AFRICA
IAHR 2022 Online Summer School

CLIMATE CHANGE ADAPTATION

Peter Goodwin

President, University of Maryland Center for Environmental Science

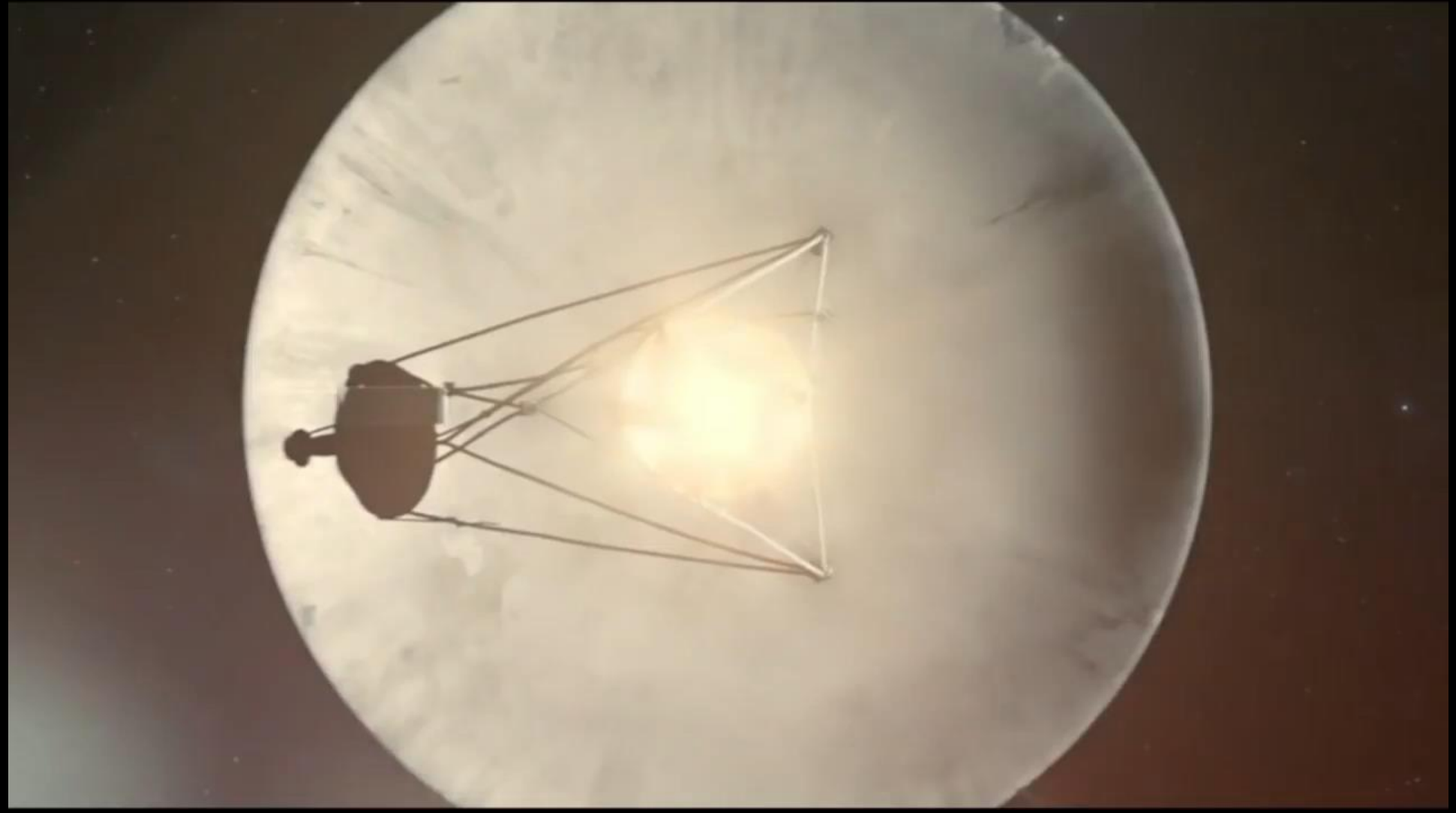
Vice Chancellor for Environmental Sustainability, University System of Maryland

