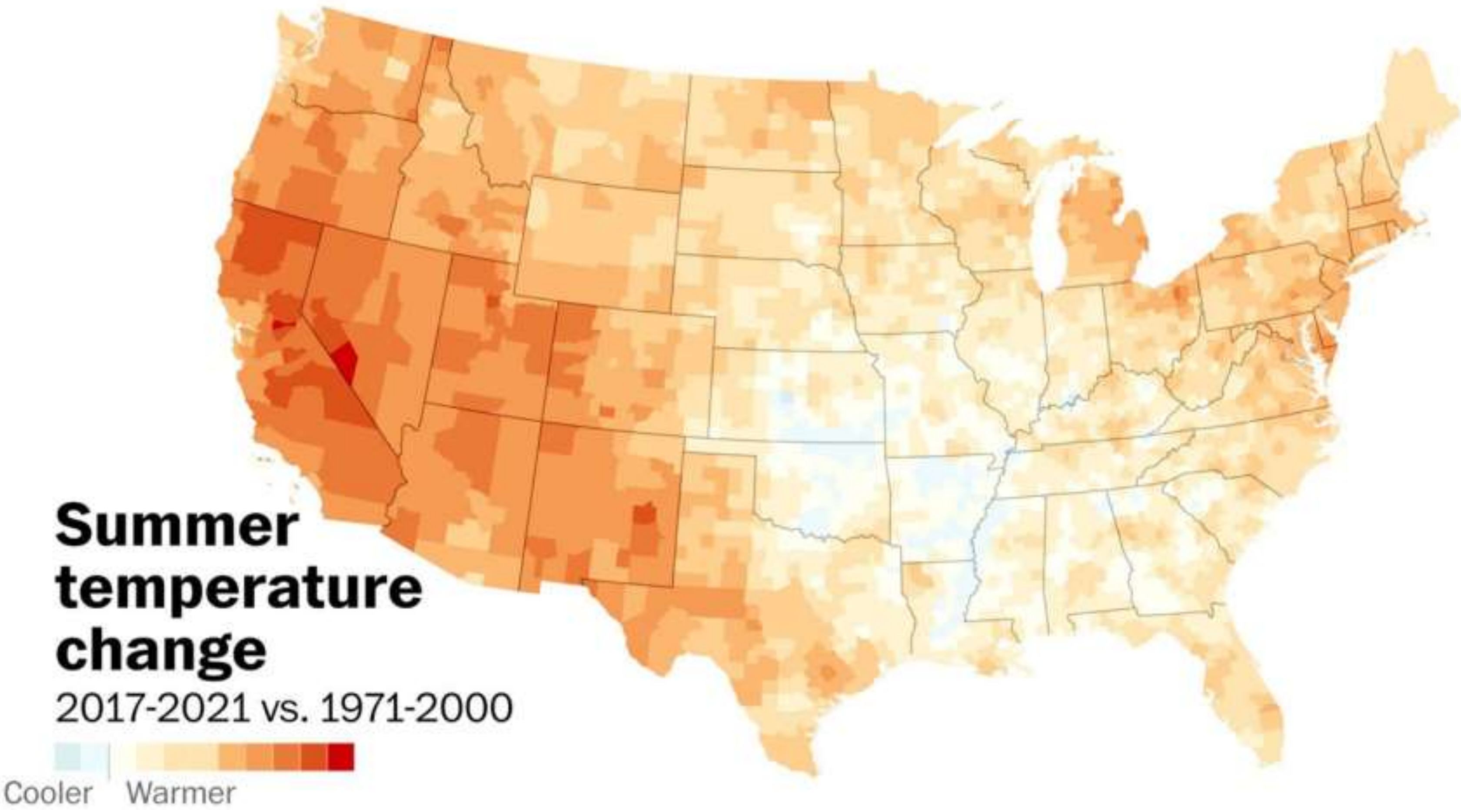
How do we know climate change is caused by humans?



Temperatures [ºC]

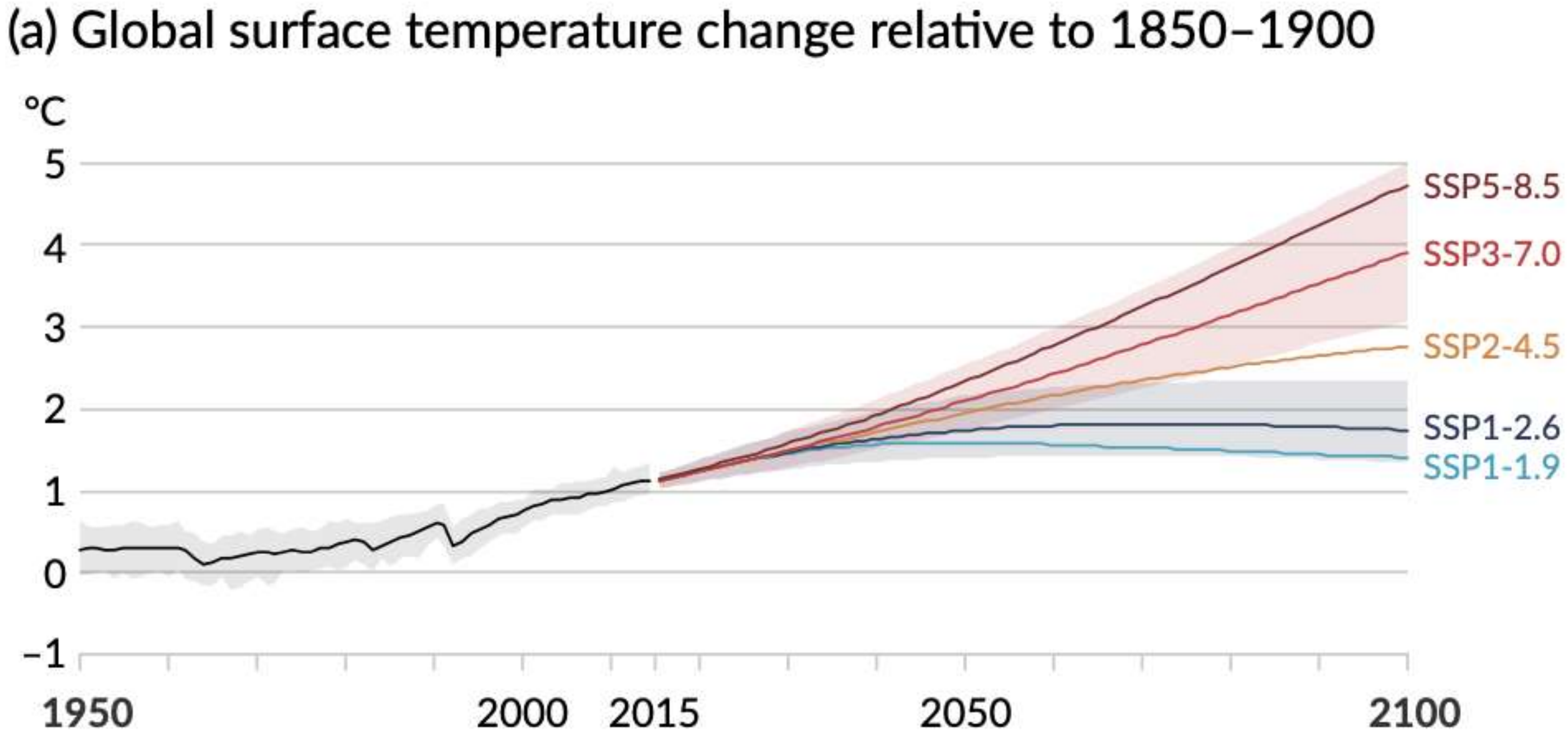
Time [years]

Recent Temperatures in the U.S. Already Showing Warming



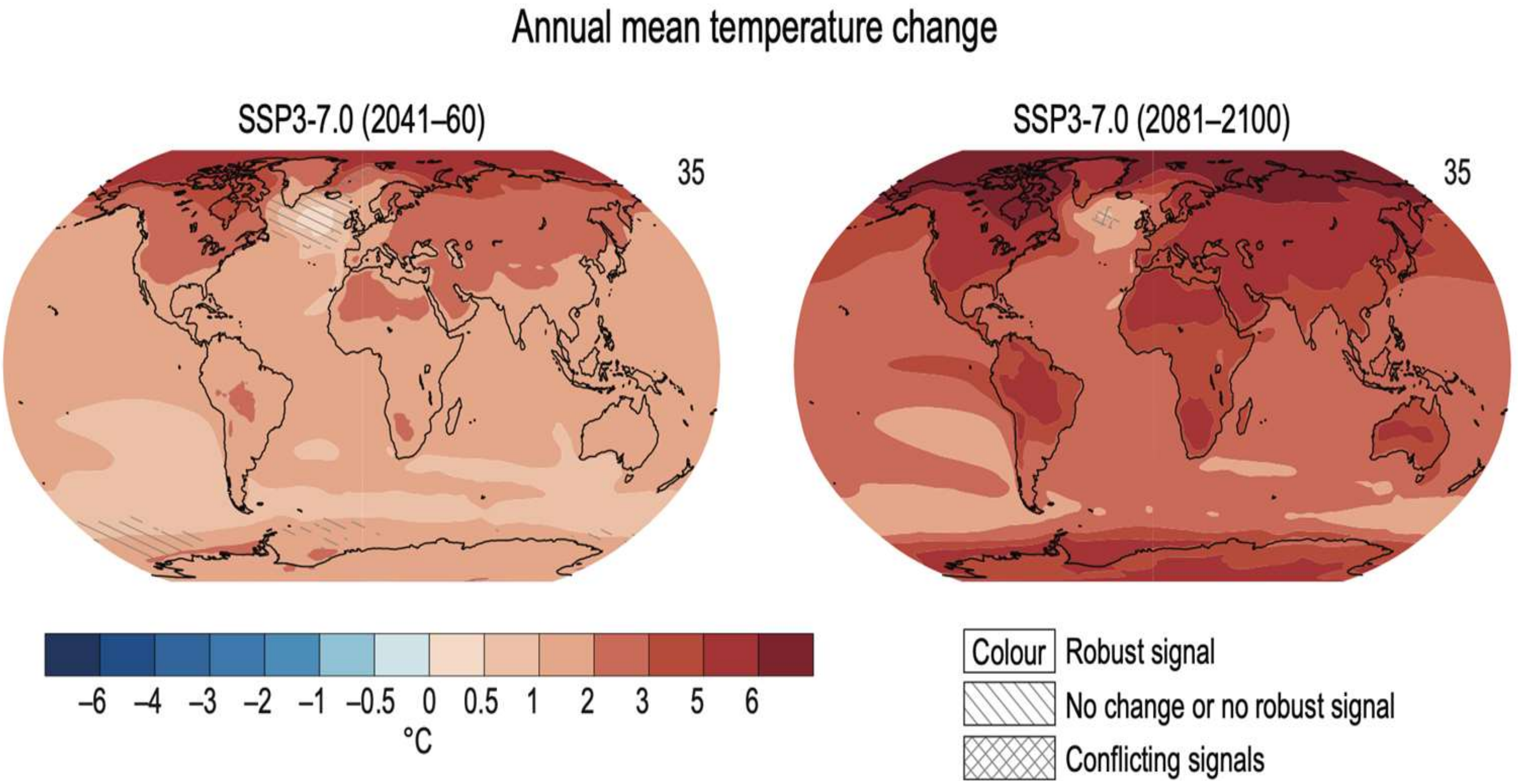
Climate Projections: Global Climate Models

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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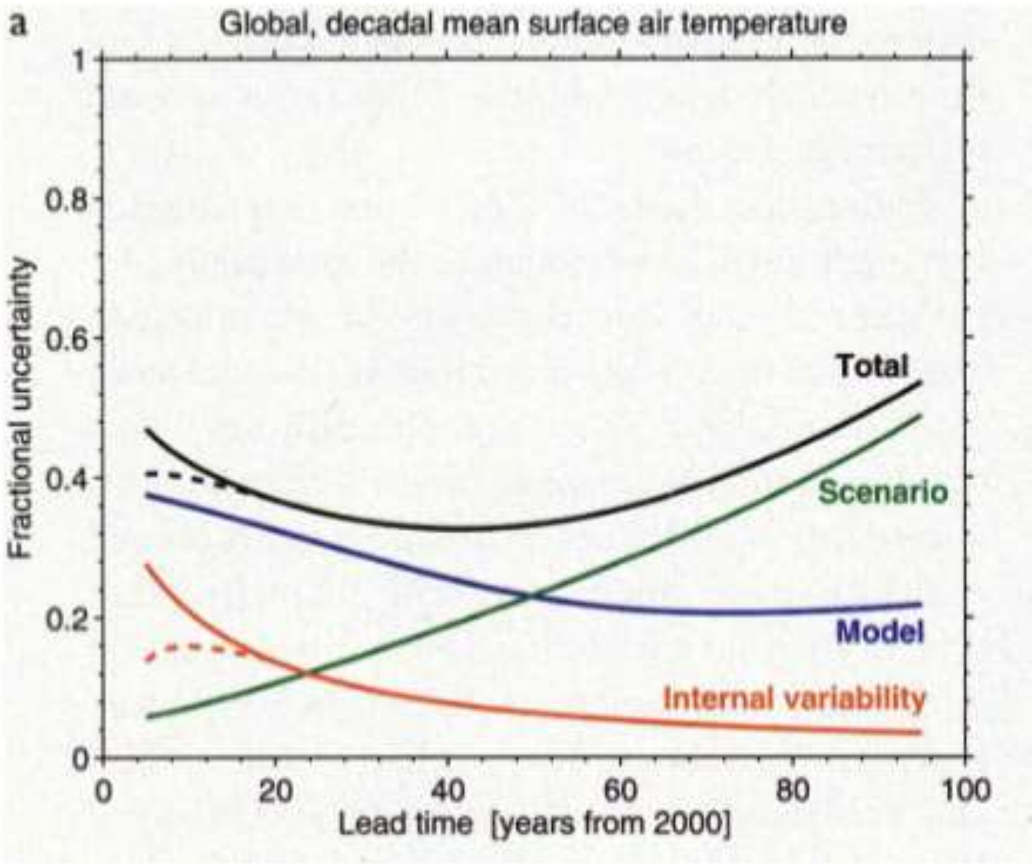
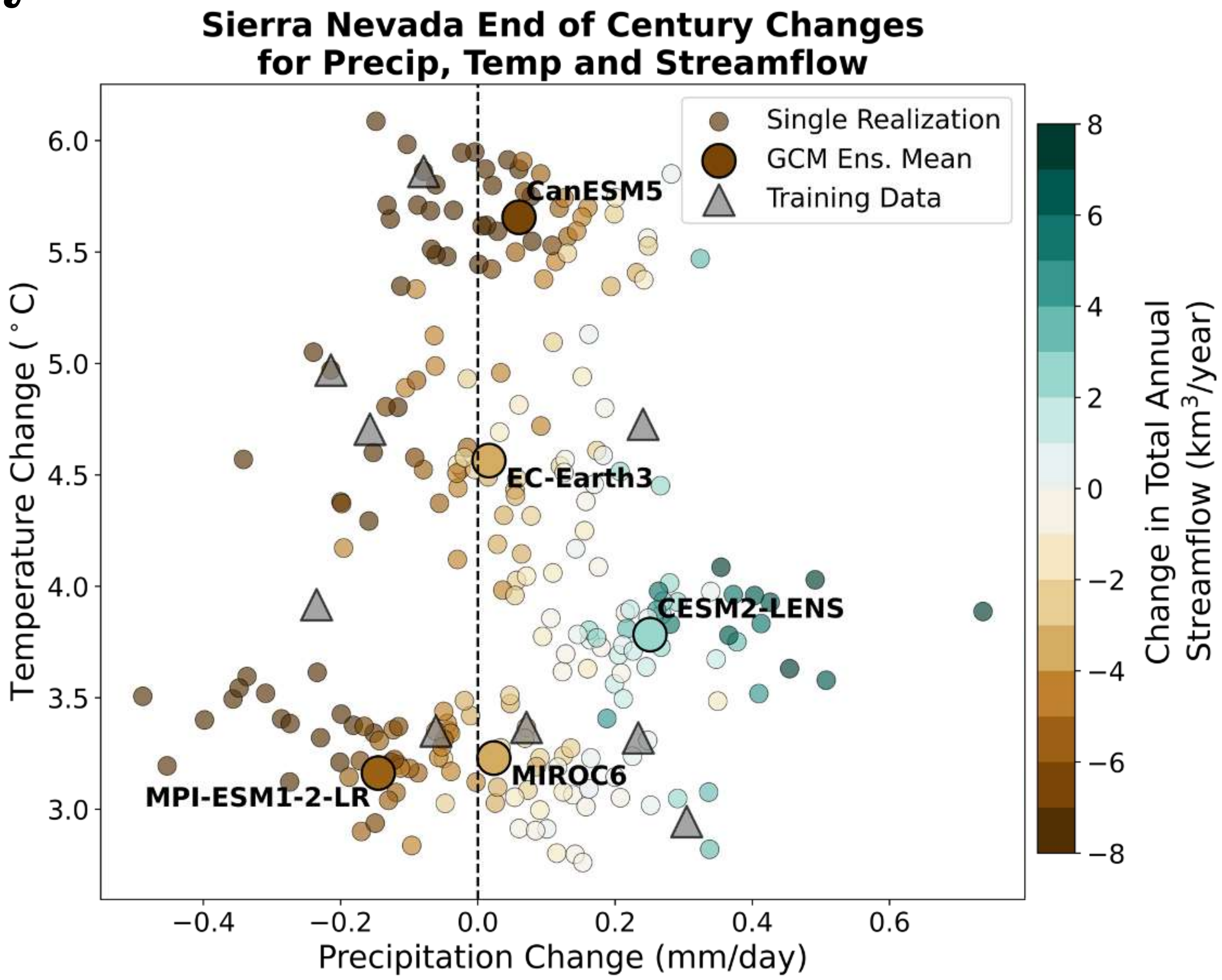
The uncertainty sources vary with forecast lead time

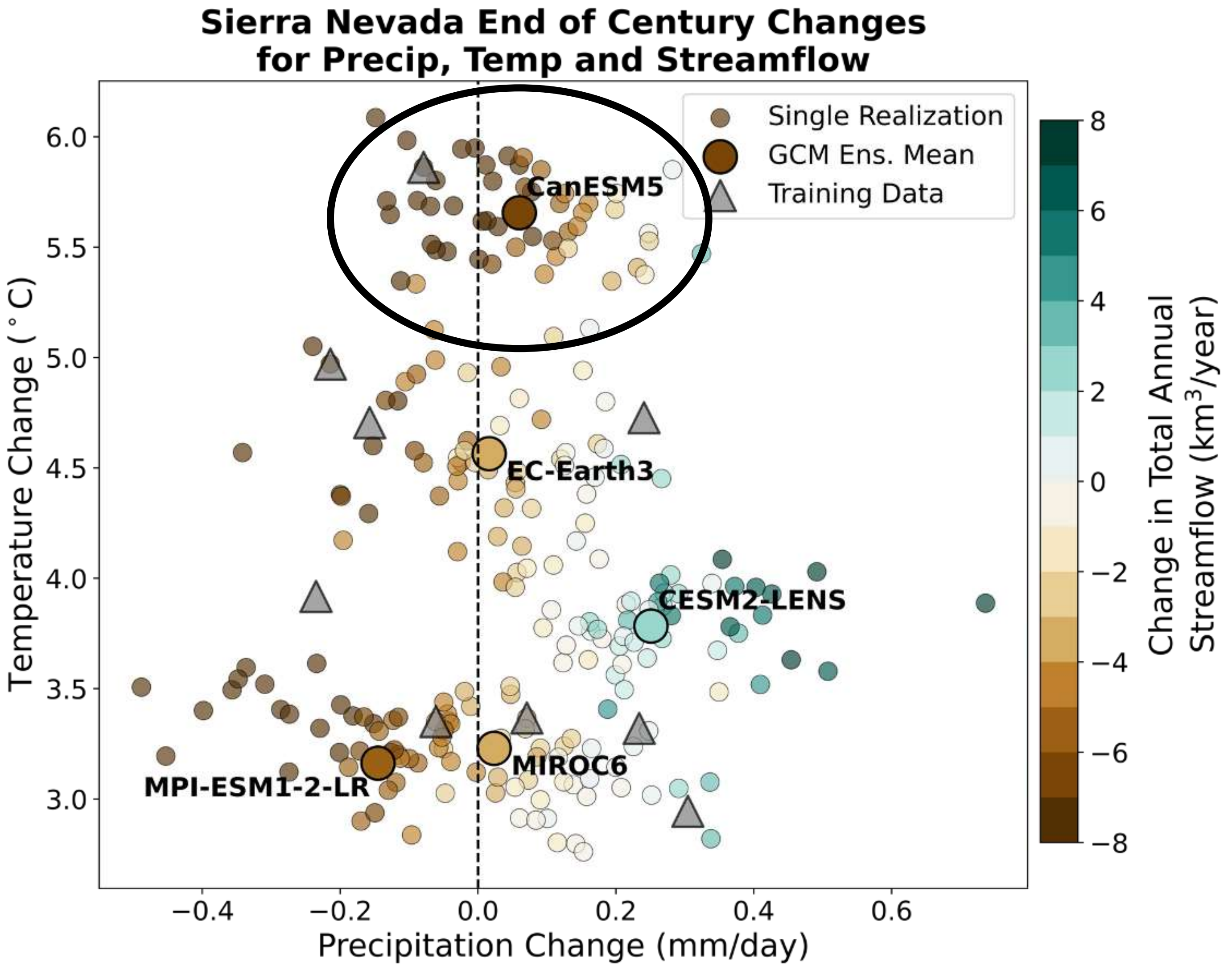


Effect of Internal Variability



Downscaled data, same emissions scenario (SSP3-7.0)

Effect of Internal Variability



Downscaled data, same emissions scenario (SSP3-7.0)

Climate Projections: Downscaling

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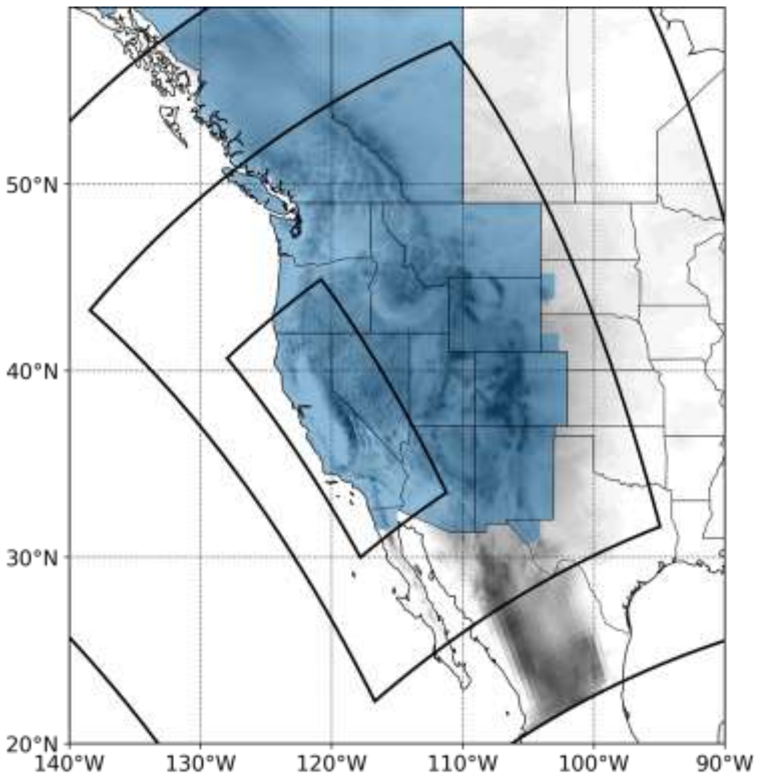

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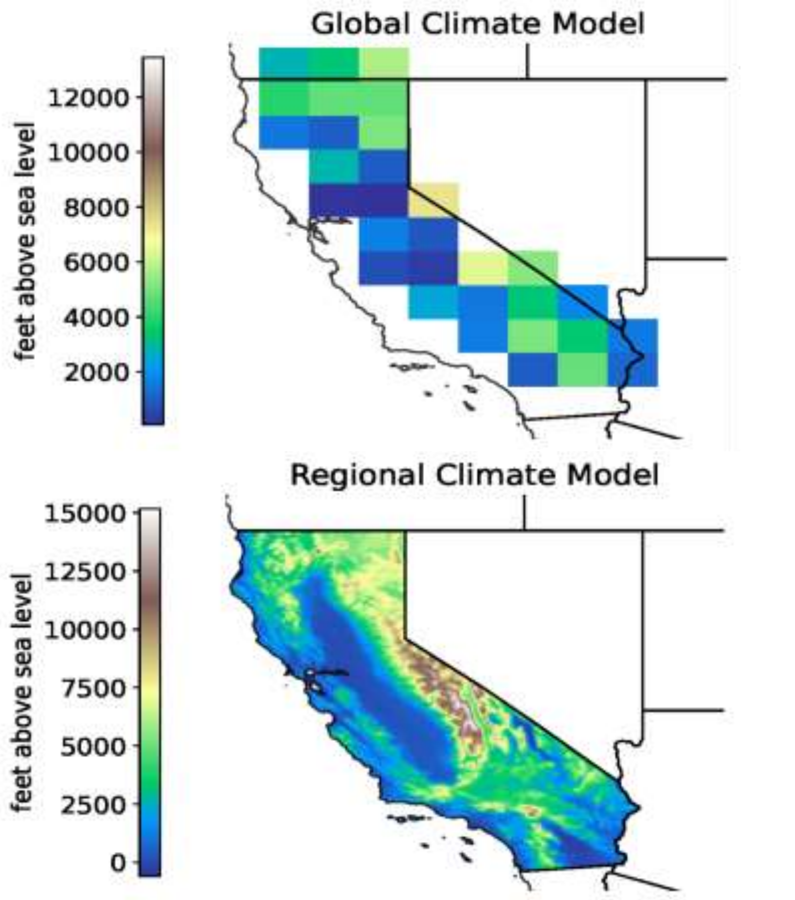
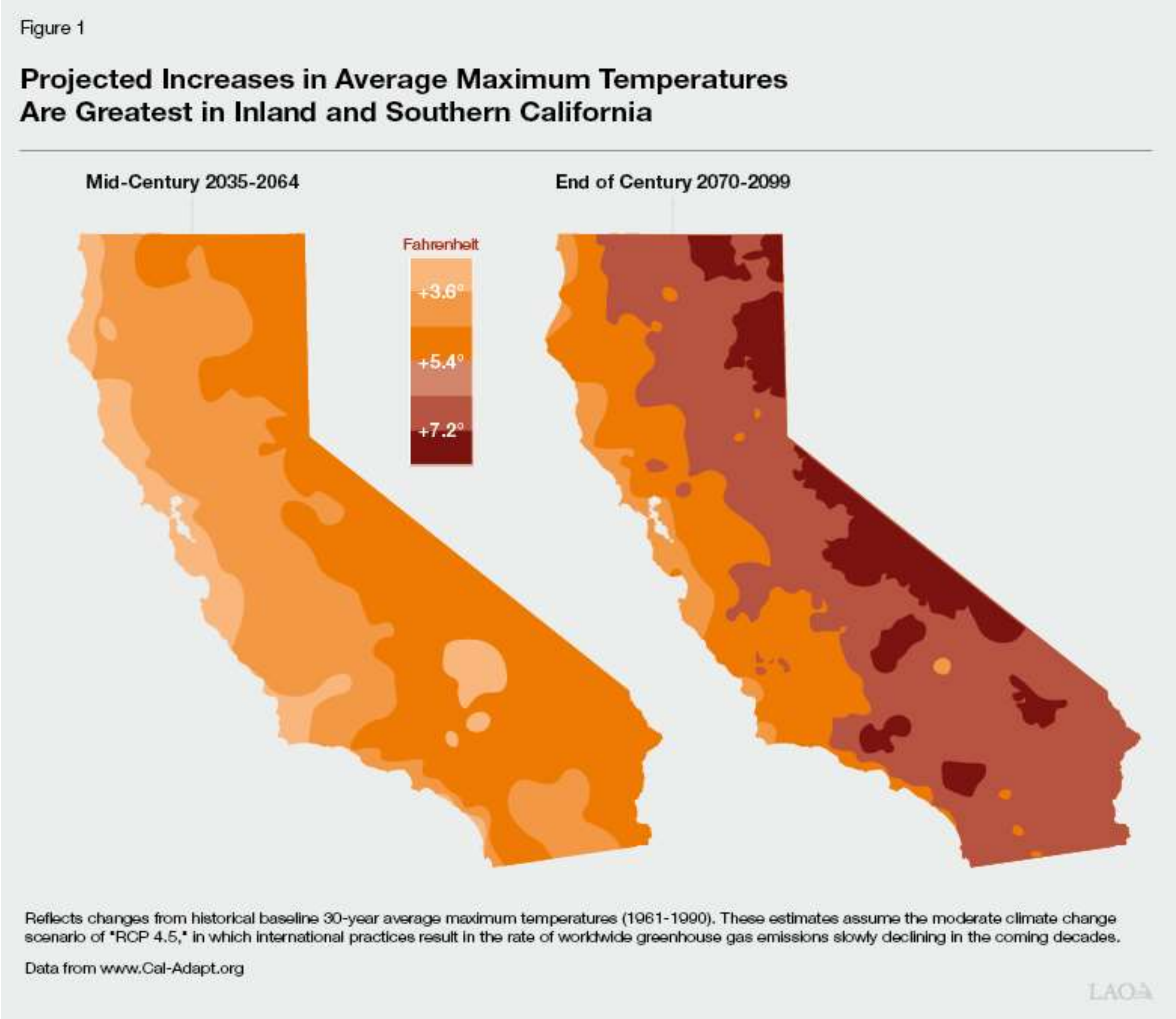


Global Climate Model

Regional Climate Model

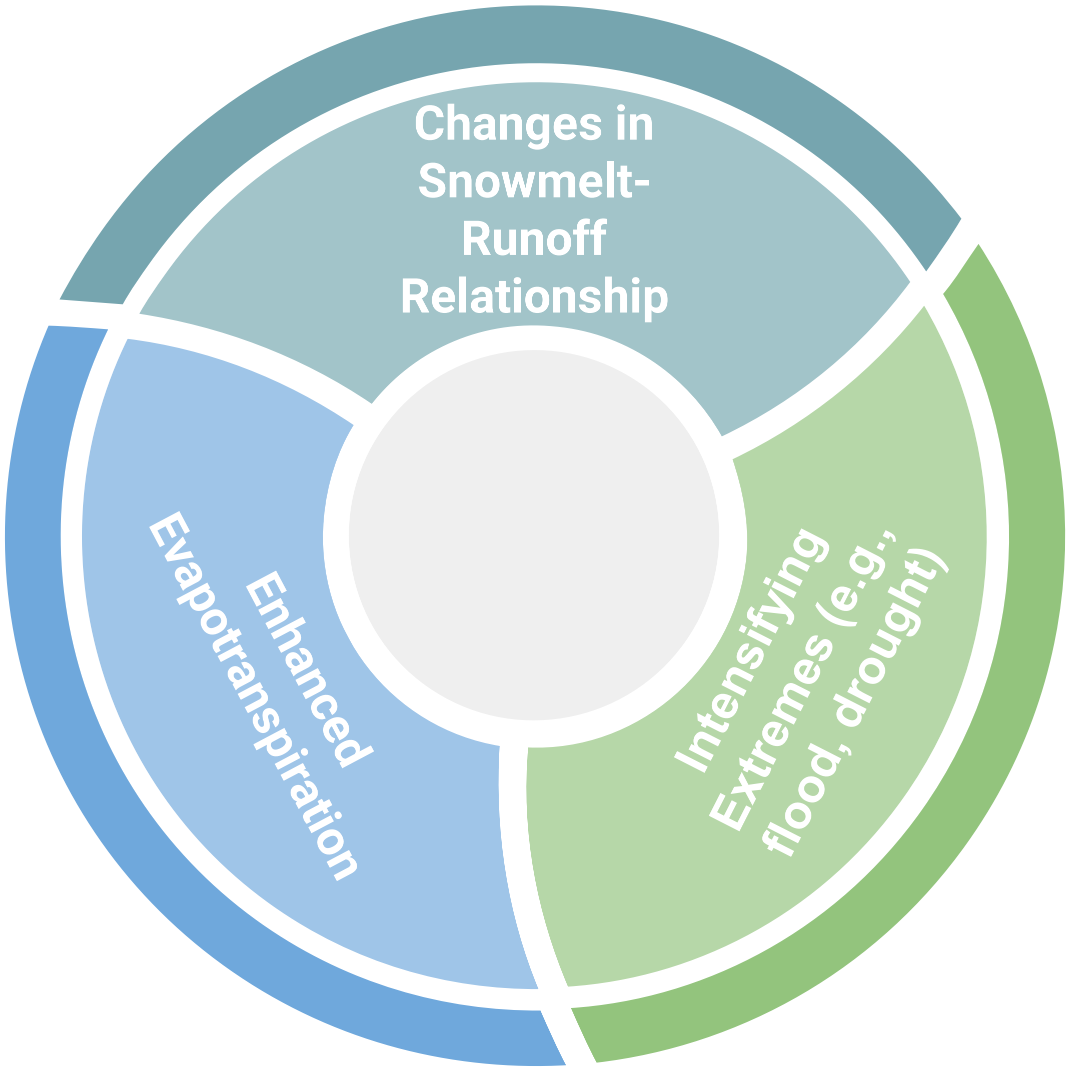
High-Resolution Downscaled Solution

California's Projected (Downscaled) Future: Maximum Temperature

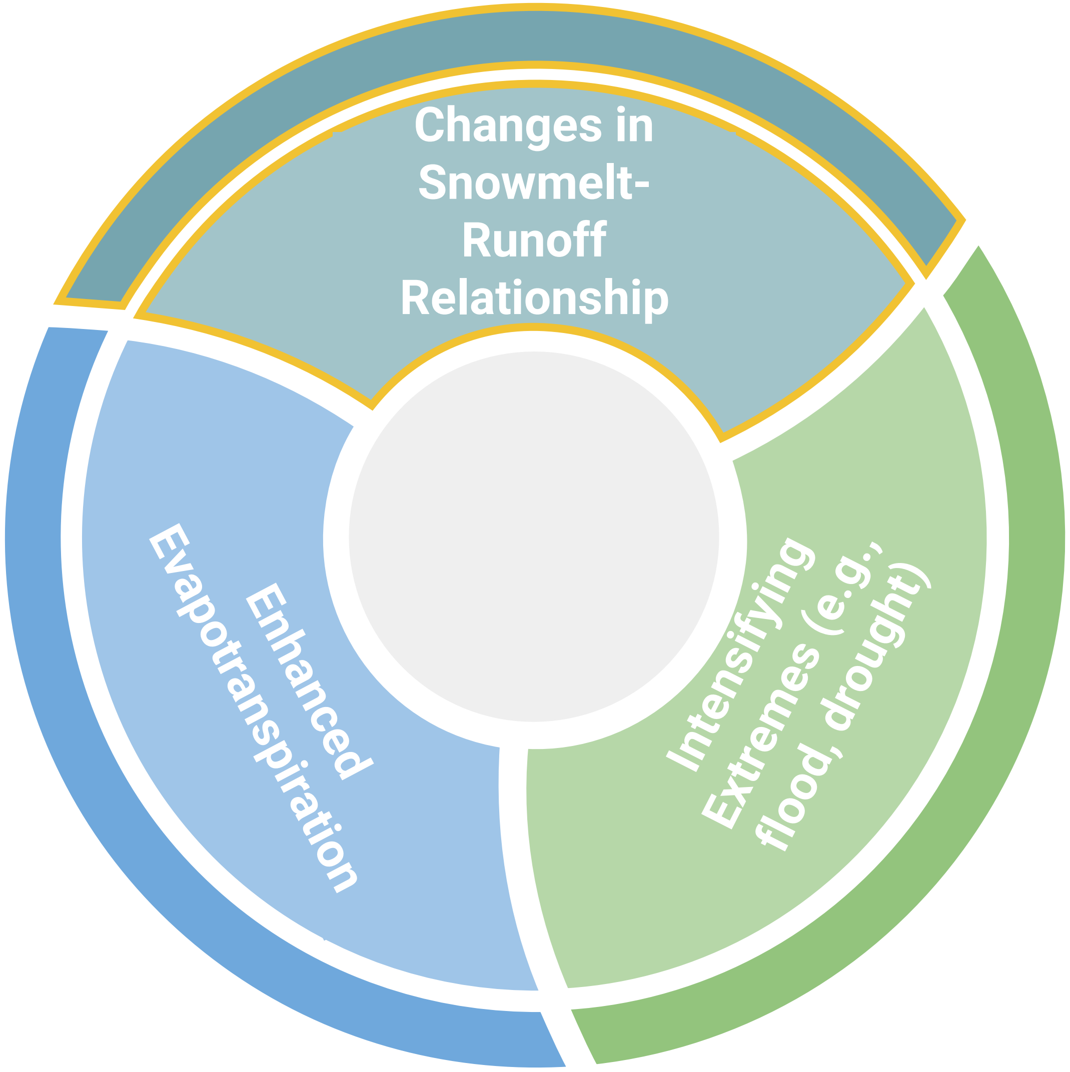


RCP4.5
emissions scenario

Aspects of the WUS Water Cycle that Respond to Climate



Aspects of the WUS Water Cycle that Respond to Climate

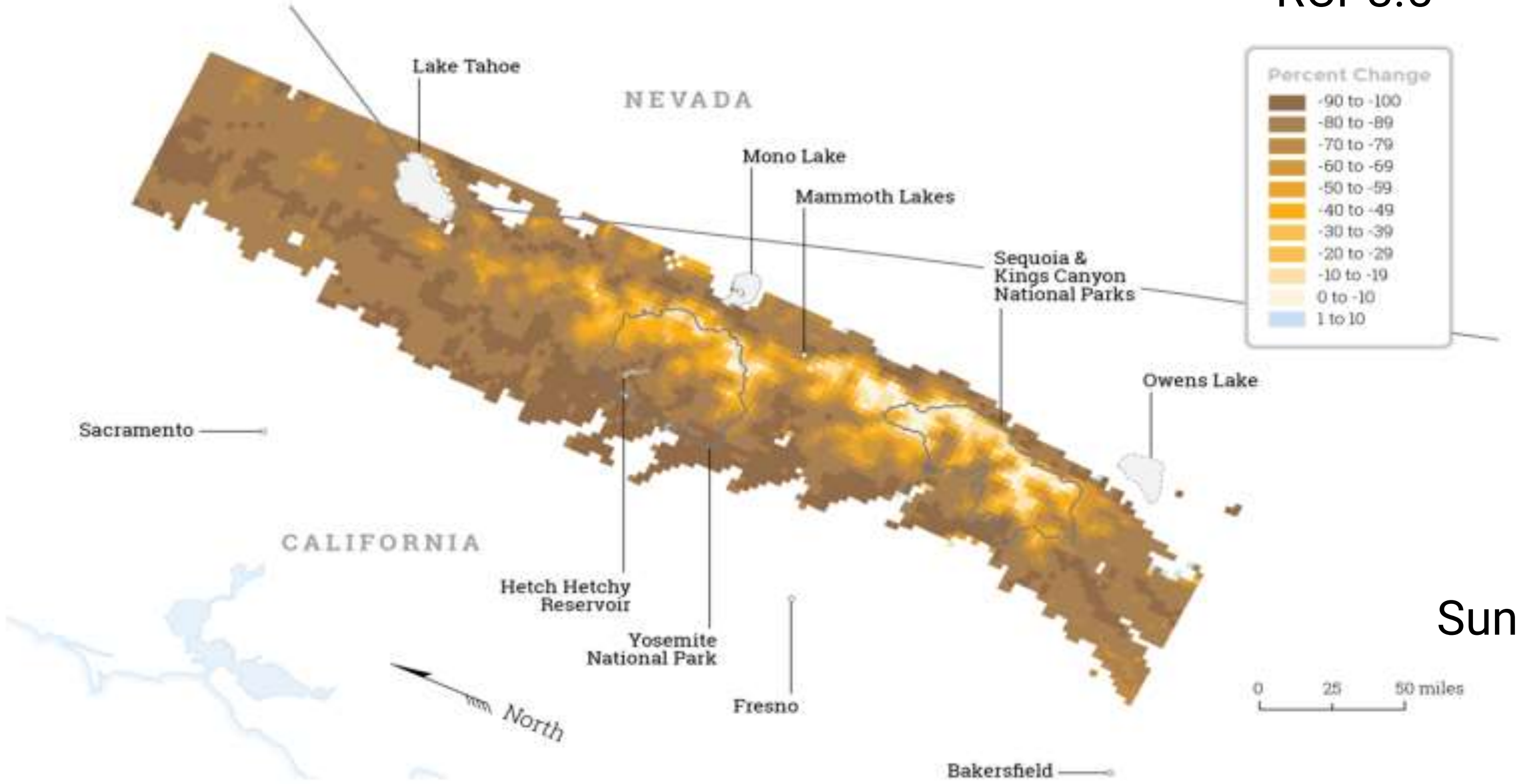


Climate Warming is Projected to Cause a Reduction in Sierra Snowpack

Sierra Nevada Mountains

Change in Snow Water Equivalent, April 1

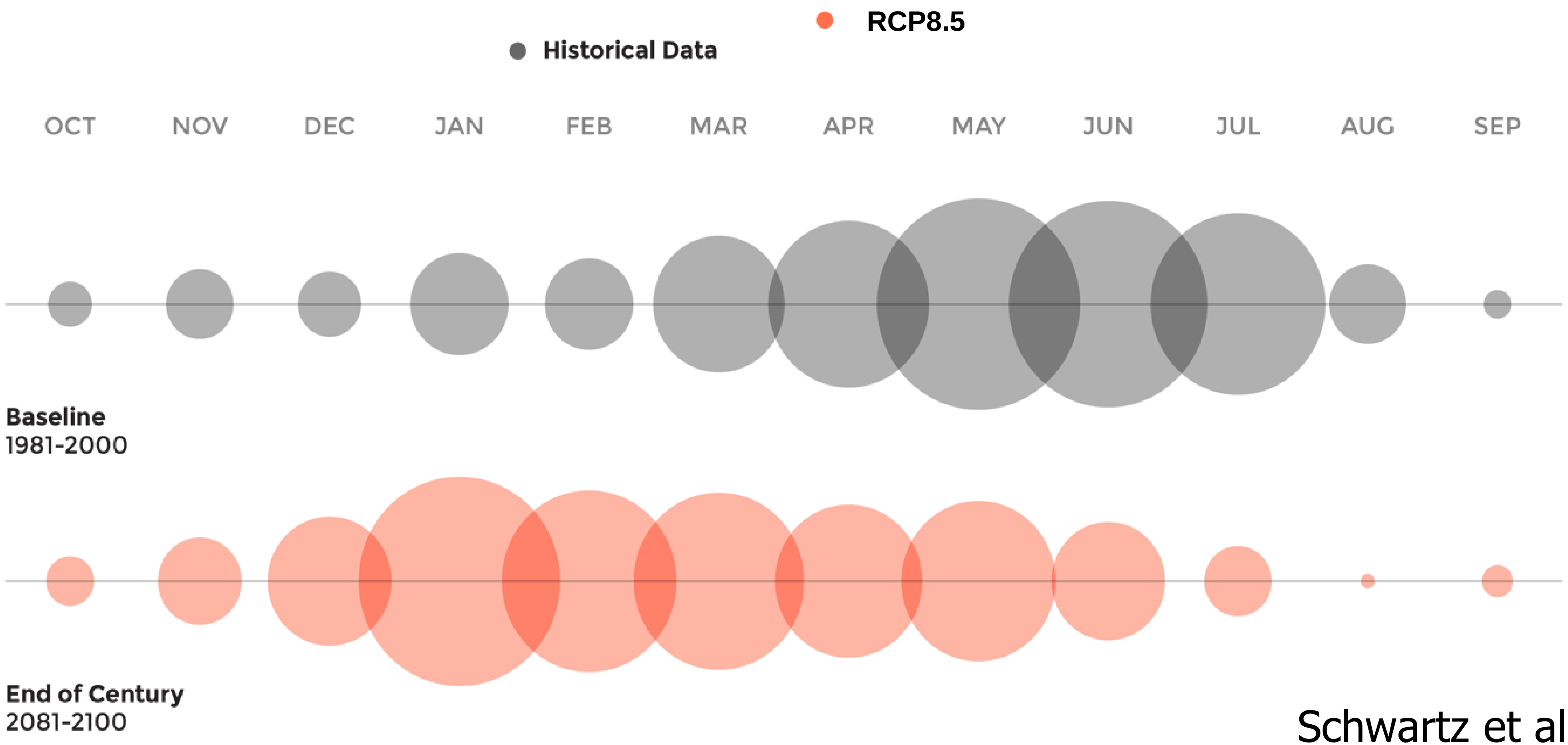
2081–2100
RCP8.5



Sun et al 2019

Downscaled Data, RCP8.5

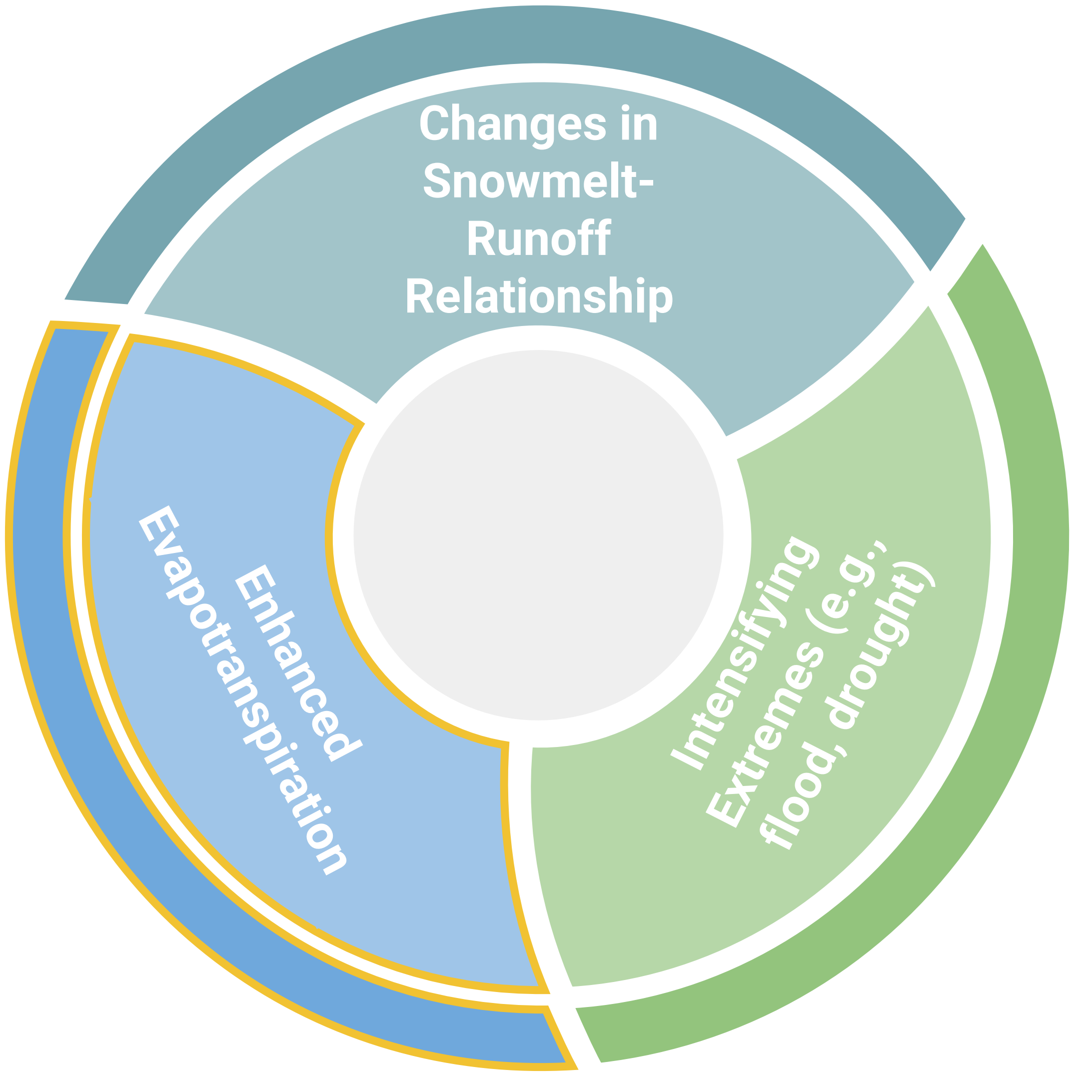
The loss of snow is associated with a change in the timing of Sierra Runoff