State of the Science

Our Common Challenges

Coastal Adaptation

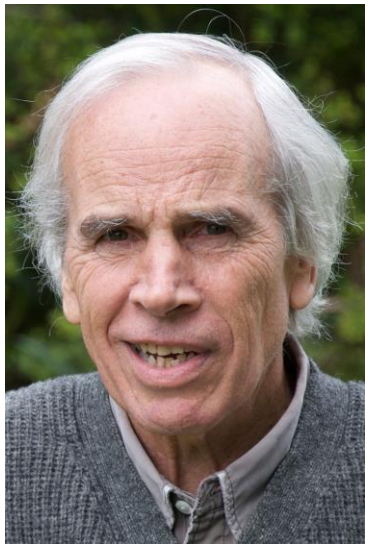
Selected Resources and Opportunities to Network



The Pale Blue Dot: A vision of the human future. Carl Sagan, 1994.
carlsagandotcom
https://www.youtube.com/watch?v=kjtuVvfRhHs

The Twin Crises:
Climate Change and Loss of Biodiversity

Crisis:
Society pulls together to seek solutions
COVID-19, Ukraine



Douglas Tomkins
1943-2015

Predicament (a wicked problem):
Society divided on solutions
Who is responsible for identifying and implementing solutions?

World Scientists' Warning of a Climate Emergency

WILLIAM J. RIPPLE, CHRISTOPHER WOLF, THOMAS M. NEWSOME, PHOEBE BARNARD, WILLIAM R. MOOMAW, AND 11,258 SCIENTIST SIGNATORIES FROM 153 COUNTRIES (LIST IN SUPPLEMENTAL FILE S1)

Scientists have a moral obligation to clearly warn humanity of any catastrophic threat and to "tell it like it is." On the basis of this obligation and the graphical indicators presented below, we declare, with more than 11,000 scientist signatories from around the world, clearly and unequivocally that planet Earth is facing a climate emergency.

Exactly 40 years ago, scientists from 50 nations met at the First World

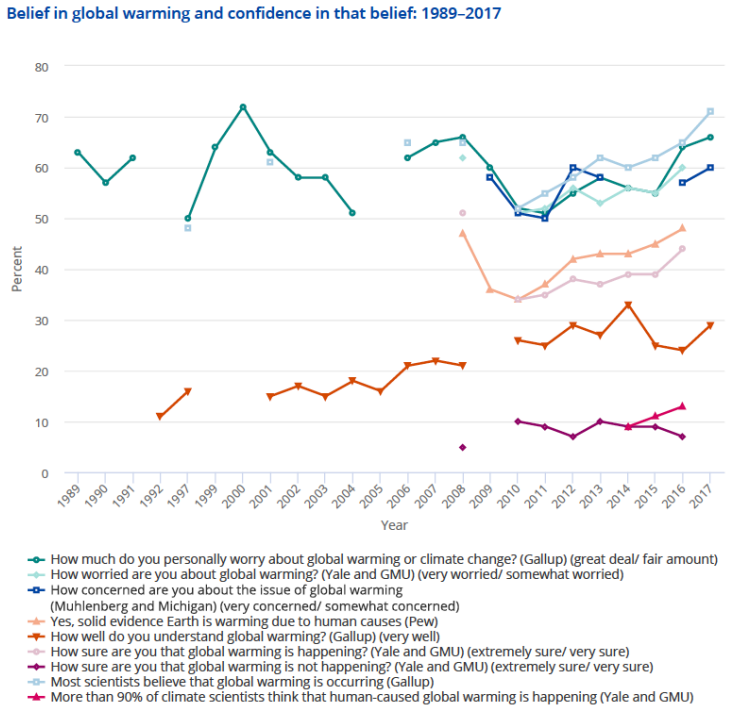
as actual climatic impacts (figure 2). We use only relevant data sets that are clear, understandable, systematically collected for at least the last 5 years, and updated at least annually.