Schwartz et al. 2017

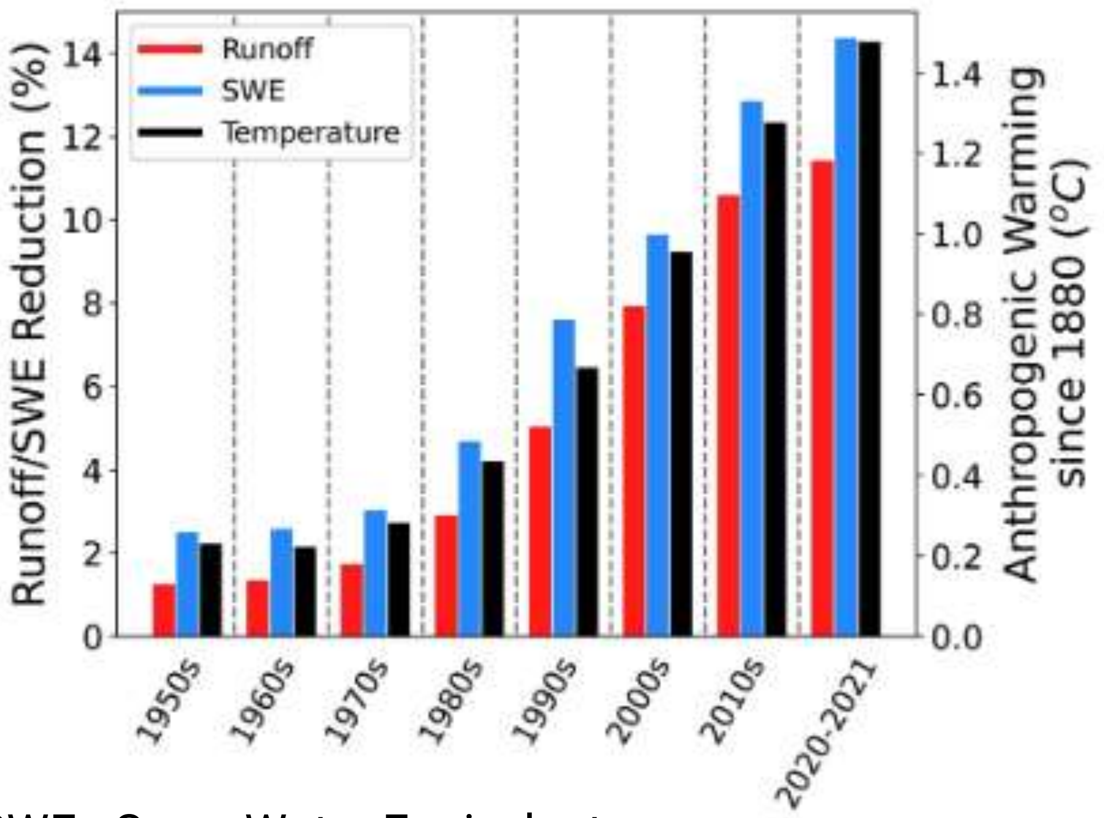
Downscaled Data

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

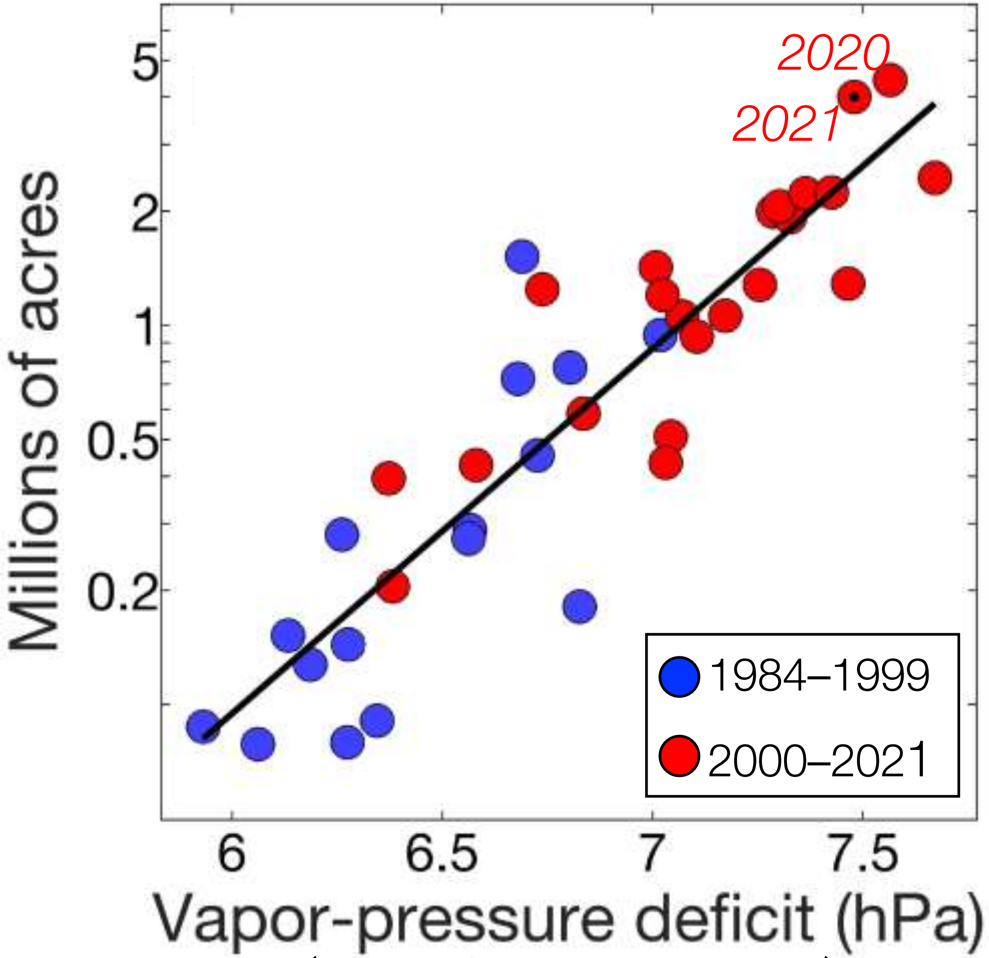
Figure 7. Reductions in runoff and peak integrated SWE, based on the overall impact of warming and CO_2, and how these reductions relate to anthropogenic warming.

Downscaled Reanalysis Data

Bass et al 2023

Temperature increases wildfire breadth and intensity

Fire in forests



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

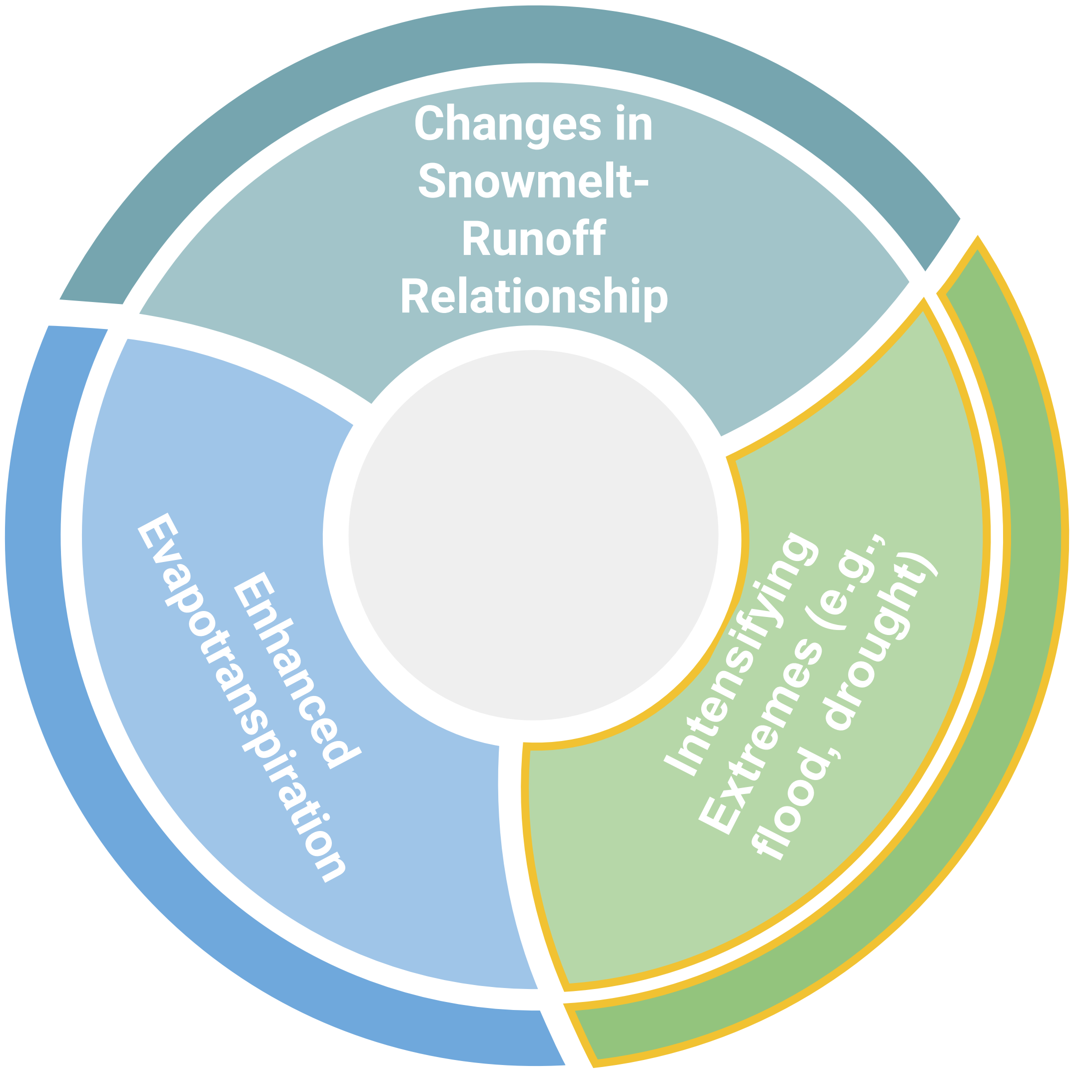
- As temperature increases so does the *Vapor Pressure Deficit (VPD)*, a metric for how dry the air is. VPS scales with warming.
- Drier air leads to drier fuels for wildfires
- It has been shown that increases in VPD leads to increases in millions of acres burned

Observed Data

Wildfires lead to sediment runoff, which can affect reservoirs

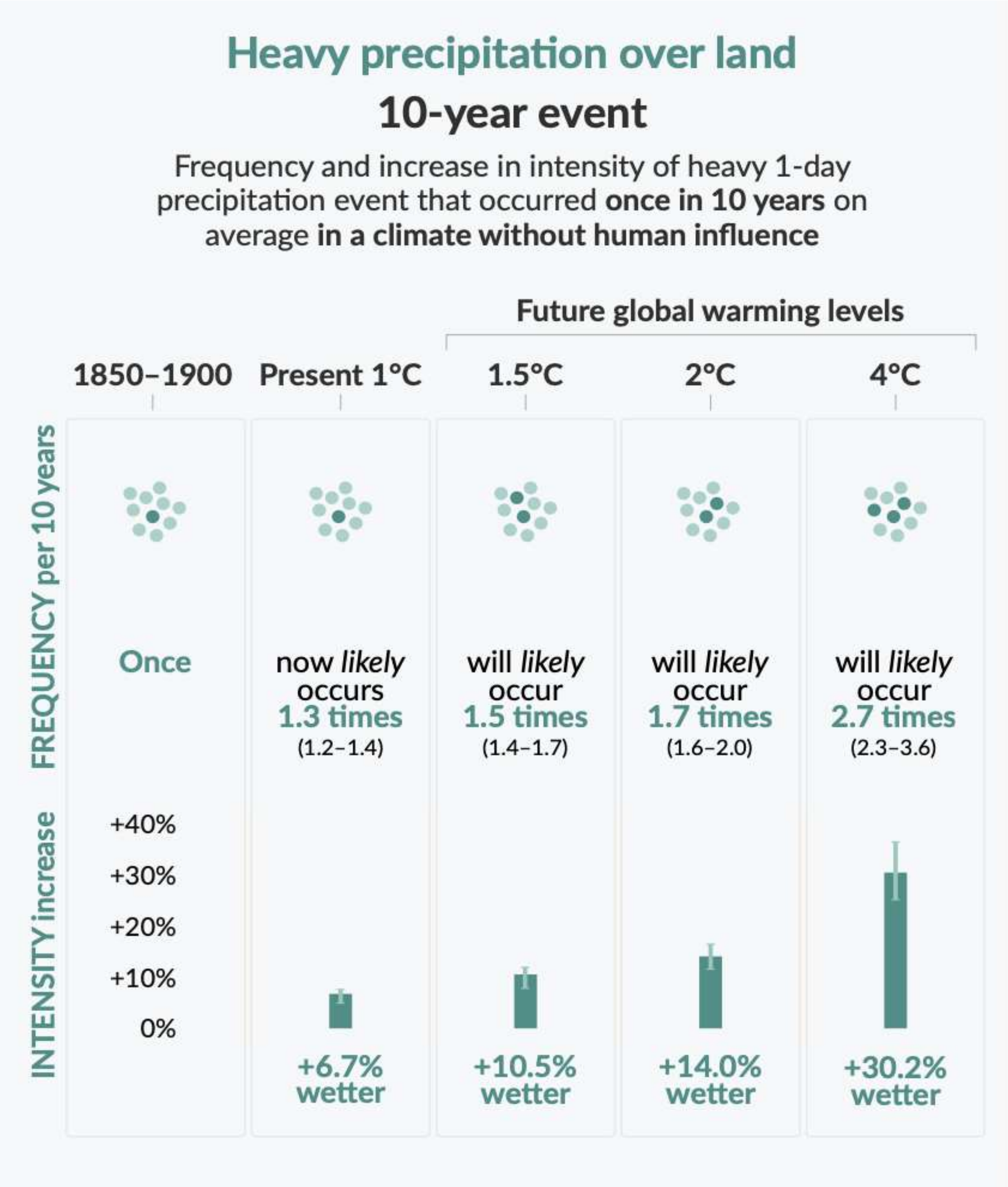
There has been so much sedimentation at the Paonia Reservoir in Gunnison County, Colorado, that the bottom of the lake is now above the outlet. (Jeffrey Beall / Flickr)

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

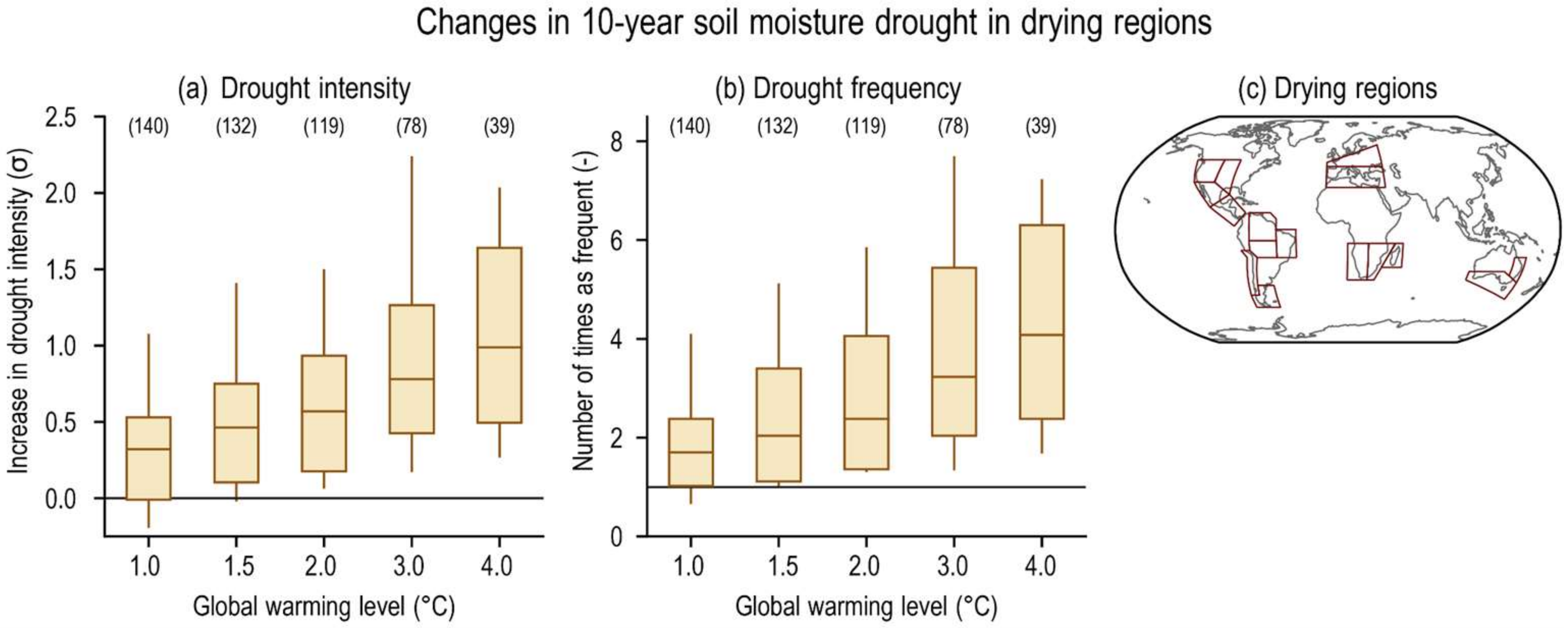
Huang et al. 2020

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

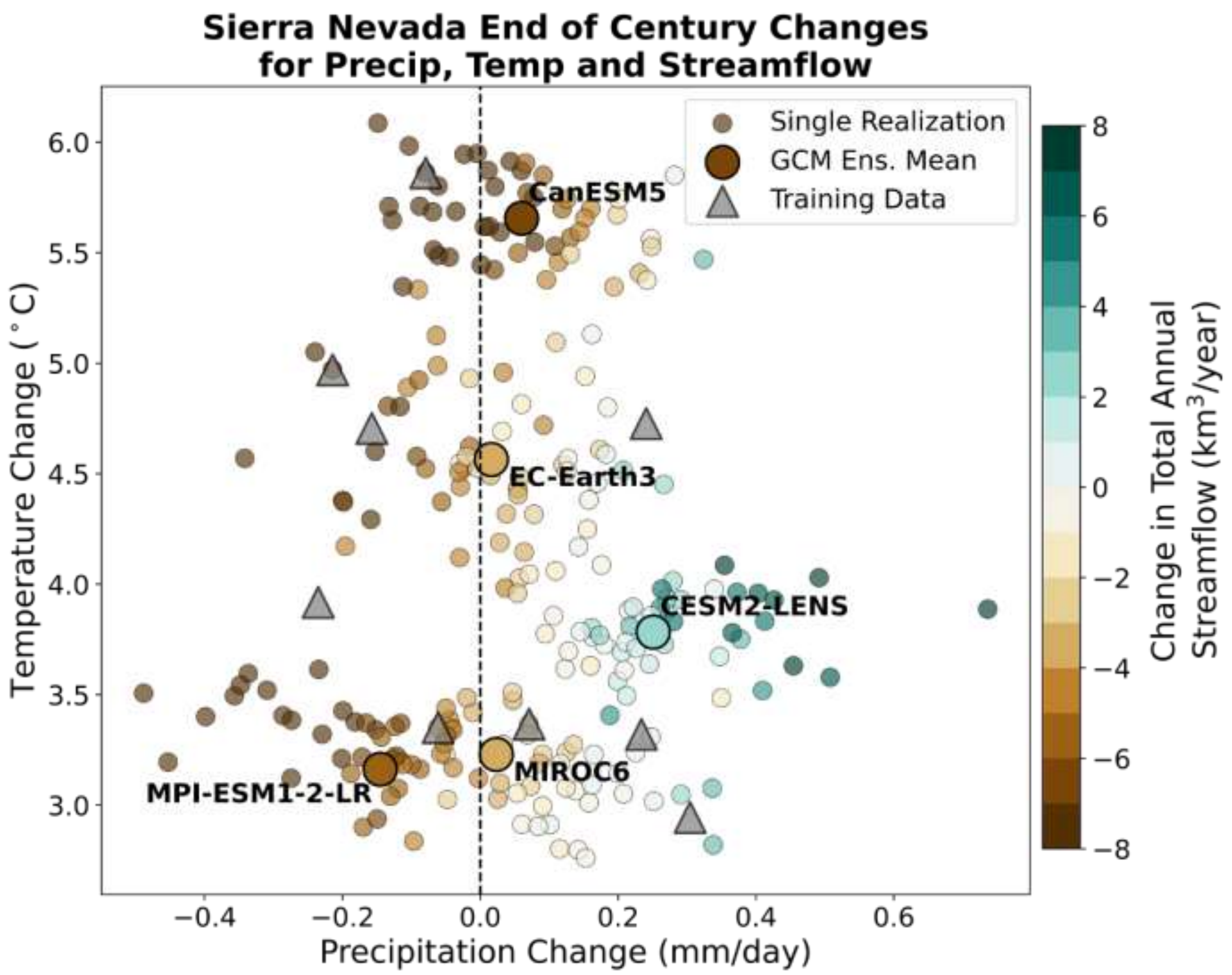
Drought frequency increases globally with climate warming



IPCC 6th Assessment Report

Global Model Data

Future of the Drought

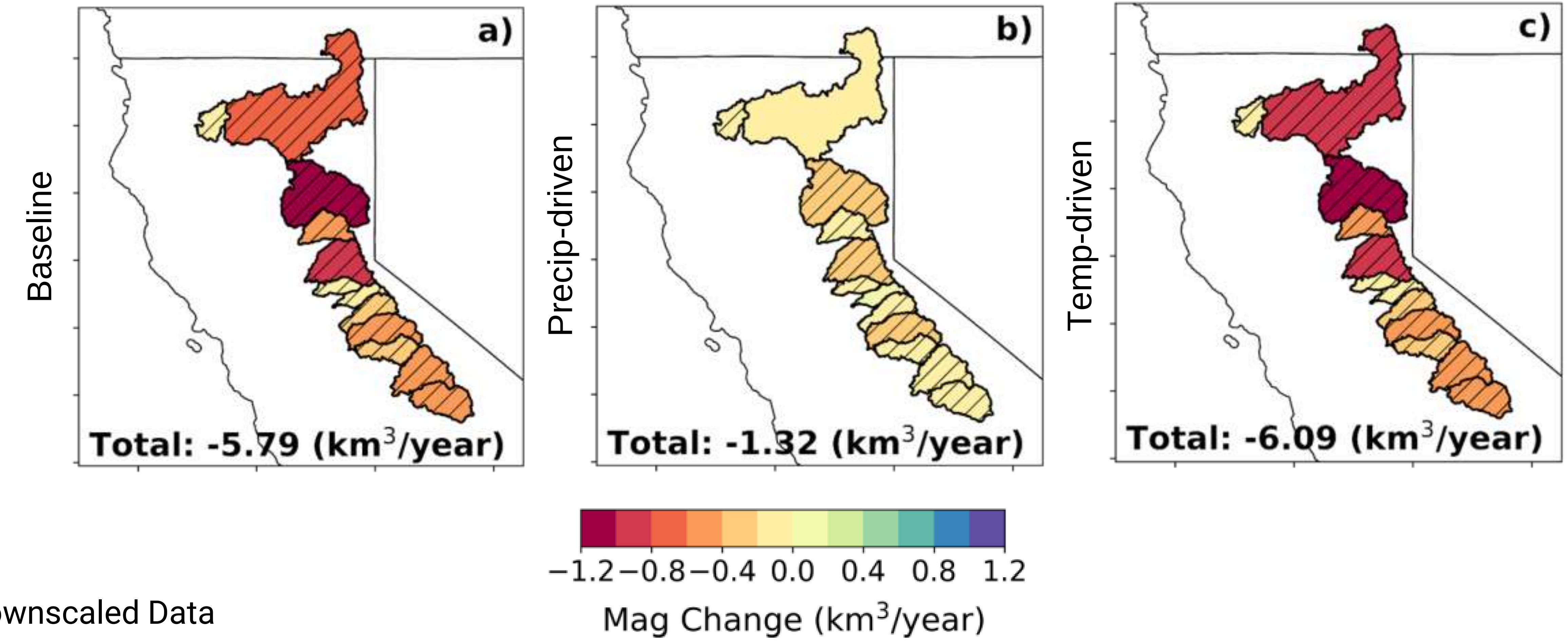


Temperature increases hydrologic (streamflow) drought severity

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

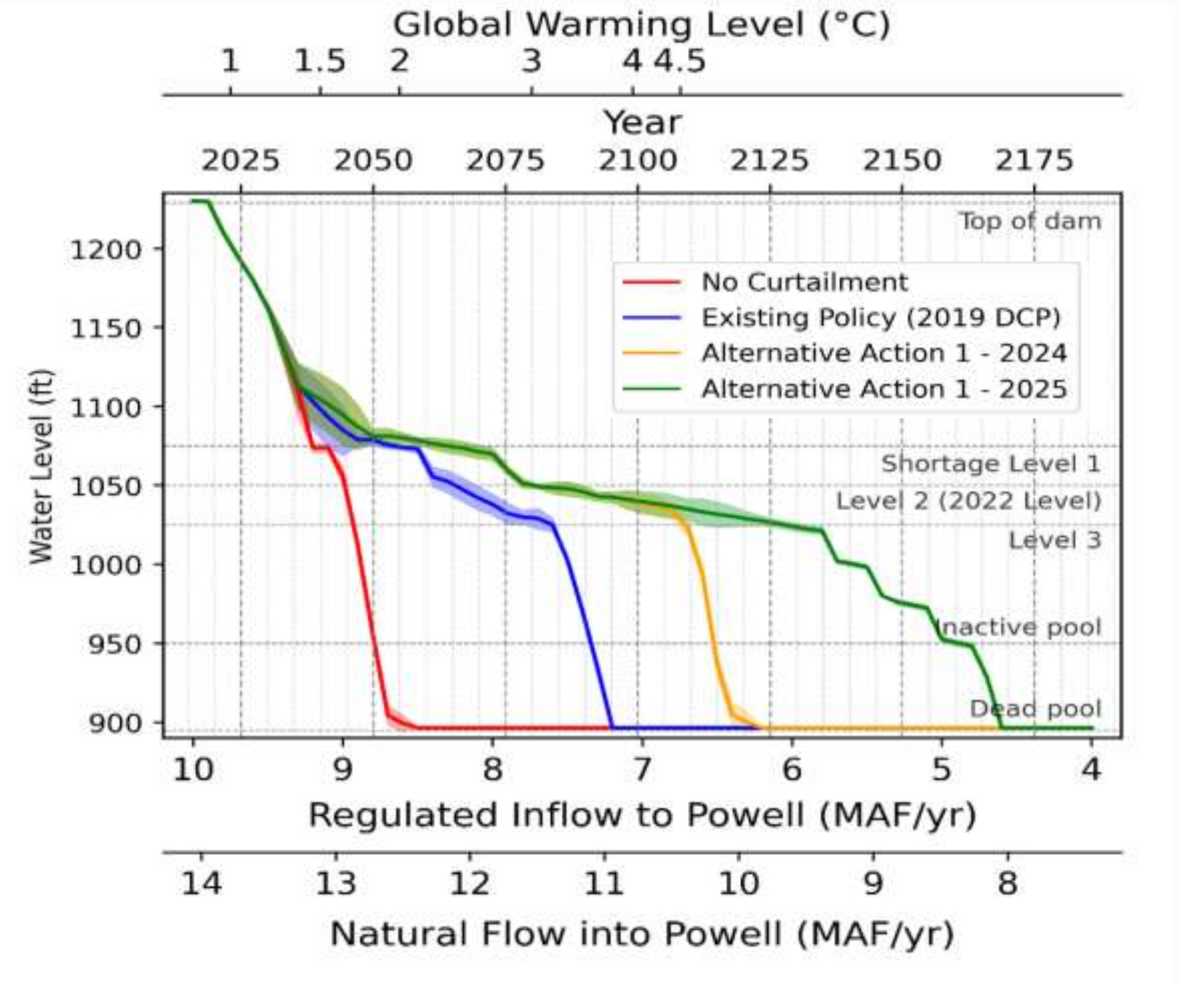
Colorado River Example:

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

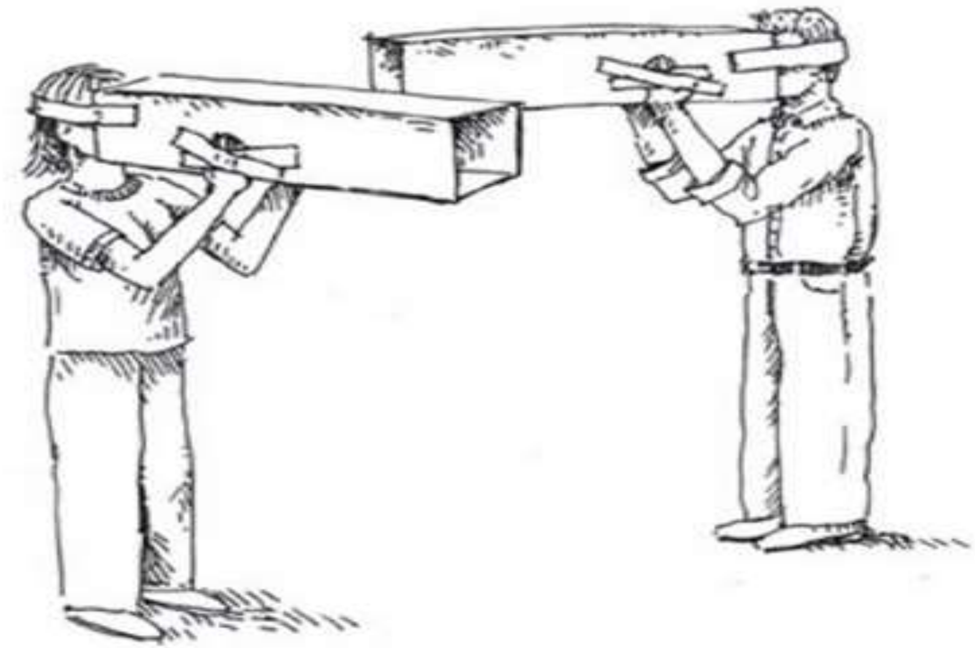
Three Approaches Can Support Water Agency Planning

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



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

But what happens when we are wrong about the future?

"The most likely scenario isn't"

Herman Kahn

Three Approaches Can Support Water Agency Planning

1. Classic Decision Analysis
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2. Scenario Planning
   – Consider a wide range of plausible futures
   – Use storylines to help understand and communicate scenarios
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3. Robust decision making
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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

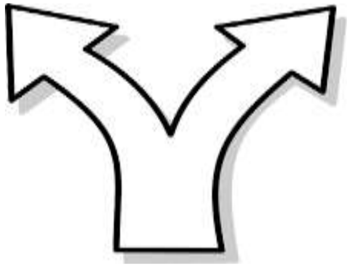
~~**Normative**
How can we reach our goals?~~

~~Used to describe alternative decision options~~

Scenarios Provide Benefits for Decision Makers

Scenarios can help:

Reduce over-confidence



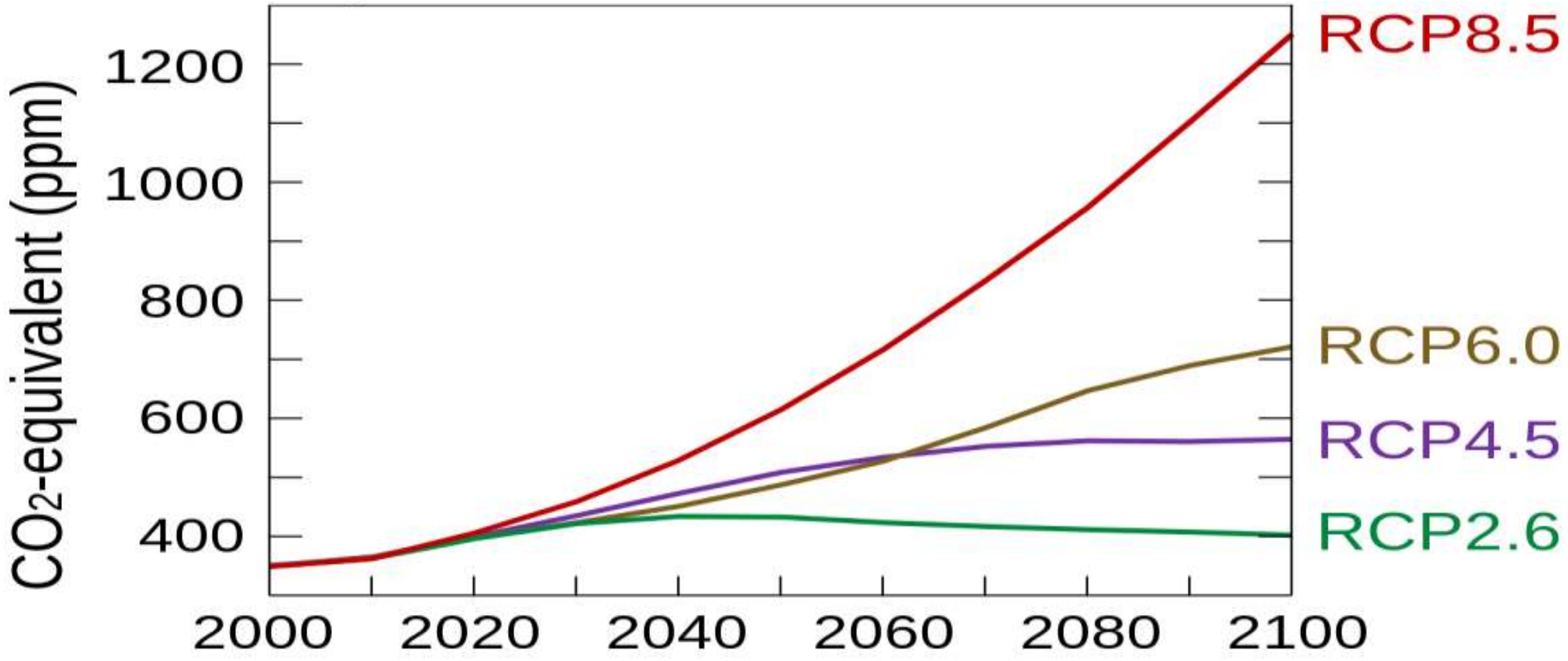
Expand the range of options considered

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

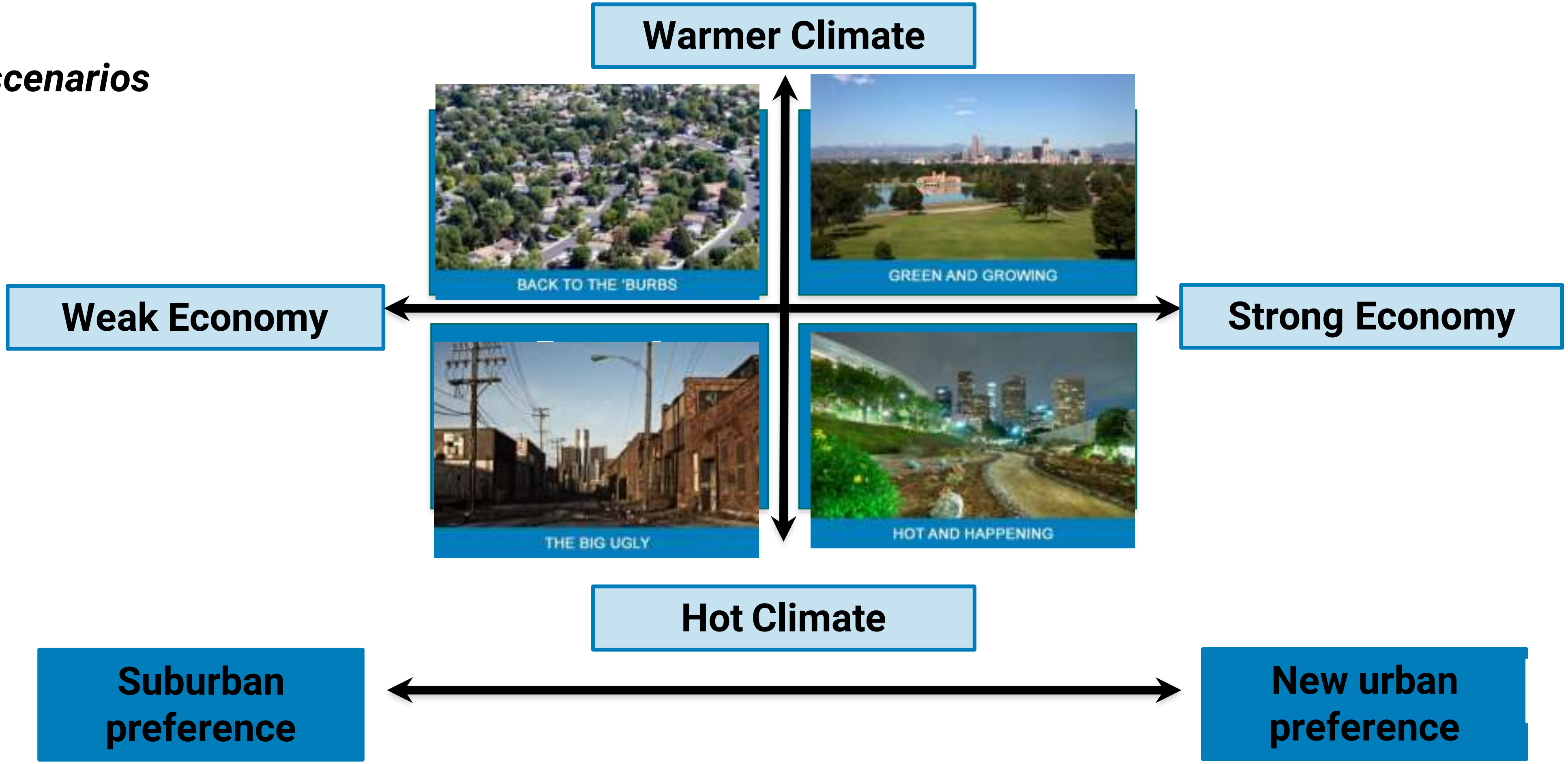
Representative Concentration Pathways developed for Intergovernmental Panel on Climate Change (IPCC)



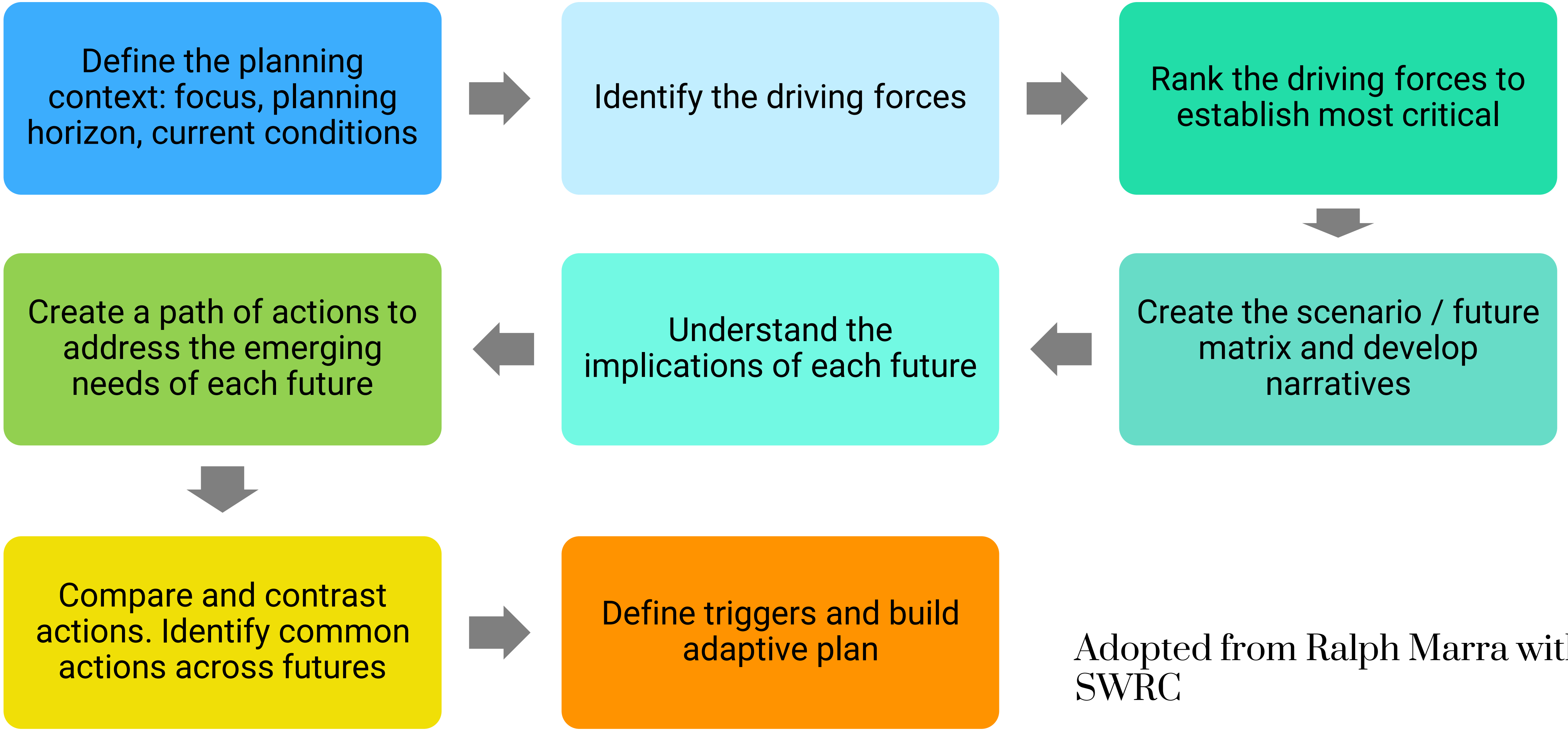
RCP number indicates radiative forcing in the year 2100 in W/m^2

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

Define the planning context: focus, planning horizon, current conditions

Identify the driving forces

Rank the driving forces to establish most critical

Create the scenario / future matrix and develop narratives

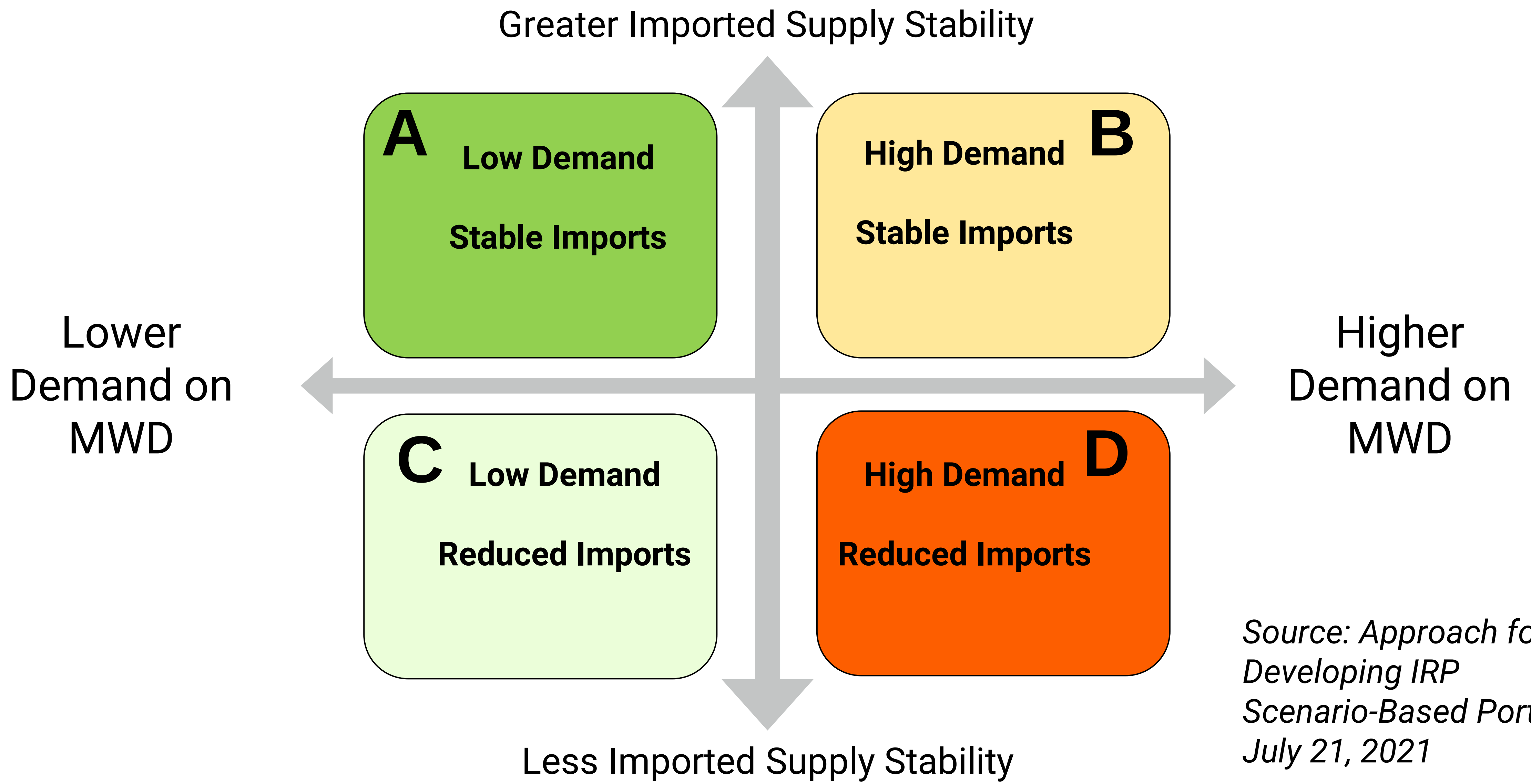
Understand the implications of each future