The climate crisis is closely linked to excessive consumption of the wealthy lifestyle. The most affluent countries are mainly responsible for the historical GHG emissions and generally have the greatest per capita emissions (table S1). In the present article we

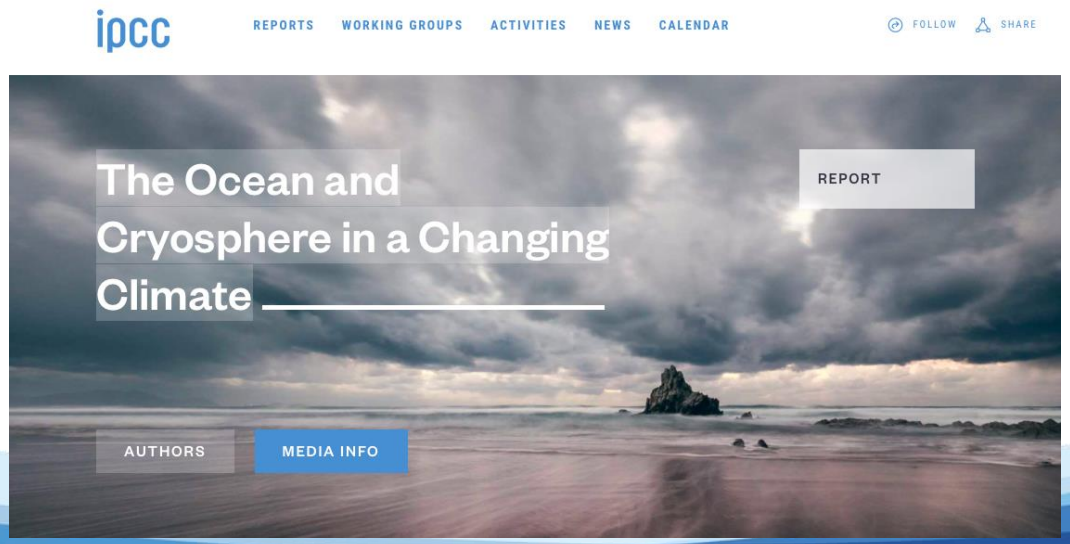
forest loss in Brazil's Amazon has now started to increase again (figure 1g). Consumption of solar and wind energy has increased 373% per decade, but in 2018, it was still 28 times smaller than fossil fuel consumption (combined gas, coal, oil; figure 1h). As of 2018, approximately 14.0% of global GHG emissions were covered by carbon pricing (figure 1m), but the global emissions-weighted average price per tonne of carbon dioxide