Create a path of actions to address the emerging needs of each future

Compare and contrast actions. Identify common actions across futures

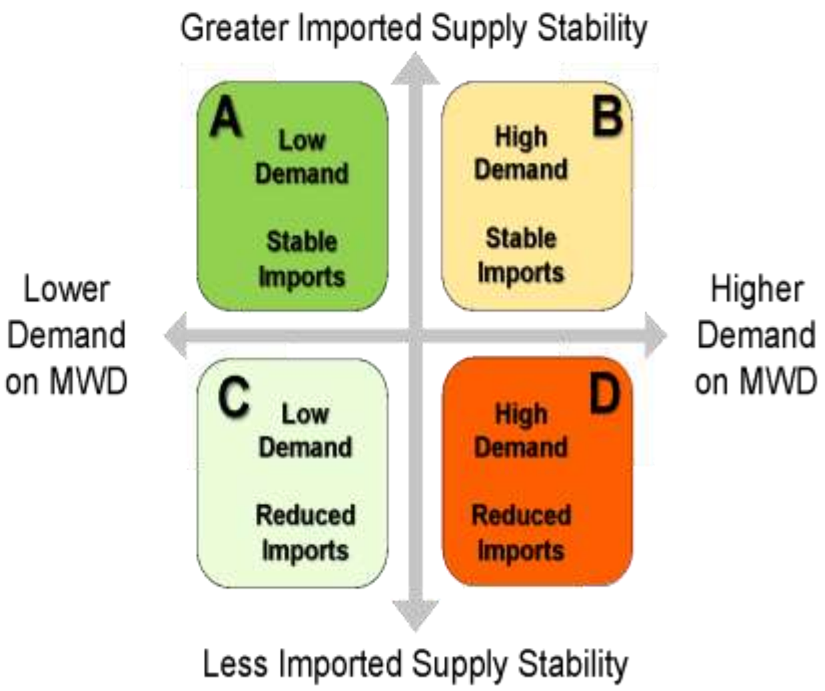
Define triggers and build adaptive plan

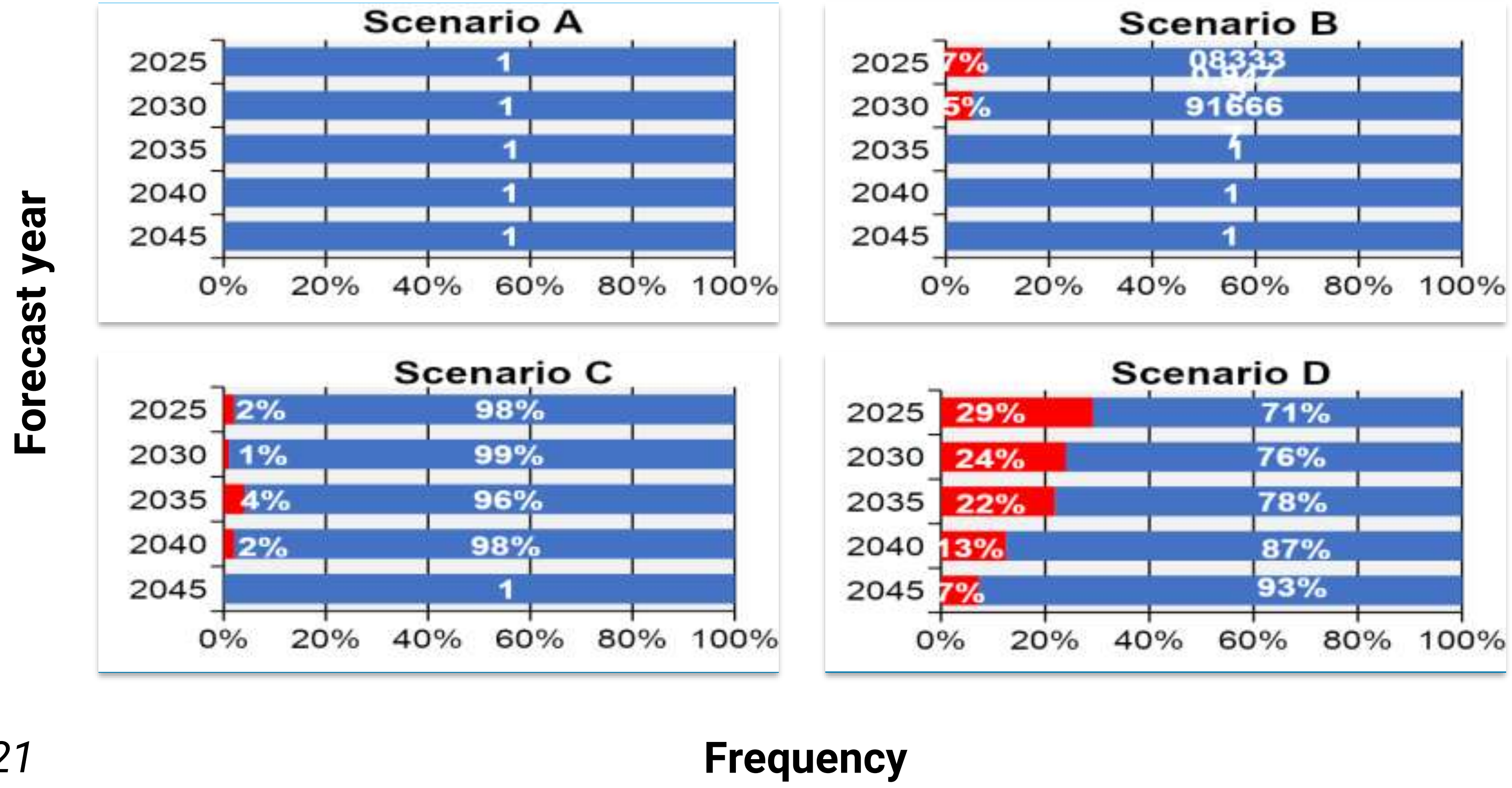
Metropolitan Has Developed Scenarios



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

Supply Gap Varies Over Scenarios





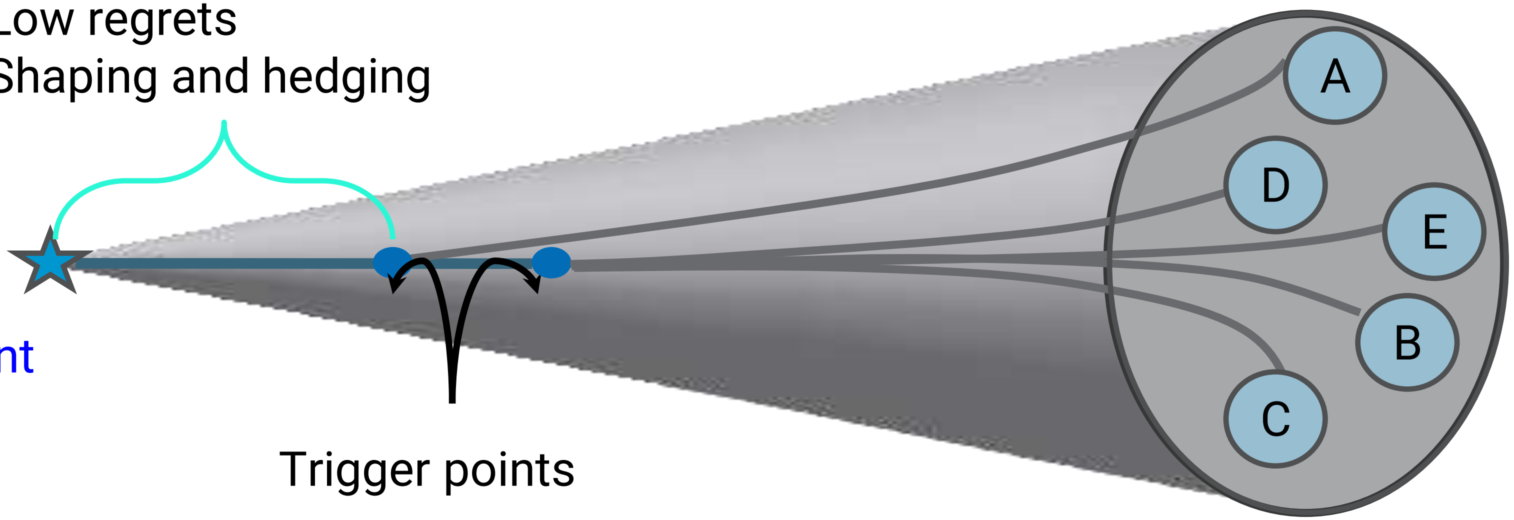
Source: Approach for Developing IRP Scenario-Based Portfolios, July 21, 2021

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



Scenarios

Present

Trigger points

Contingent actions

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

1. Define the planning context: focus, planning horizon, current conditions
2. Identify the driving forces
3. Rank the driving forces to establish most critical
4. Create the scenario / future matrix and develop narratives
5. Understand the implications of each future
6. Create a path of actions to address the emerging needs of each future
7. Compare and contrast actions. Identify common actions across futures
8. Define triggers and build adaptive plan

Simple Example of Scenarios and Time-Bound Target

Example based on South Florida Water Management District

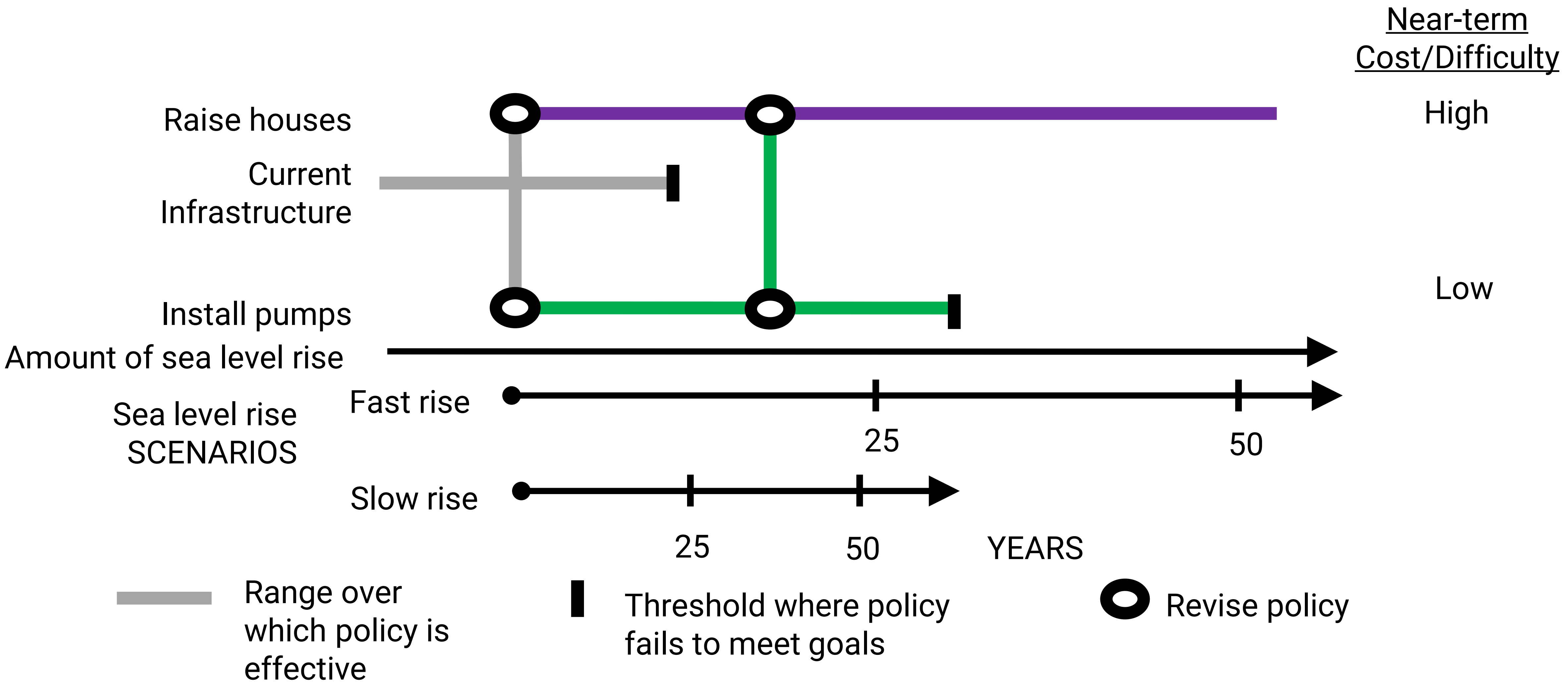
- Challenge:
  - Extensive infrastructure exists to drain residential neighborhoods in South Florida, but rising sea levels increase flood risk
- Overall Goal:
  - Hold flood risk constant at current levels
- Options include
  1. Retain current infrastructure
  2. Install new pumps over next two years
  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

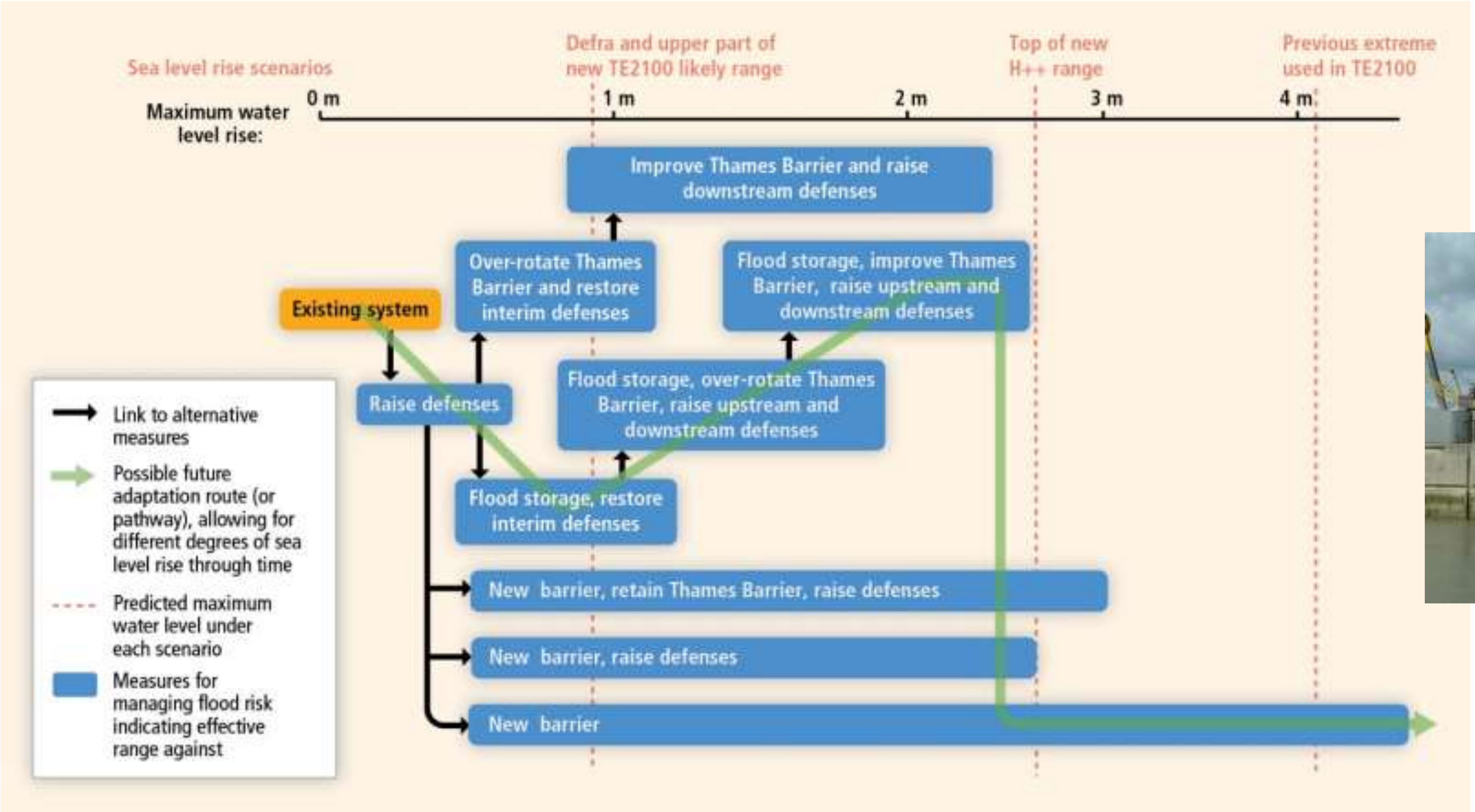
Bouwer, Haasnoot, Wagenaar, Roscoe (2018) Assessment of alternative flood mitigation strategies for the C-7 Basin in Miami, Florida Deltares

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

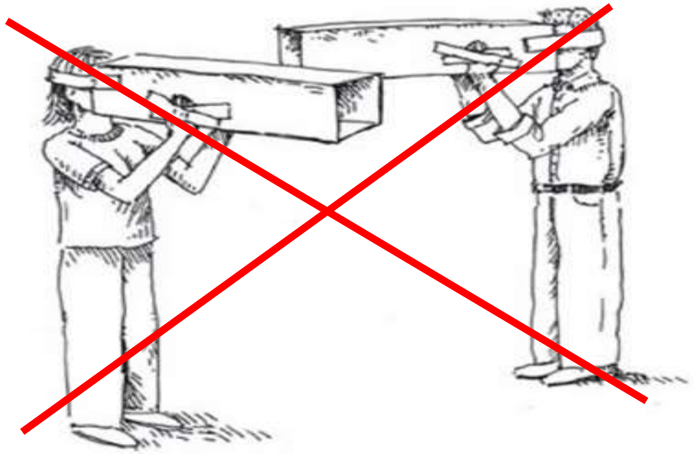
- Scenario Planning IS about being prepared for whatever happens in the future

- 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

THE SOCIETY FOR
Decision
Making under
Deep
Uncertainty

RAND

Pardee Center

http://www.deepuncertainty.org

Session 2: Q&A and Discussion

LUNCH

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

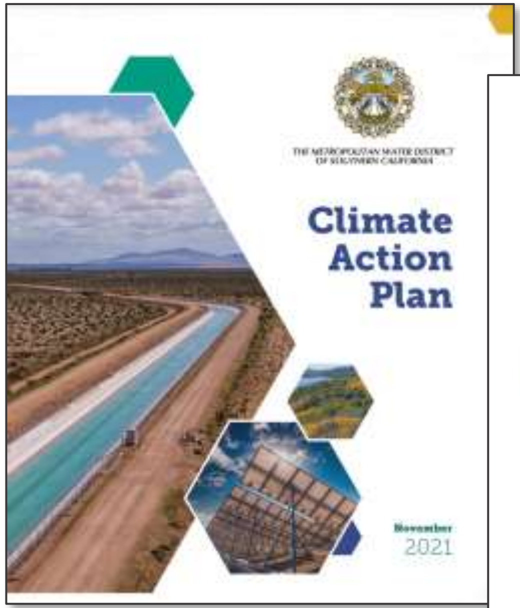
Adaptation Planning and Adaptation Pathways

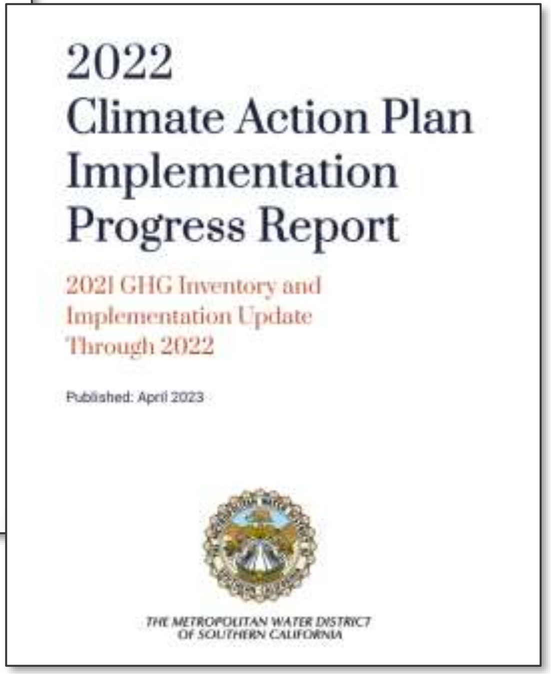
Juliette Finzi Hart, Ph.D.
Pathways Climate Institute
March 18, 2024

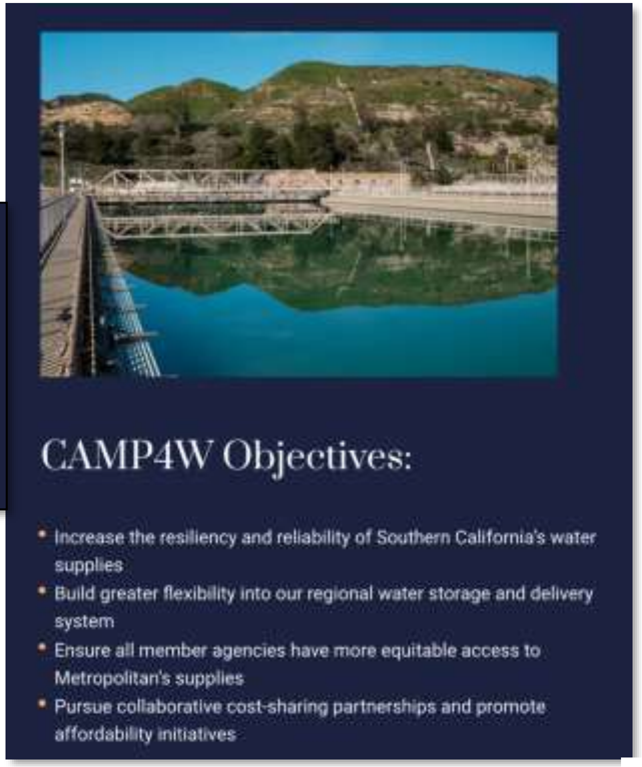
Climate Action Terminology

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

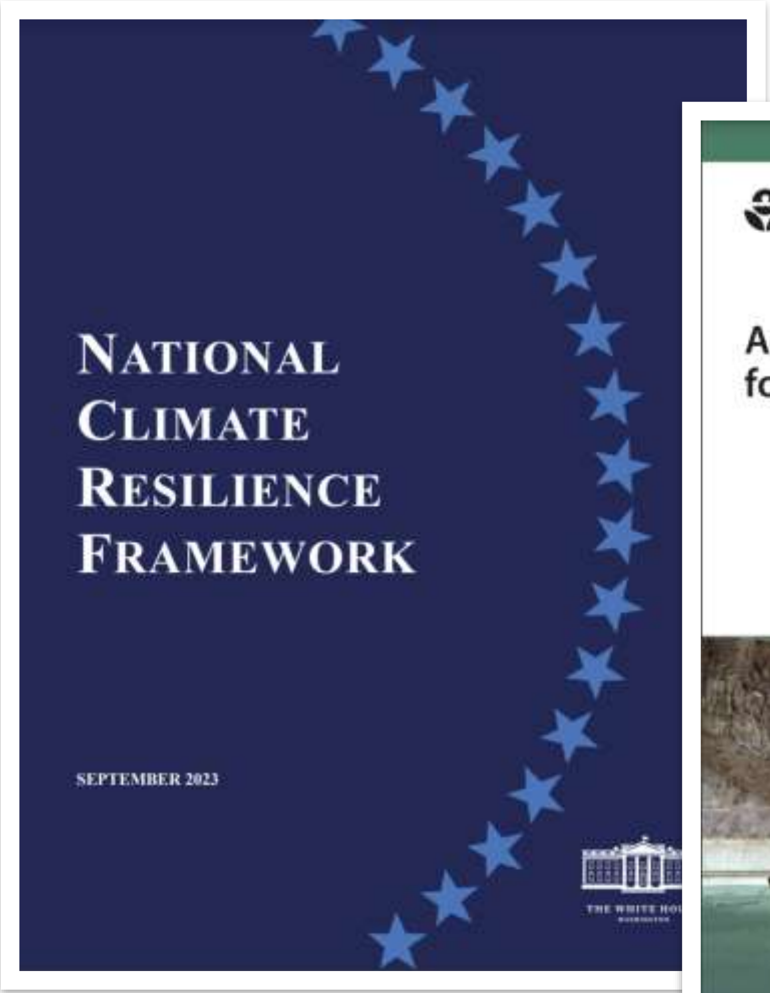
Adaptation pathways is an approach that allows decision makers to build adaptive capacity, prioritize strategies, stagger investment, and maintain flexibility.

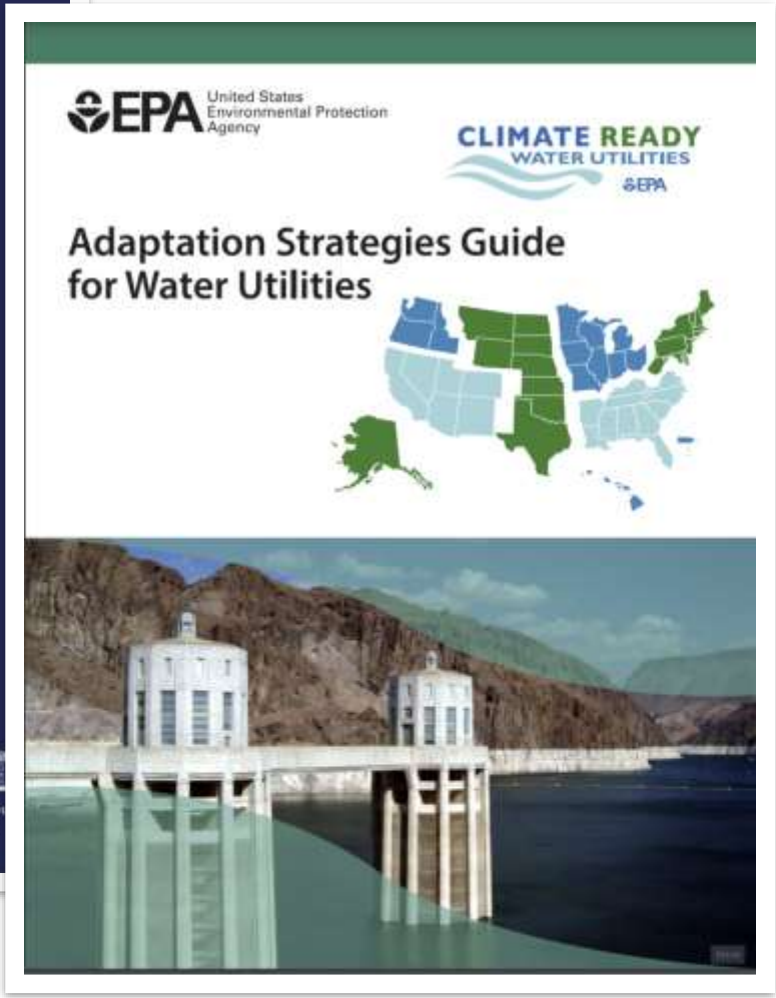
Adaptive capacity is the ability of a human or natural system to adjust to climate change by moderating potential damages, taking advantage of opportunities, or coping with the consequences.

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

Federal Climate Adaptation Policies

adaptation planning

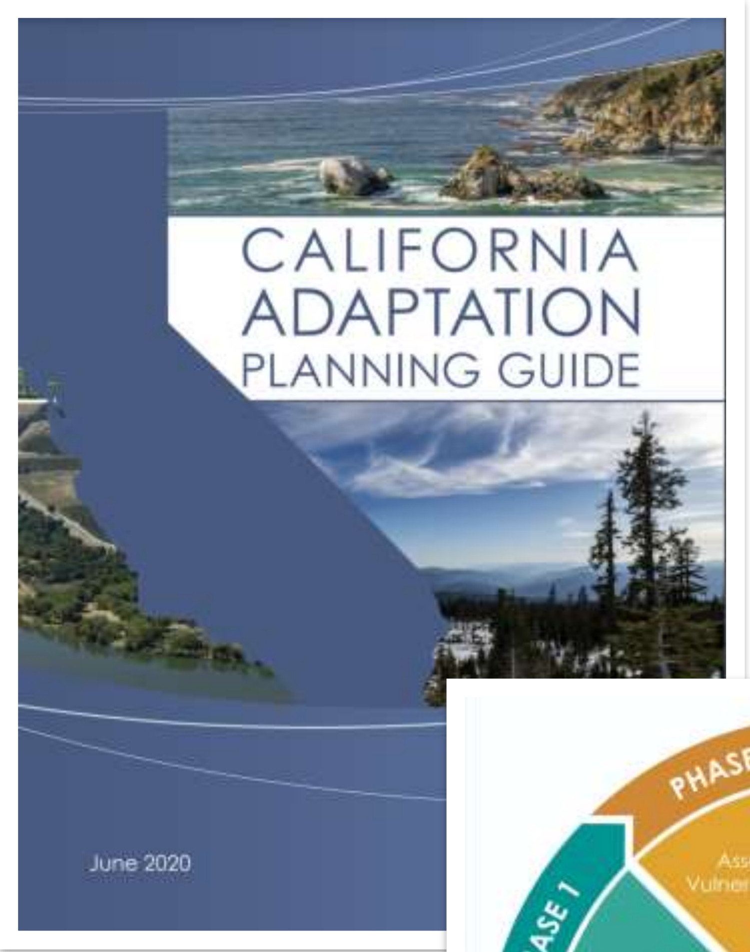


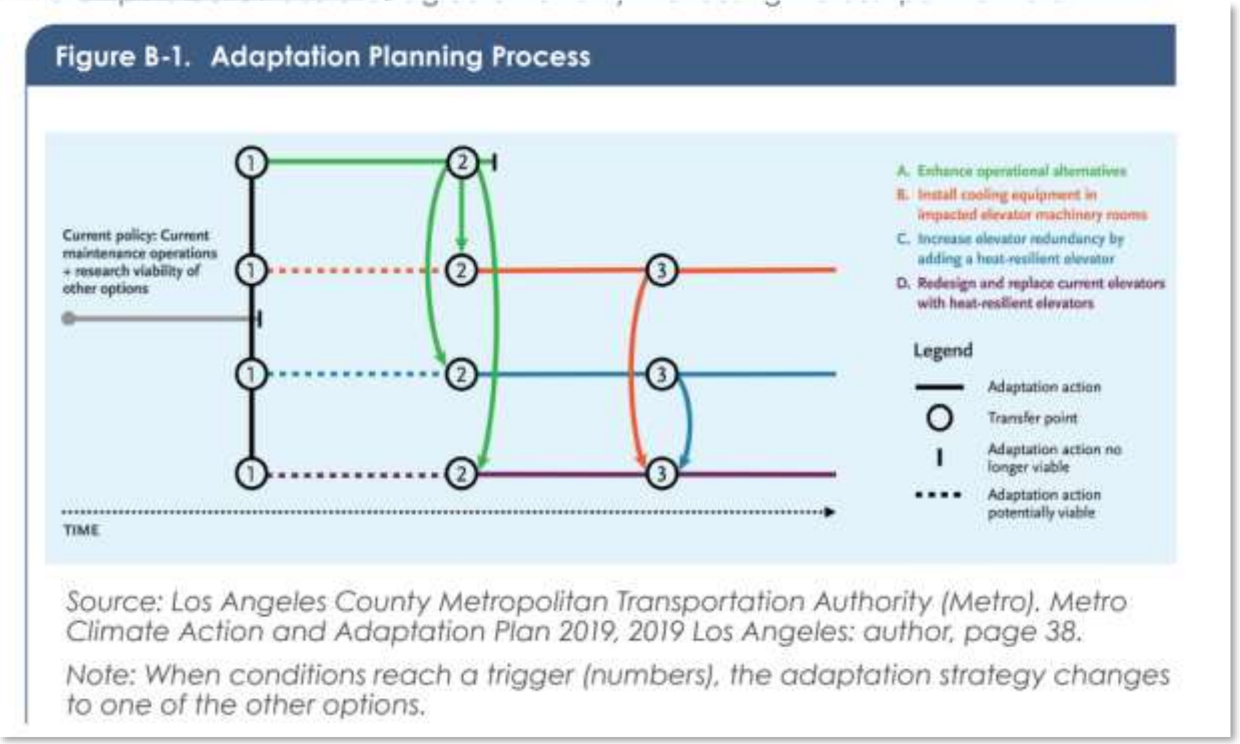


California Climate Adaptation Policies

adaptation planning

adaptation pathways

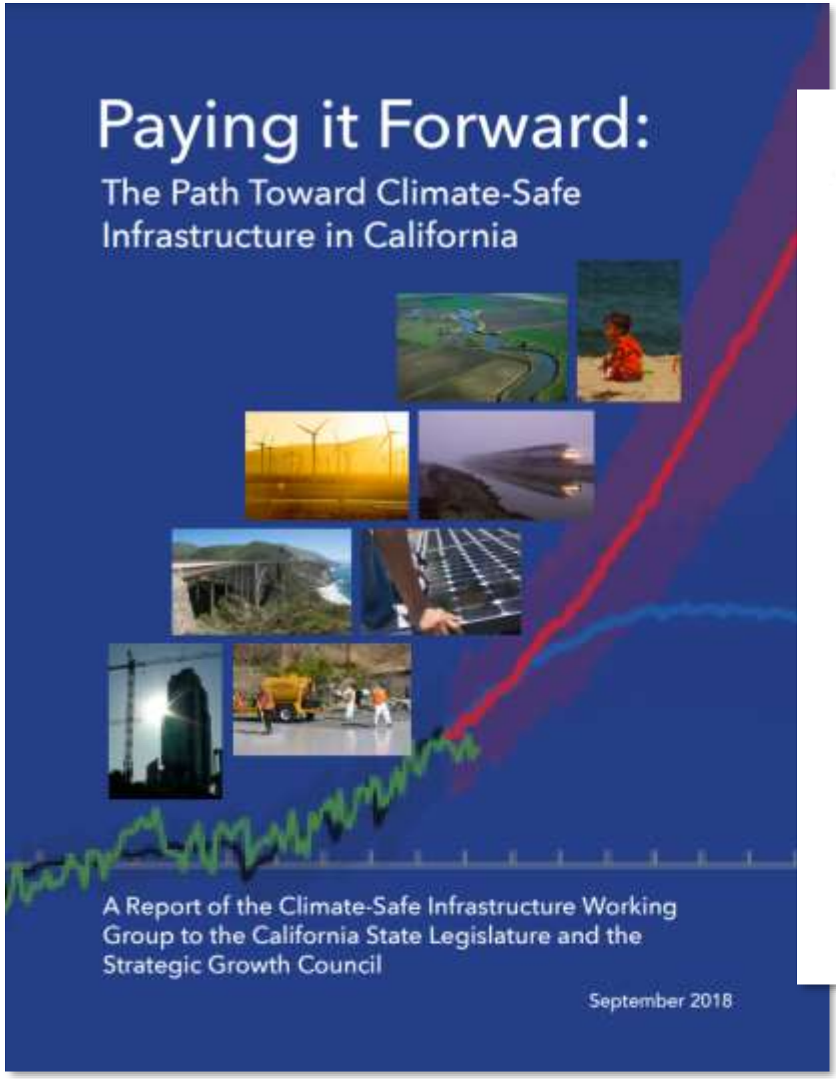


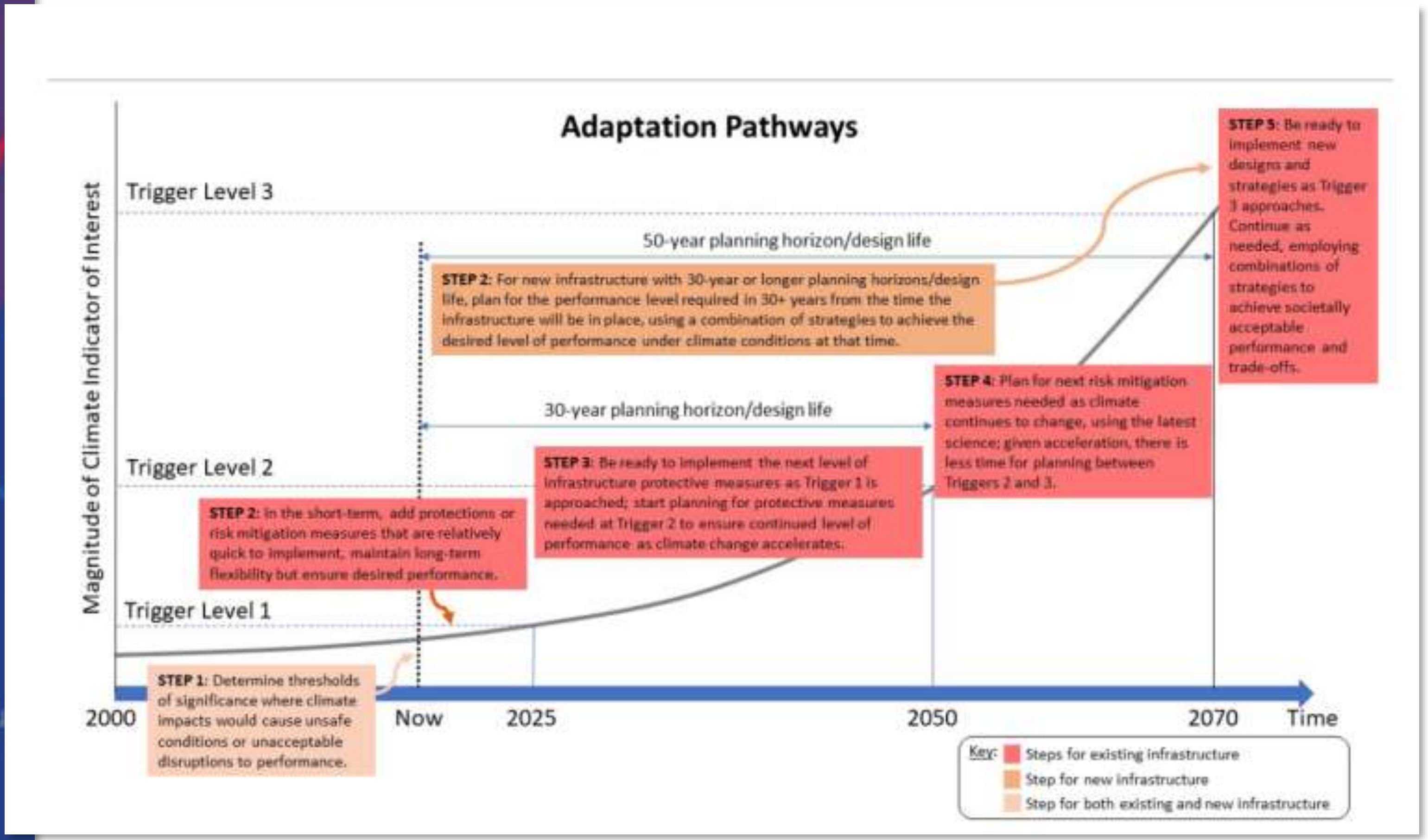


https://resilientca.org/apg/

CA Climate-Safe Infrastructure

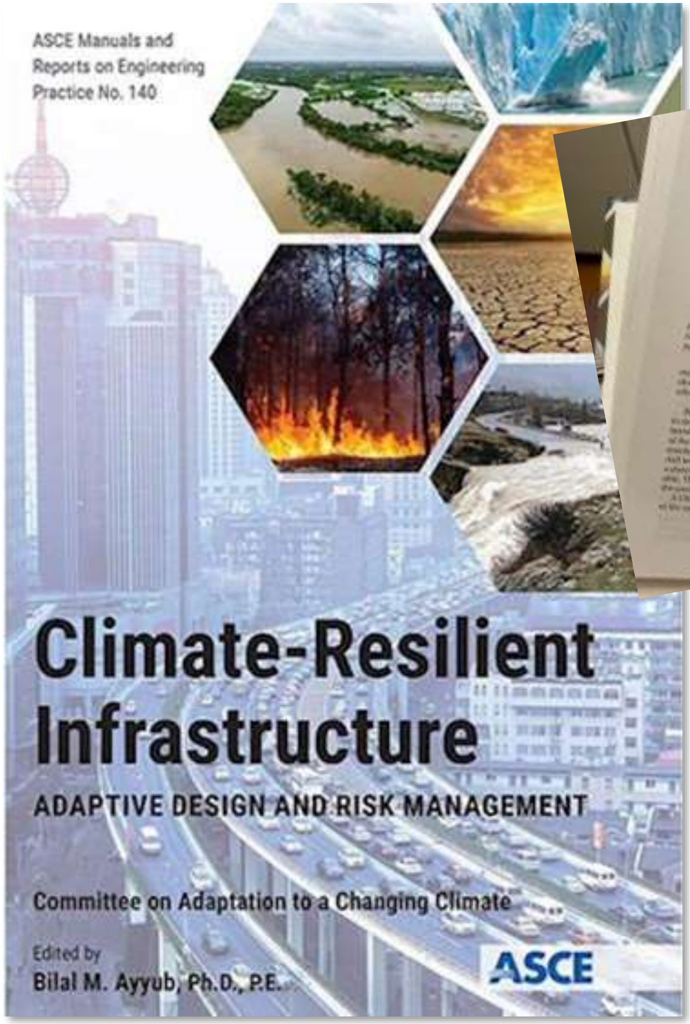
adaptation pathways

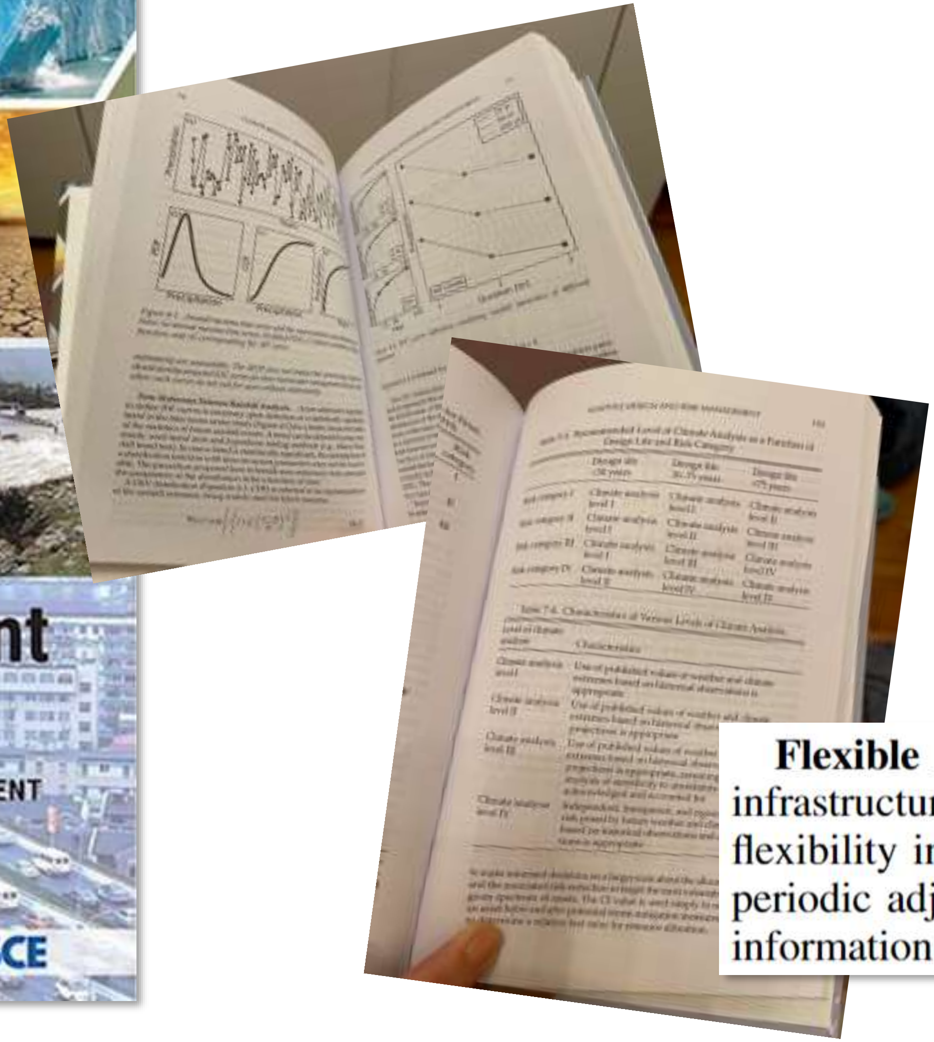




Even Water Engineers Do it

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

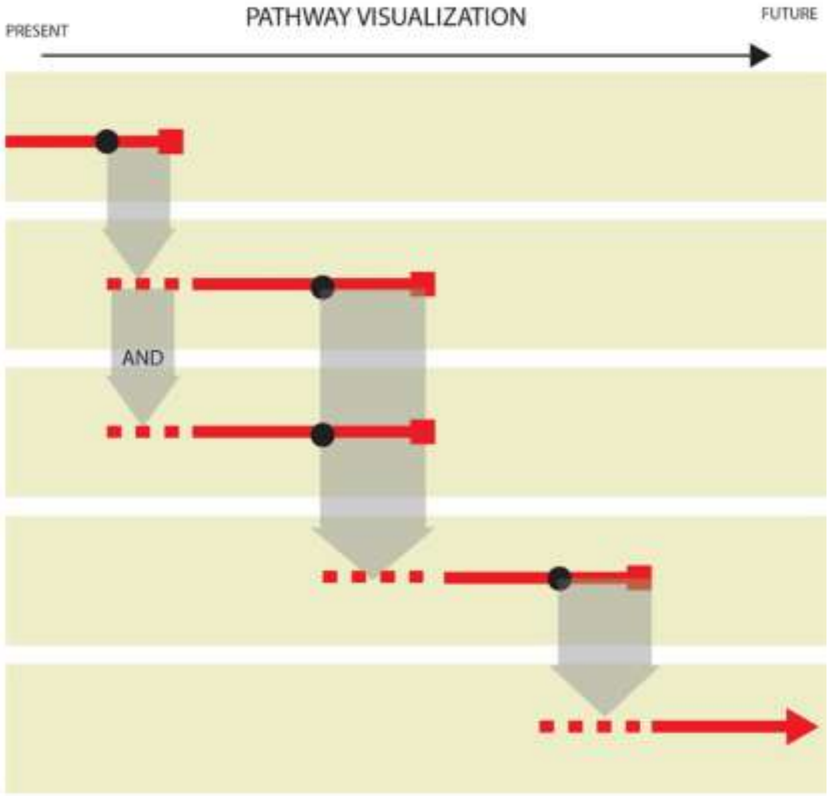
CITY OF SANTA CRUZ

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	$-$$$$
Long-Term	3	Beach width, Loss of use and access, Cost exceedance, Repairs frequency	Managed retreat	$-$$$$$



PLANNING PHASE
IMPLEMENTATION PHASE
STRATEGY NO LONGER EFFECTIVE
ONGOING USE OF STRATEGY
TRIGGER POINT TO NEXT PHASE
TRANSITION TO DIFFERENT STRATEGY