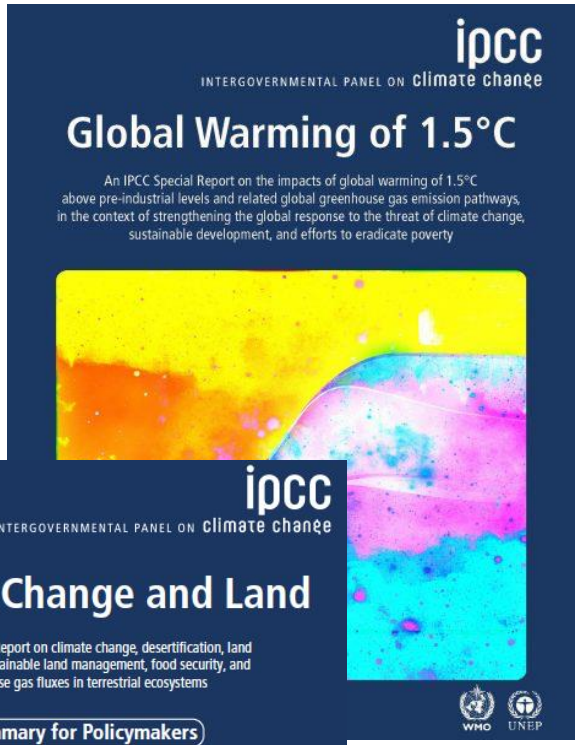
BioScience, November 2019

Stationarity is Dead



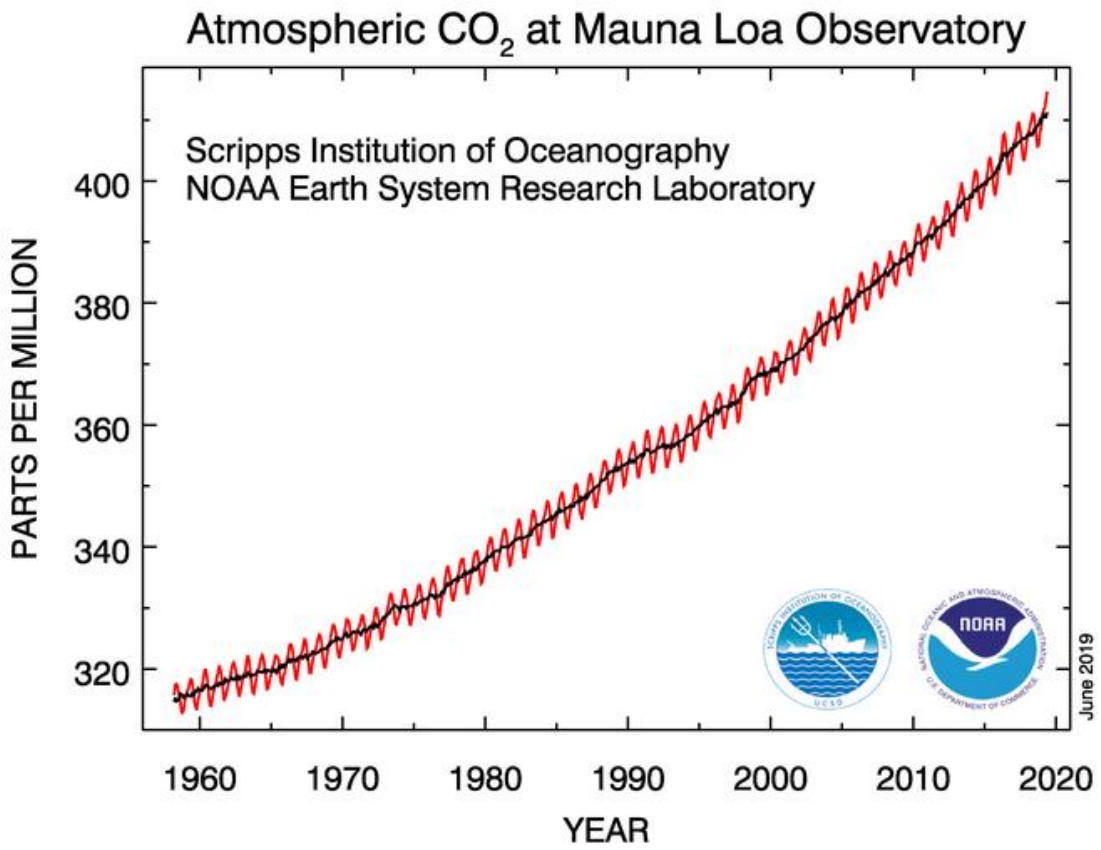
Science and Engineering Indicators 2018 (NSB-2018-1) | Digest (NSB-2018-2)