$:	0-10K
$$:	10K-100K
$$$:	100K-500K
$$$$:	500K-1mil
$$$$$:	1 mil +

Sea Level Rise Pathways – Port of San Francisco

adaptation pathways

San Francisco Chronicle   e-Edition   Account

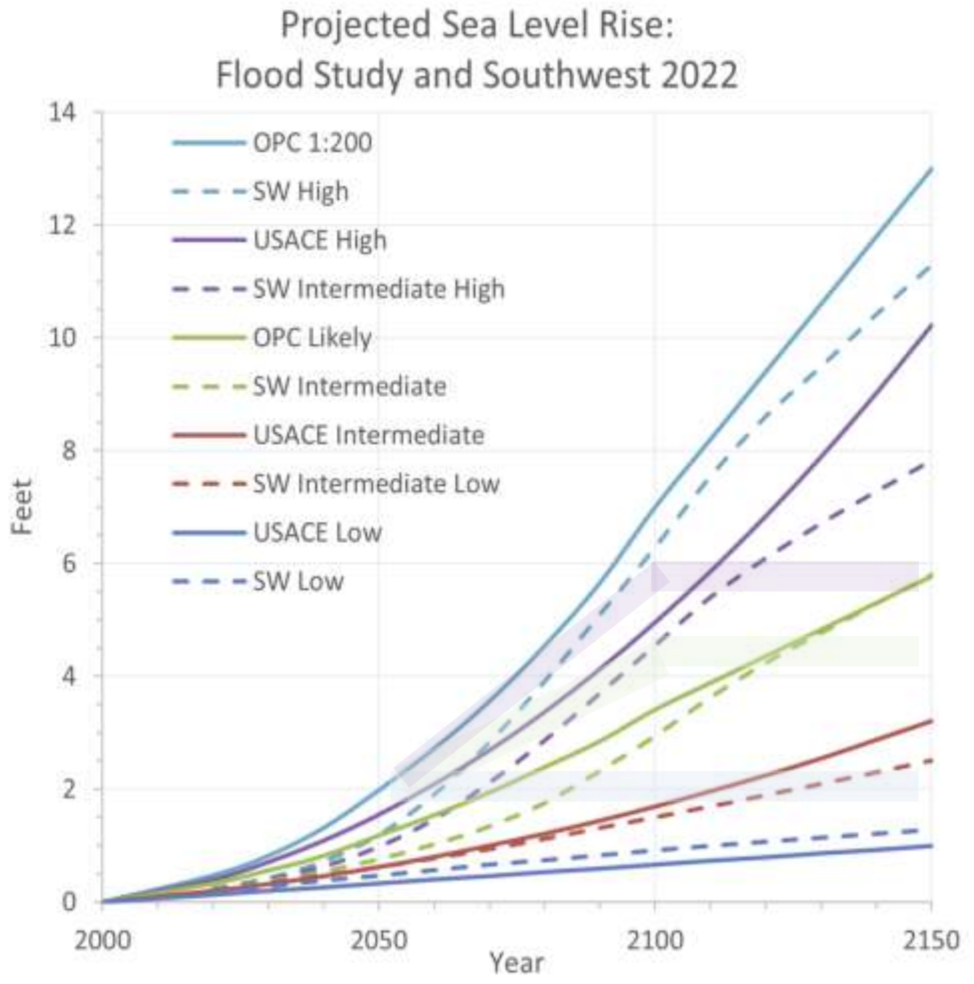
BAY AREA // SAN FRANCISCO

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

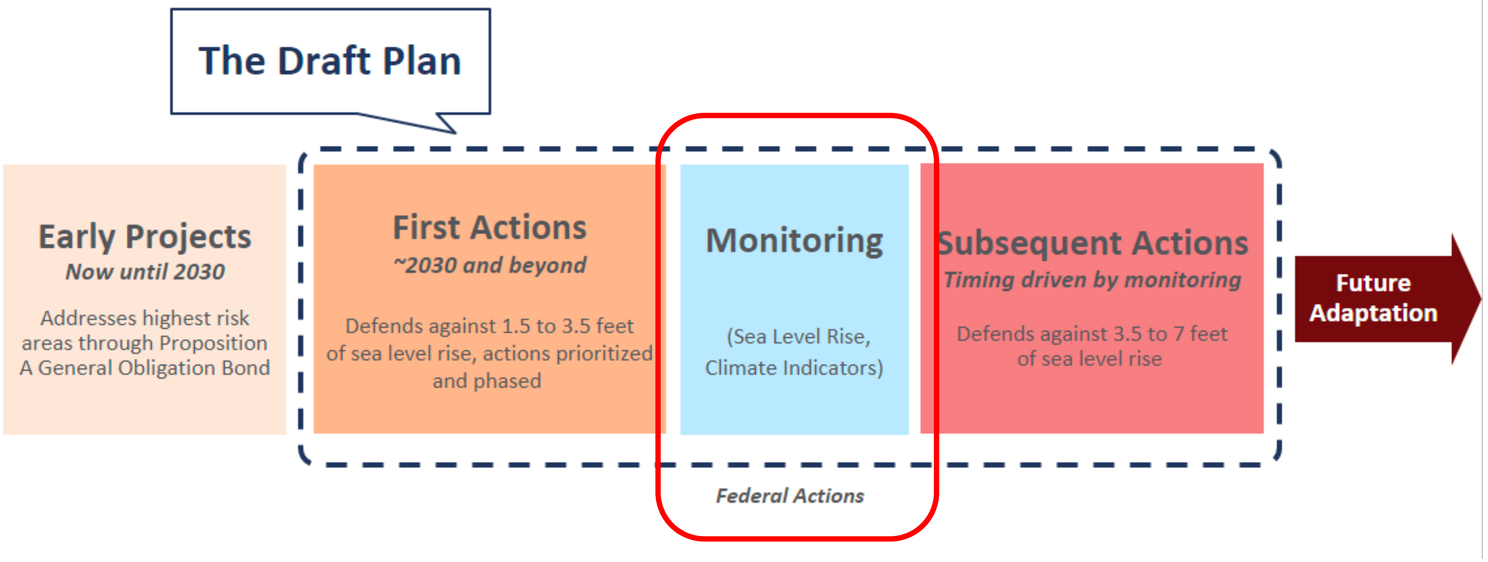
By John King
Jan 26, 2024

Sea Level Rise Pathways – Port of San Francisco

adaptation pathways



San Francisco Waterfront Coastal Flood Study



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

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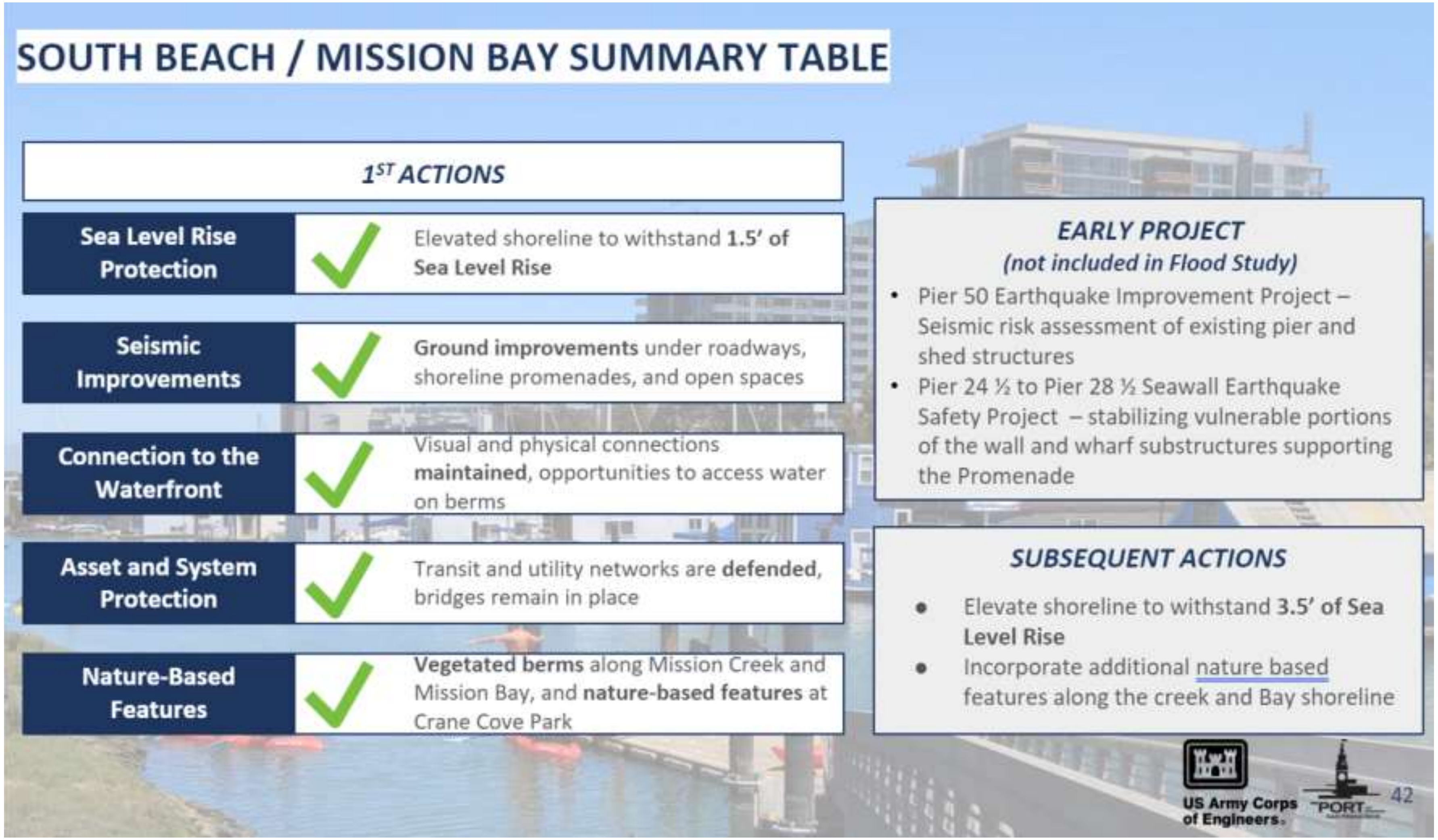
Jan 26, 2024

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."

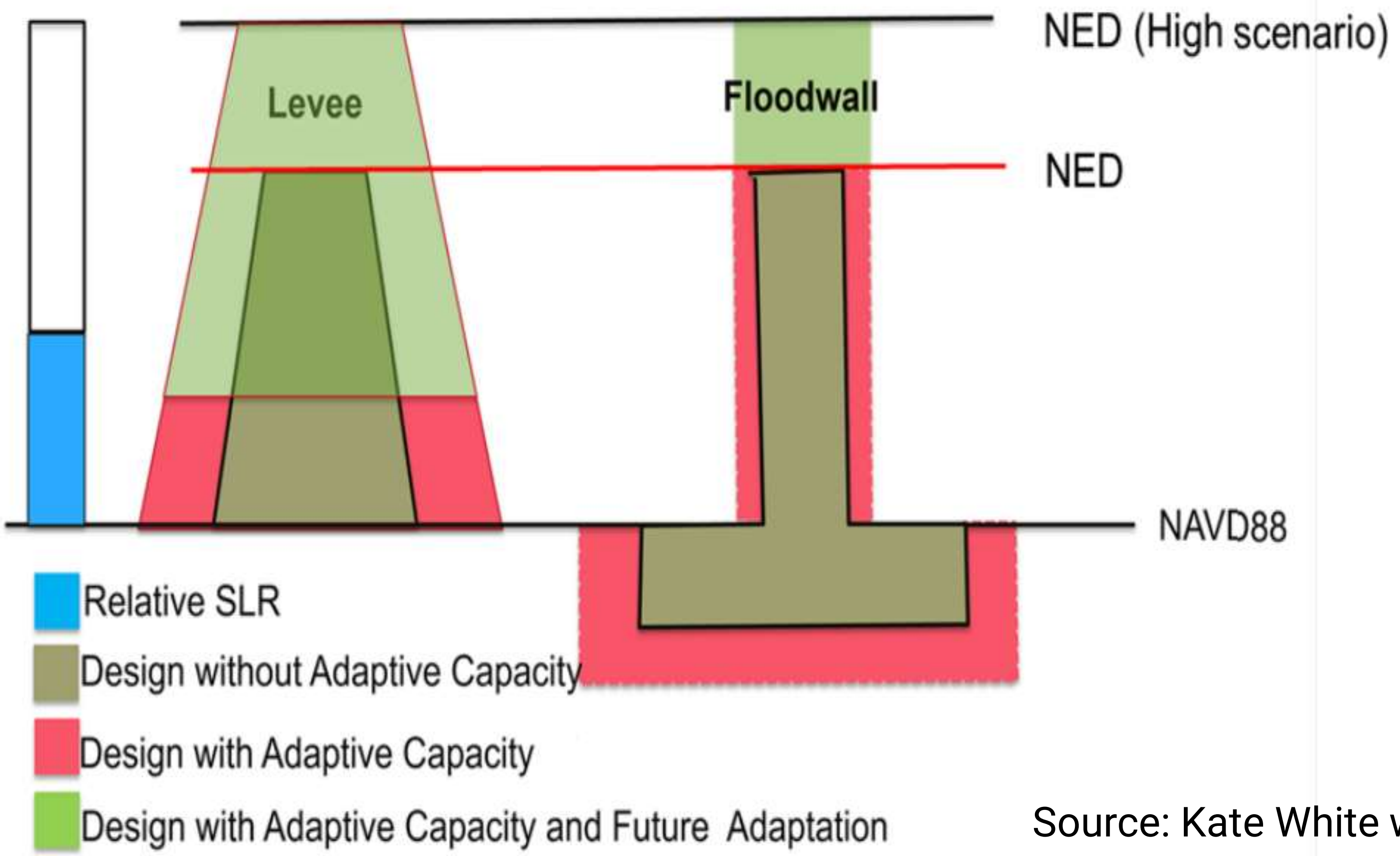
Sea Level Rise Pathways – Port of San Francisco

adaptation pathways



USACE Adaptive Capacity Analysis

adaptive design

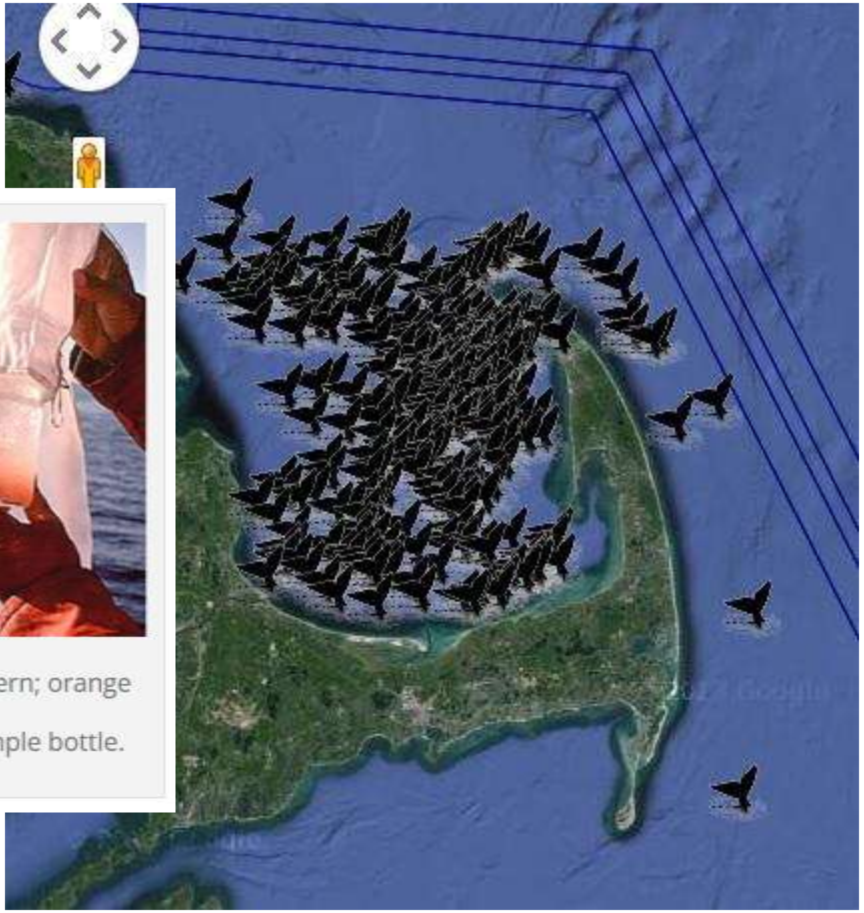


Source: Kate White webinar 2018, USACE

North Atlantic Right Whales

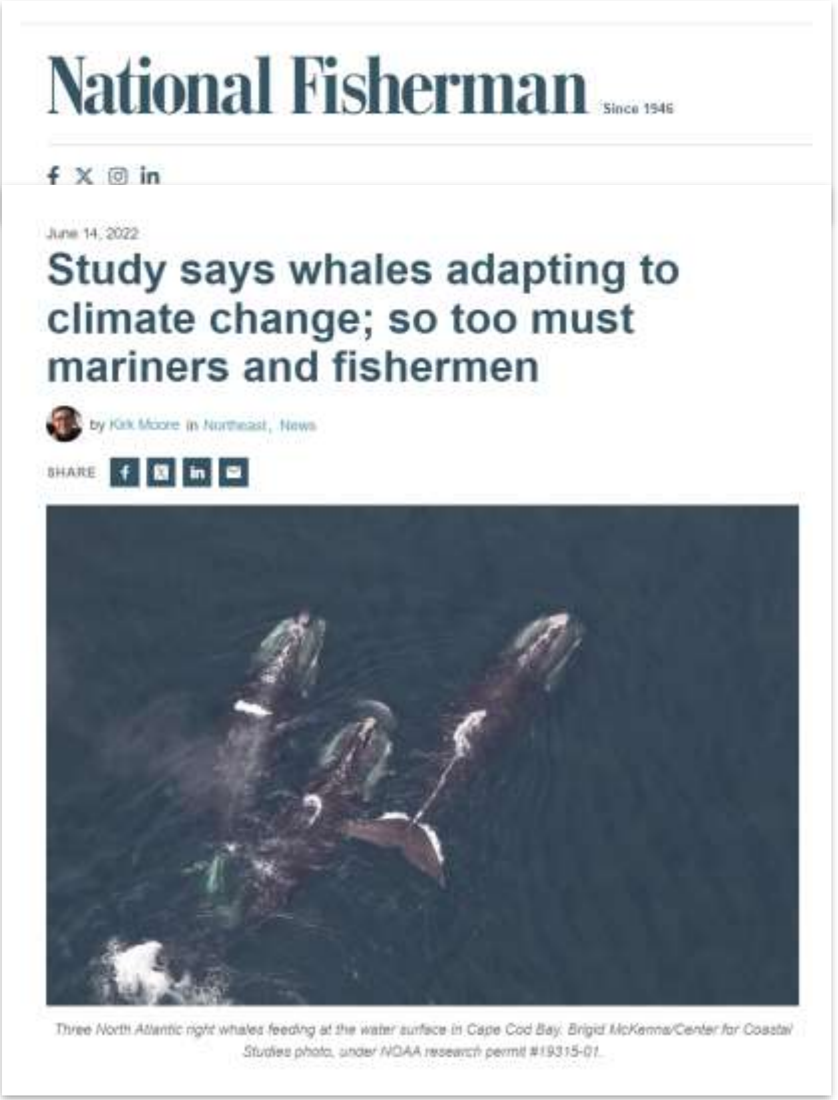
adaptation pathways

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

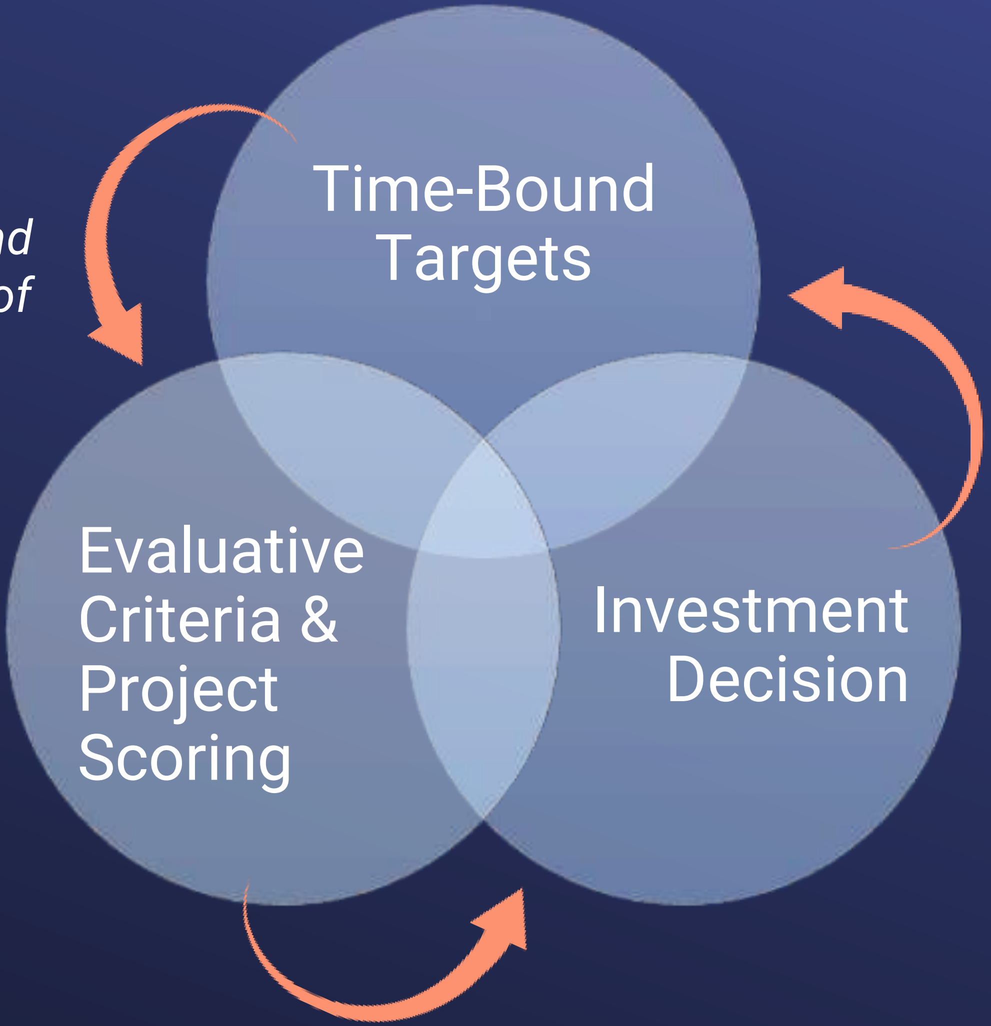
Purpose

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



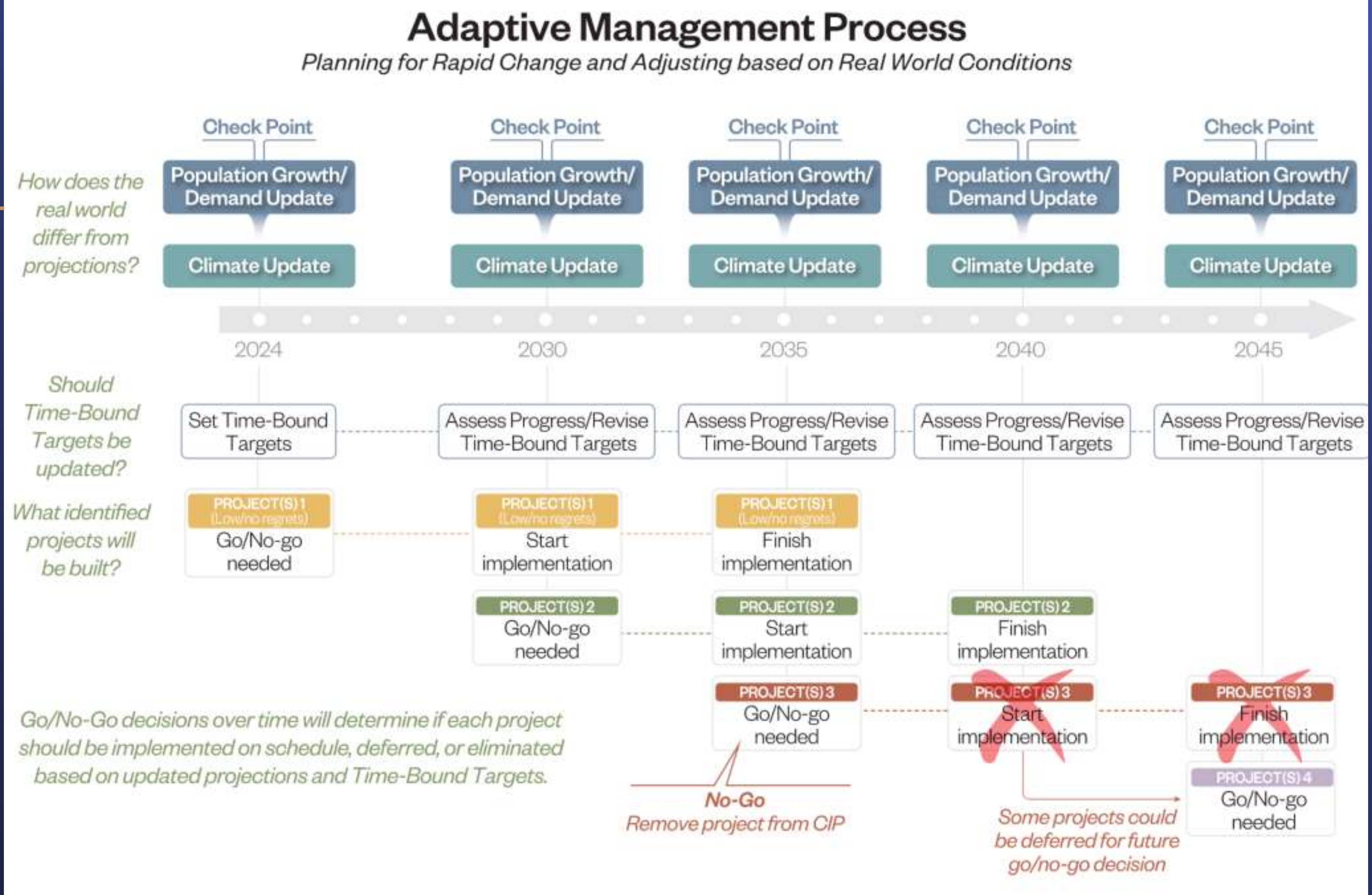
Scores and Time-Bound Targets inform decision-making

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*

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

Decisions for the Decade:

A serious game on long-term decision making

Robert Lempert

RAND CORPORATION

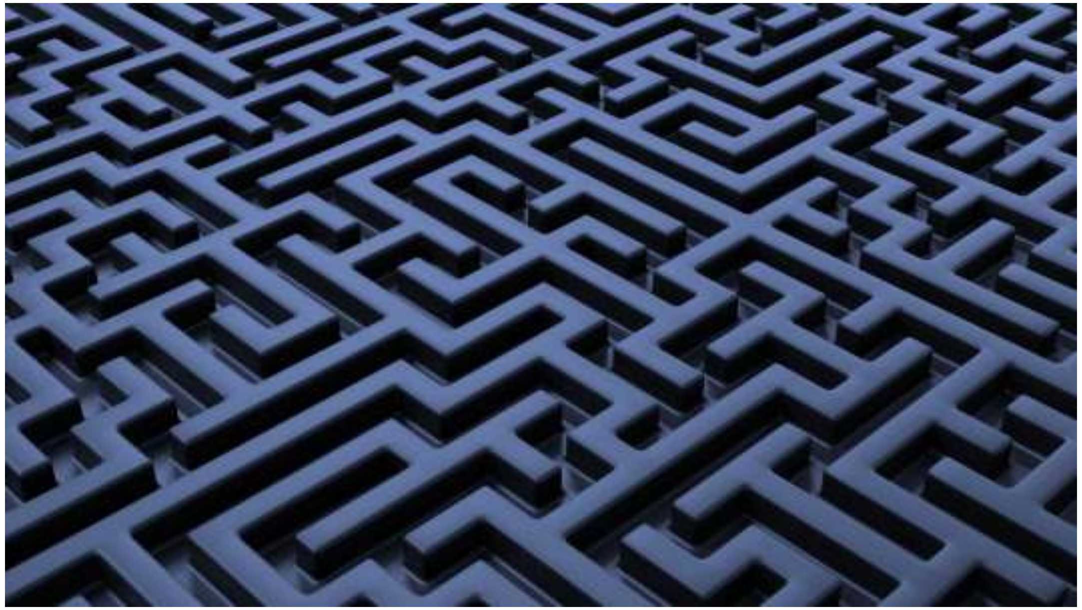
Gegham Qalajyan via Getty Images

“Serious games” can help improve risk management

Powerful methods now exist to help manage risk under conditions of deep uncertainty

Data and argument alone are insufficient for effective risk communication

Serious games provide a compelling means to help disseminate new methods for risk management



Decisions for the Decade

How do we make smart long-term decisions?