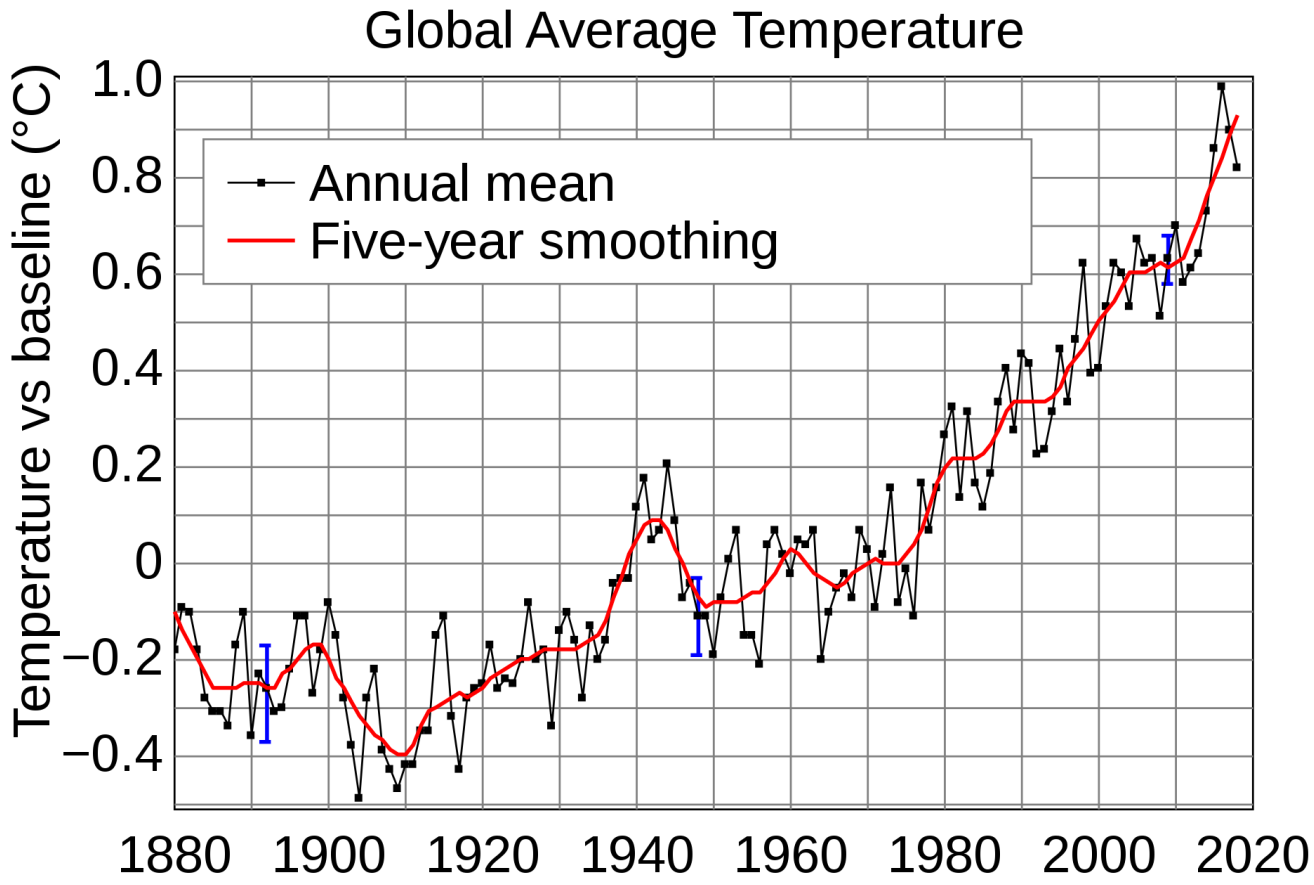


Cause of Global Warming

Emissions of Greenhouse Gases Continue to Rise



Global Temperatures Continue to Rise

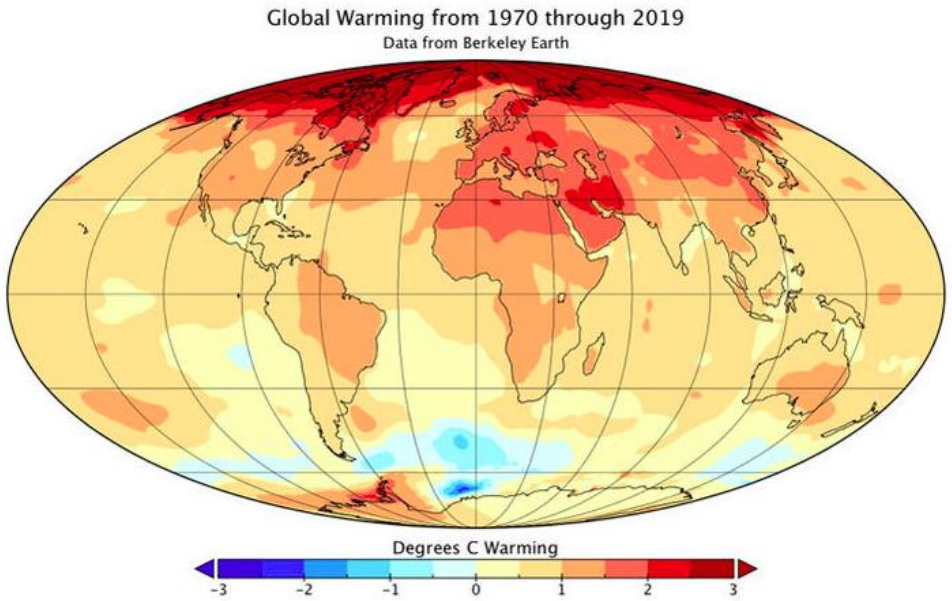


Accuracy of Global Warming Predictions

10 of 17 forecasts from 1970-2001 showed no statistical difference between observations and predictions

5 of 7 – corrected for actual pollutants gave accurate predictions.

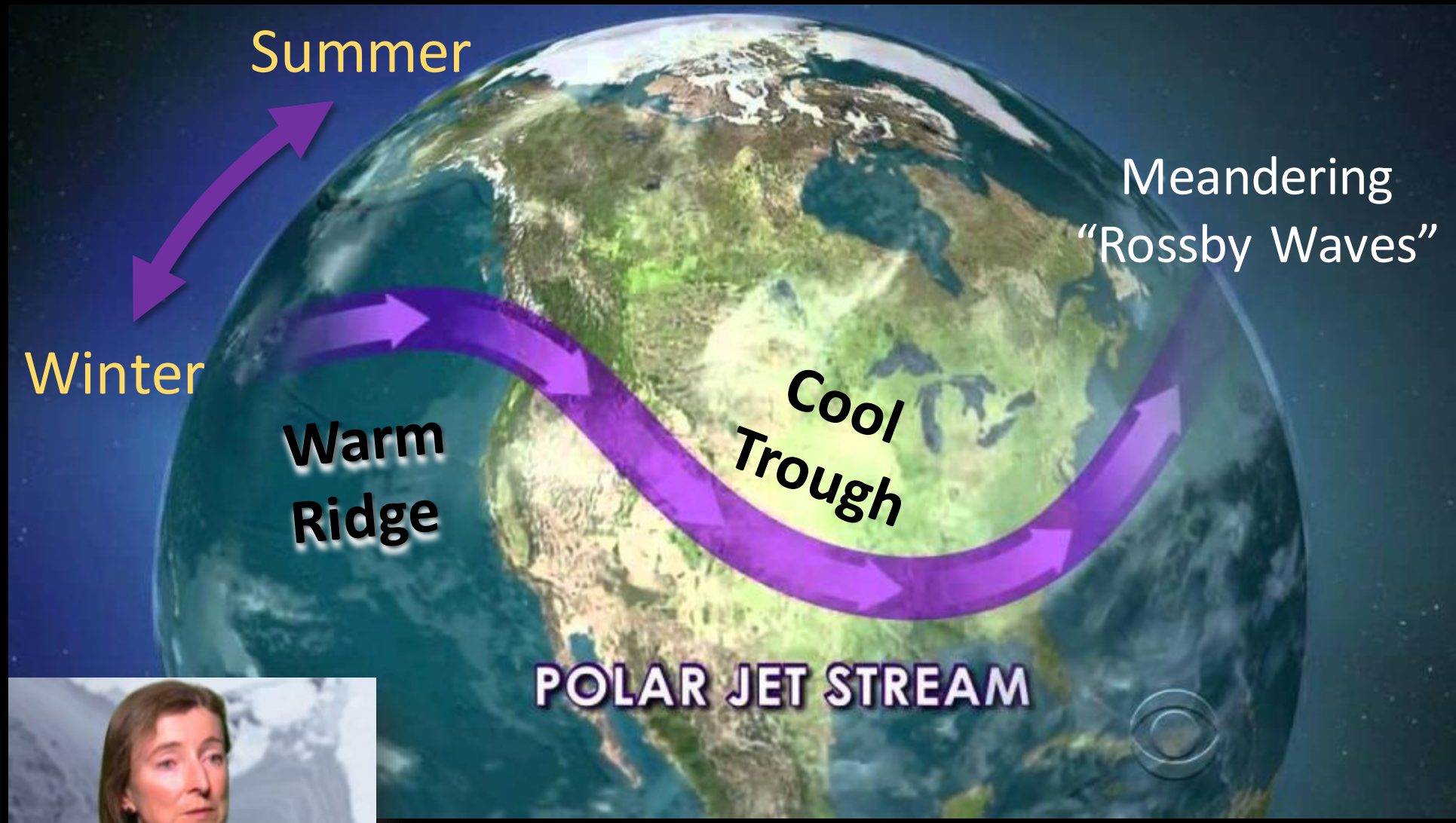
New knowledge of physics explains discrepancies