All Participate
(...expect confusion...)

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THE WORLD BANK

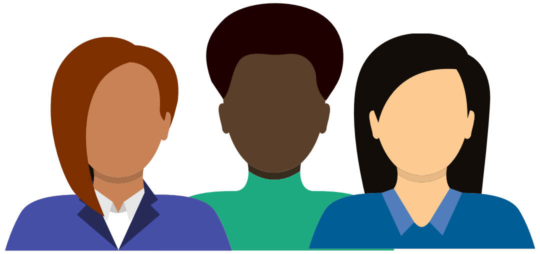
RED CROSS/RED CRESCENT CLIMATE CENTRE

International Federation of Red Cross and Red Crescent Societies

The Netherlands Red Cross

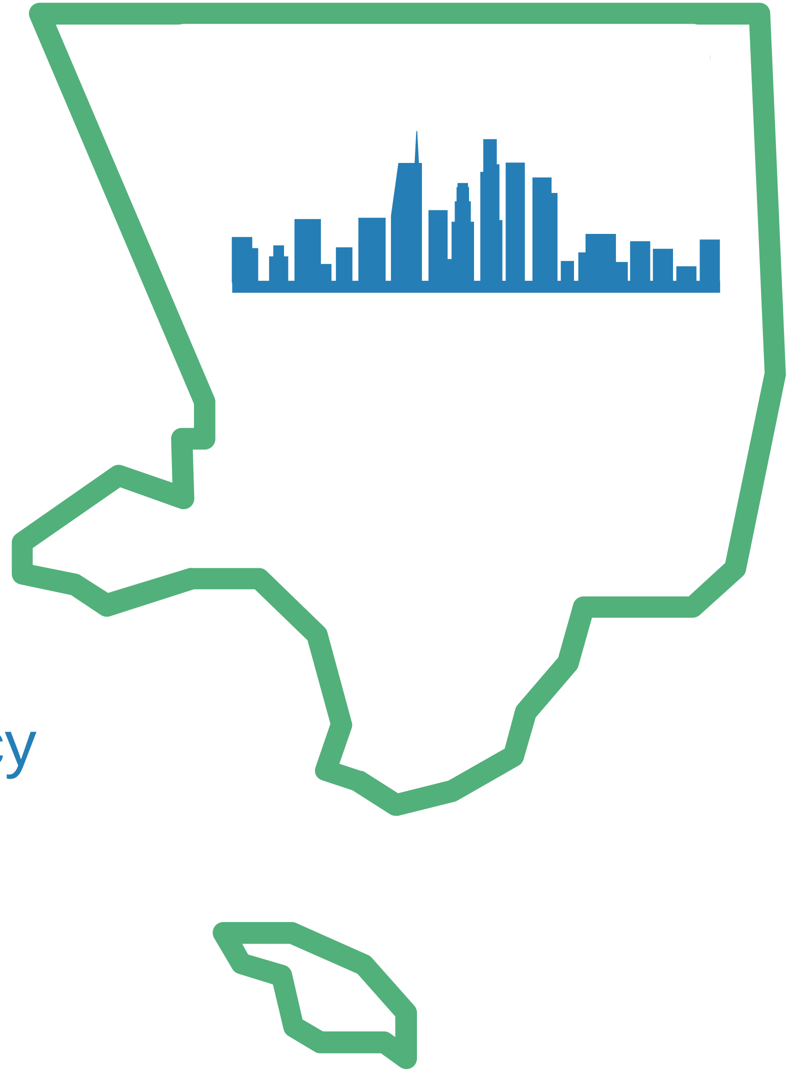
Special thanks to Pablo Suarez and Janot Mendler de Suarez (Red Cross / Red Crescent Climate Centre)

Your role….



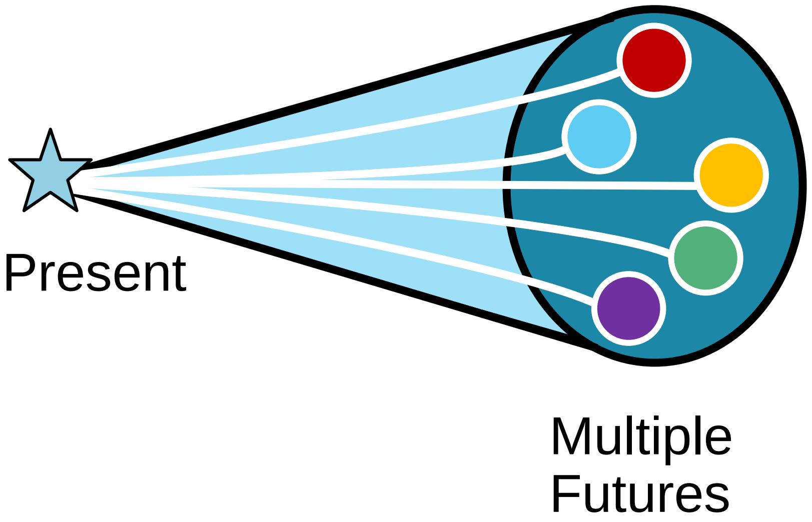
The principal planners

of a regional water agency



Your objective….
prepare your region for the future

The Cone of Uncertainty



- What will the future bring?
- Will it be different from the past? In what way?
- What investment decisions should we make?
- Will we be prepared?

Credit: WUCA and Denver Water

The Set-up

Making Decisions

Regional decisions require <u>teamwork</u>

- Use single *Region* board and brown beans

REGION BOARD

If you roll a flood: lose 1 bean

Earn 1 Prosperity Point per bean, ***but only if no crisis***

If you roll a drought: lose 1 bean

How to win

Winning Region

- **Most Prosperity**
- Tiebreaker: Region with fewest crises

	2. INVESTMENT DECISIONS				3. OBSERVATIONS	4. RESULTS	
Decade	**FLOOD Protection (0–9)**	**INVESTMENT and O&M (1–10)**	**DROUGHT Protection (0–9)**	Choose **Insurance?**	**Annual Precipitation**	**# Crises**	***# Prosperity Points***
1							
2				Yes / No			
3				Yes / No			
4				Yes / No			
					TOTAL:		

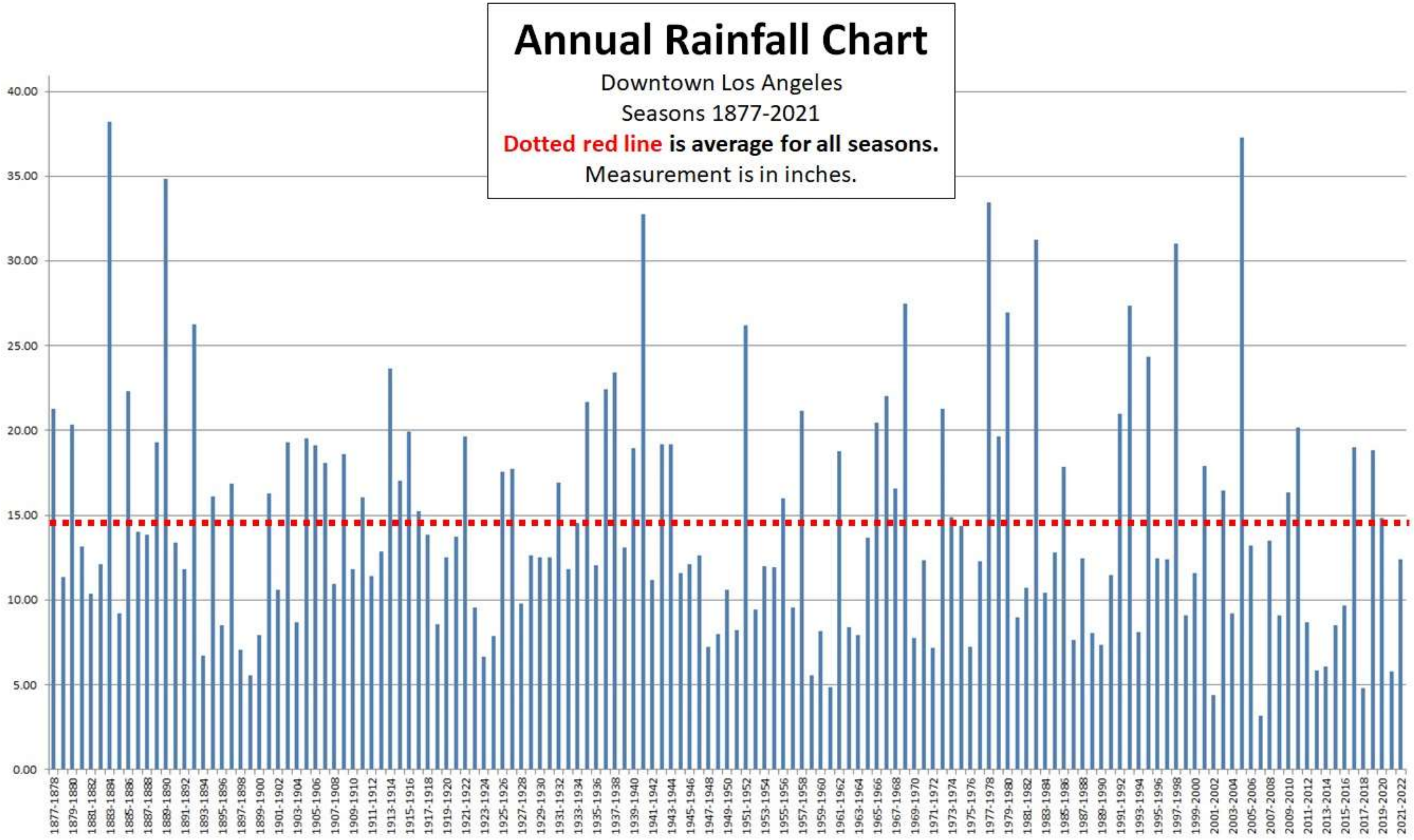
Steps of the Game

1. Receive scientific information
2. Make decisions
3. Record observations
4. Tally results

Steps of the Game

1. Receive scientific information
2. Make decisions
3. Record observations
4. Tally results

1 Scientific Information



1 Scientific Information

Your source of information

? = **Flood** 

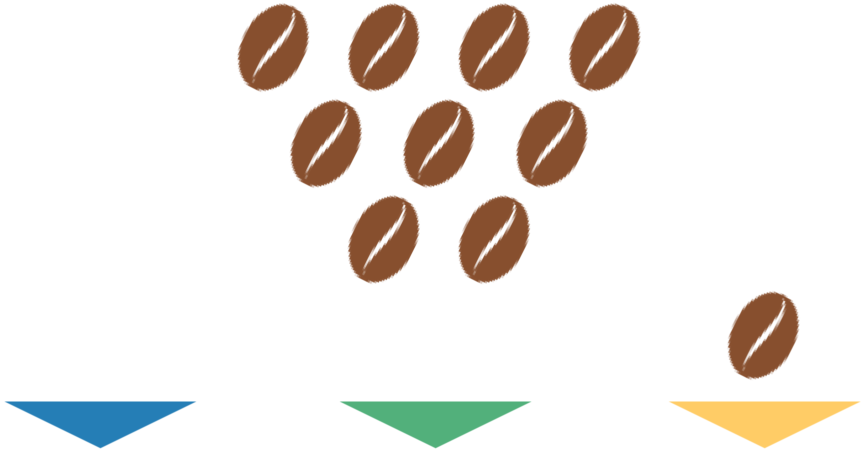
? = **Drought**

2 Make decisions

Allocate resources for each decade (10 beans total)

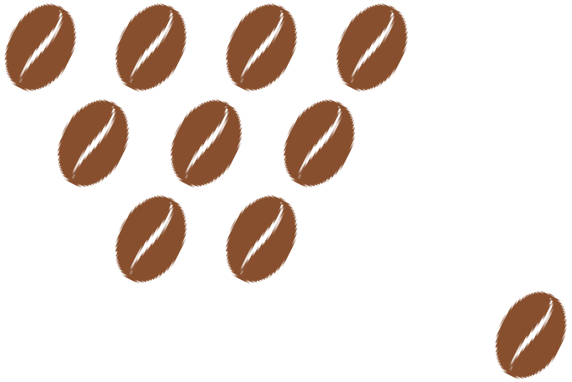
	2. INVESTMENT DECISIONS				3. OBSERVATIONS	4. RESULTS	
Decade	**FLOOD Protection (0–9)**	**INVESTMENT and O&M (1–10)**	**DROUGHT Protection (0–9)**	Choose Insurance?	Annual Precipitation	# Crises	*# Prosperity Points*
1							
2				Yes / No			
3				Yes / No			
4				Yes / No			
					TOTAL:		

2 Make decisions



	2. INVESTMENT DECISIONS				3. OBSERVATIONS	4. RESULTS	
Decade	**FLOOD Protection (0–9)**	**INVESTMENT and O&M (1–10)**	**DROUGHT Protection (0–9)**	Choose Insurance?	Annual Precipitation	# Crises	*# Prosperity Points*
1	0	9	1				
2				Yes / No			
3				Yes / No			
4				Yes / No			
					TOTAL:		

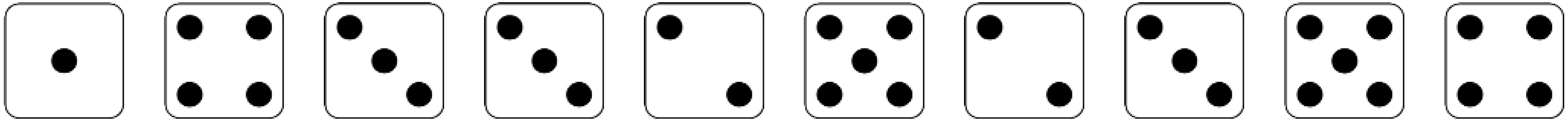
2 Make decisions



	2. INVESTMENT DECISIONS				3. OBSERVATIONS	4. RESULTS	
Decade	FLOOD Protection (0–9)	INVESTMENT and O&M (1–10)	DROUGHT Protection (0–9)	Choose Insurance?	Annual Precipitation	# Crises	# Prosperity Points
1	1	8	1				
2				Yes / No			
3				Yes / No			
4				Yes / No			
					TOTAL:		

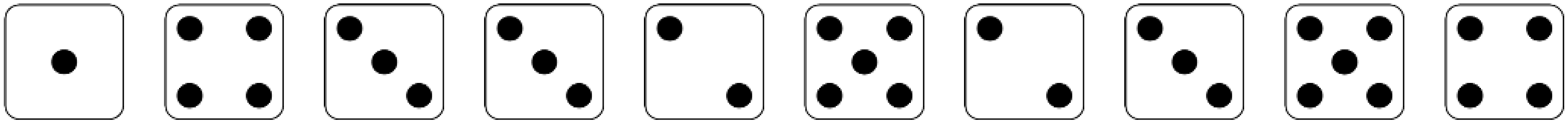
3 Record observations

10 rolls = 10 years of precipitation



3 Record observations

10 rolls = 10 years of precipitation



	2. INVESTMENT DECISIONS				3. OBSERVATIONS	4. RESULTS	
Decade	FLOOD Protection (0–9)	INVESTMENT & DEVELOPMENT (1–10)	DROUGHT Protection (0–9)	Choose Insurance?	Annual Precipitation	# Crises	# Prosperity Points
1	0	9	1		1, 4, 3, 3, 2, 5, 2, 3, 5, 4		
2				Yes / No	One Drought		
3				Yes / No			
4				Yes / No			
					TOTAL:		

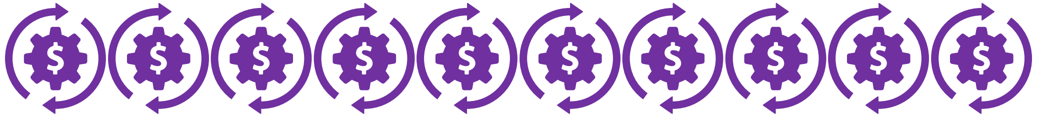
4 Tally results

Since one drought occurs, we "consume" one protection bean

We protected against 1 drought

	2. INVESTMENT DECISIONS				3. OBSERVATIONS	4. RESULTS	
Decade	FLOOD Protection (0–9)	INVESTMENT and O&M (1–10)	DROUGHT Protection (0–9)	Choose Insurance?	Annual Precipitation	# Crises	# Prosperity Points
1	0	9	1				
2				Yes / No			
3				Yes / No			
4				Yes / No			
					TOTAL:		

4 Tally results



We get 9 Prosperity Points for the remaining beans!

	2. INVESTMENT DECISIONS				3. OBSERVATIONS	4. RESULTS	
Decade	FLOOD Protection (0–9)	INVESTMENT and O&M (1–10)	DROUGHT Protection (0–9)	Choose Insurance?	Annual Precipitation	# Crises	# Prosperity Points
1	0	9	1				
2				Yes / No			
3				Yes / No			
4				Yes / No			
					TOTAL:		

4 Tally results

But what if we had a second drought?

	2. INVESTMENT DECISIONS				3. OBSERVATIONS	4. RESULTS	
Decade	**FLOOD Protection (0–9)**	**INVESTMENT and O&M (1–10)**	**DROUGHT Protection (0–9)**	Choose Insurance?	**Annual Precipitation**	**# Crises**	***# Prosperity Points***
1							
2				Yes / No			
3				Yes / No			
4				Yes / No			
					TOTAL:		

4 Tally results

Each shortage of protection is a new crisis!

Not enough protection means…
…a social and environmental crisis
…and 0 Prosperity Points!

	2. INVESTMENT DECISIONS				3. OBSERVATIONS	4. RESULTS	
Decade	FLOOD Protection (0–9)	INVESTMENT and O&M (1–10)	DROUGHT Protection (0–9)	Choose Insurance?	Annual Precipitation	# Crises	# Prosperity Points
1							
2				Yes / No			
3				Yes / No			
4				Yes / No			
					TOTAL:		

4 Tally results

If one drought occurs:

	FLOOD Protection	INVESTMENT and O&M	DROUGHT Protection	# Crises	# Prosperity Points
Region 1		x9	x1	0	x9
Region 2	x2	x8		x2	0

	2. INVESTMENT DECISIONS				3. OBSERVATIONS	4. RESULTS	
Decade	**FLOOD Protection (0–9)**	**INVESTMENT and O&M (1–10)**	**DROUGHT Protection (0–9)**	Choose Insurance?	**Annual Precipitation**	**# Crises**	***# Prosperity Points***
1							
2				Yes / No			
3				Yes / No			
4				Yes / No			
					TOTAL:		

Repeat steps 1 through 4

1. Receive scientific information
2. Make decisions
3. Record observations
4. Tally results

Key Rules

Simplification of reality
No challenging the rules!

Decisions are collaborative
But only within your region!

We will play 4 decades of decision making
Each round is 10 years

Winning the game

The Winning Region has:

- *Most Prosperity Points*
- *Tiebreaker: Region with fewest crises*

There are prizes!!!


Let’s Play!!!

One last task..

In your groups, identify:

- One thing you learned from the game, and
- One thing you felt

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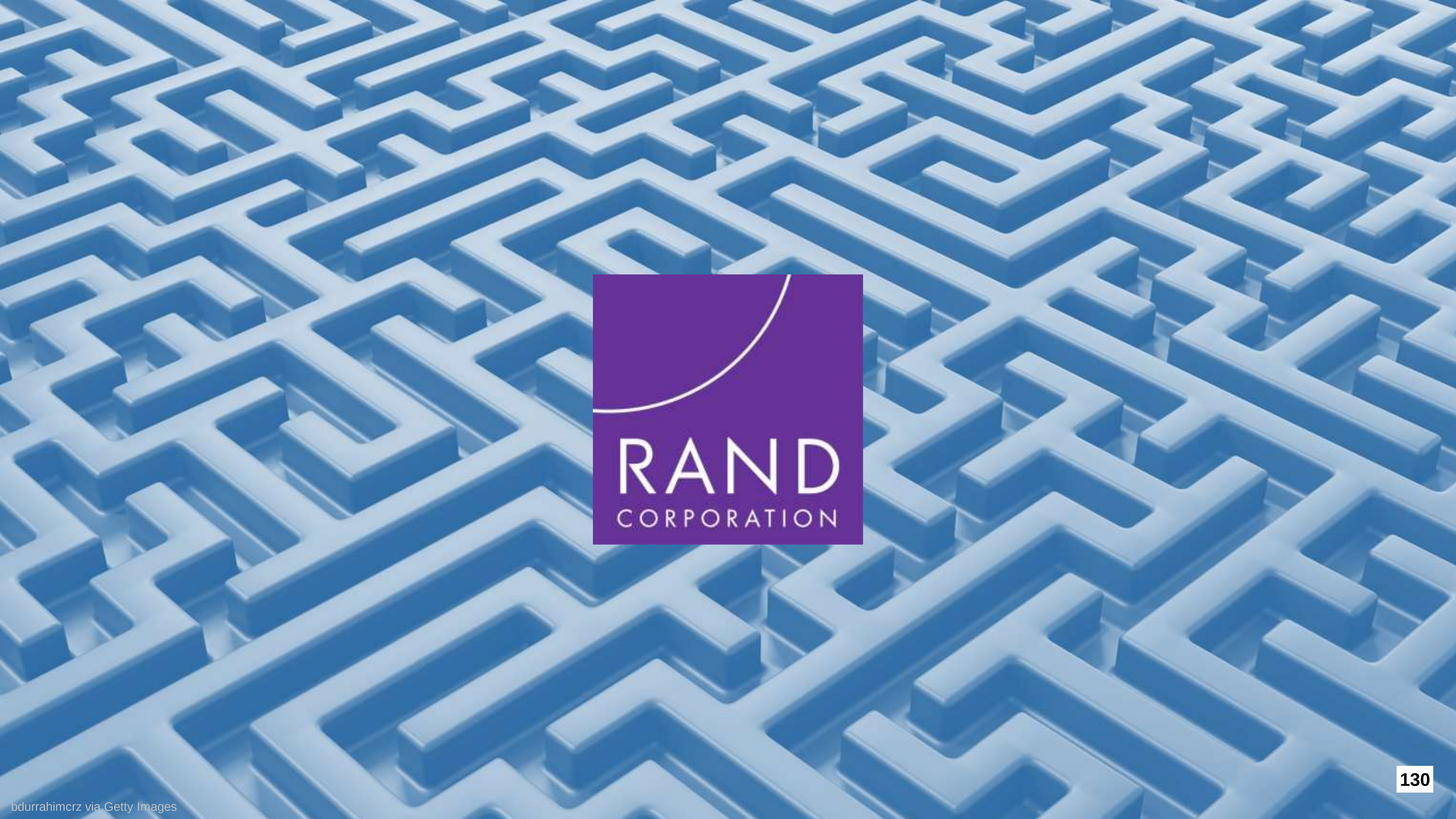

bdurrahimcrz via Getty Images