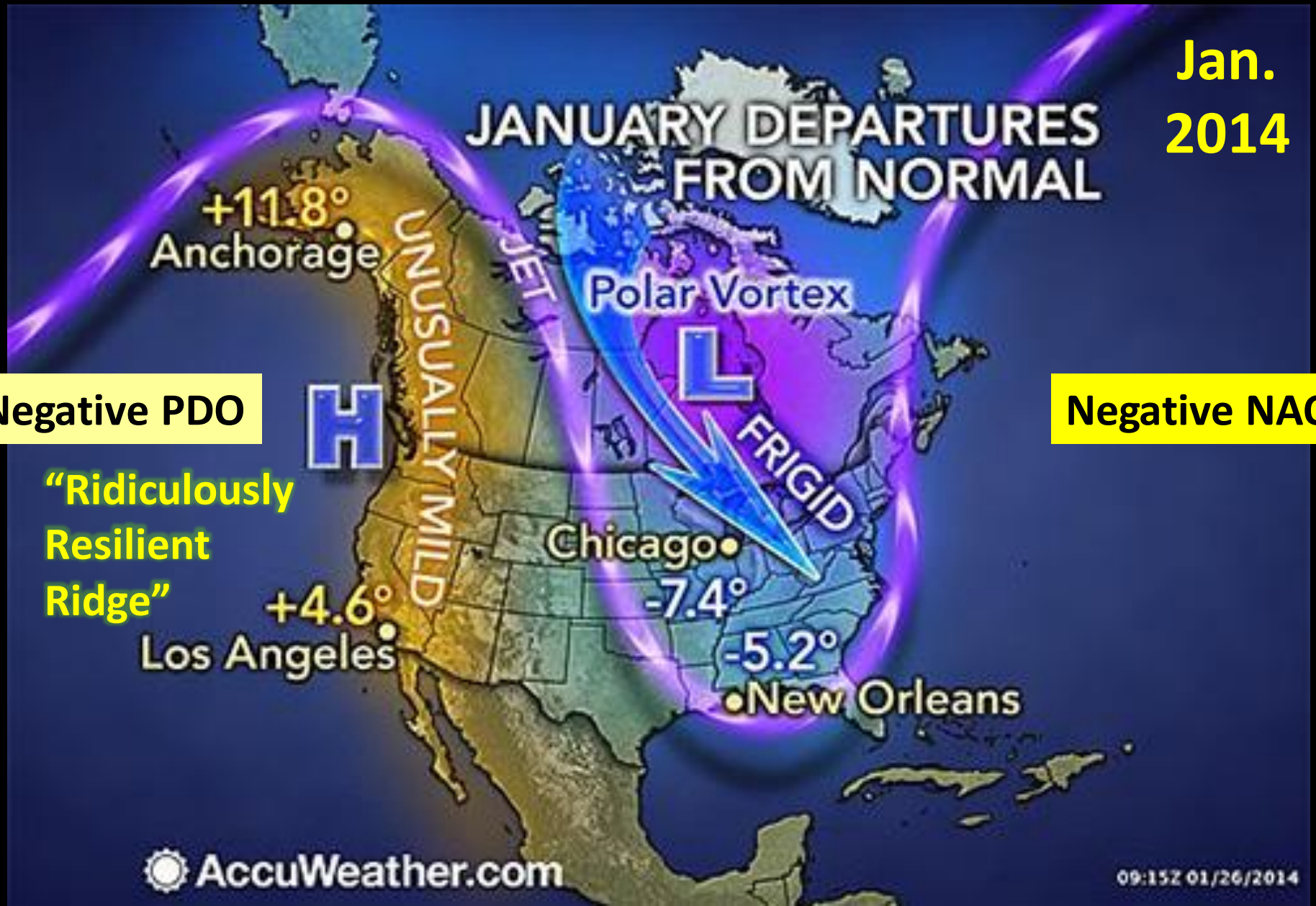


Global temperatures have risen approximately 0.9°C since 1970, though some areas have warmed much more than others. BERKELEY EARTH

Even 50-year-old climate models correctly predicted global warming
By Warren Cornwall Science Dec. 4, 2019

Polar Jet Stream meanders & moves




JANUARY DEPARTURES FROM NORMAL
Jan. 2014
+11.8°
Anchorage
UNUSUALLY MILD
JET
Polar Vortex
L
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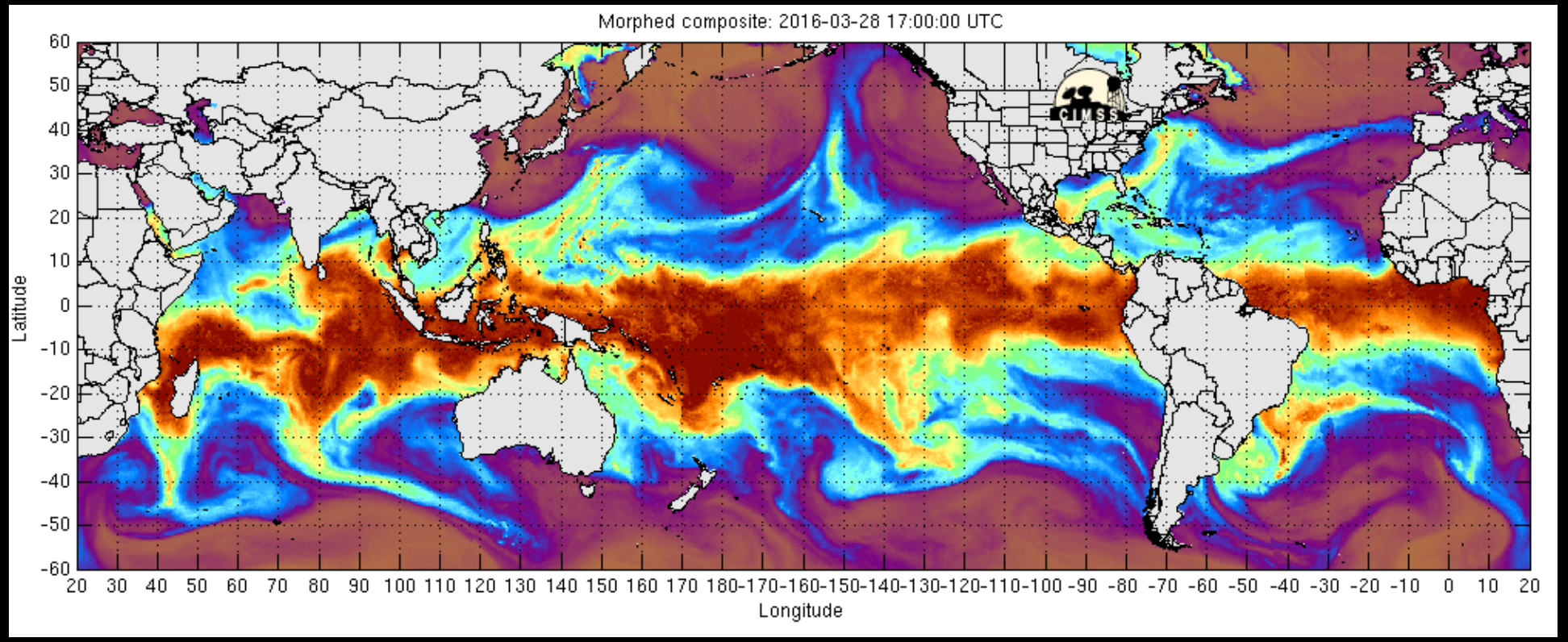
FRIGID
Negative PDO
Negative NAO
"Ridiculously Resilient Ridge"
Chicago
-7.4°
+4.6°
Los Angeles
-5.2°
New Orleans
AccuWeather.com
09:15Z 01/26/2014


Taking steps to
conserve water
during the drought.
DGS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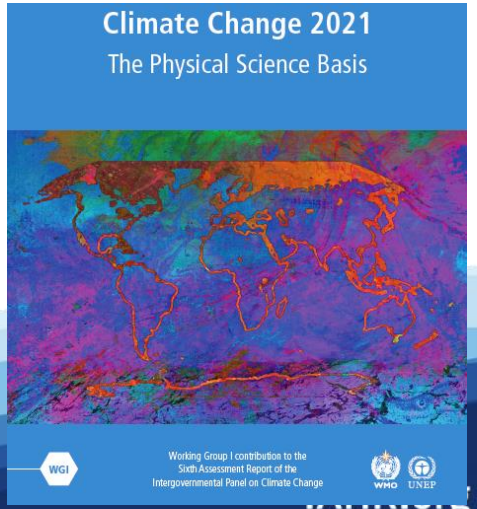
20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 -170 -160 -150 -140 -130 -120 -110 -100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20
CIMSS

The United Nations Intergovernmental Panel on Climate Change (IPCC) released the Physical Science Basis Report (PSB Report) Sixth Assessment in August 2021

234 contributing authors synthesizing more than 14,000 scientific references

- *It is unequivocal that human influence has warmed the atmosphere, ocean, and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred. [Finding A.1]*

- *Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events. [Finding B.3]*



- Things are worse than projected or understood.

  40% of world population is highly vulnerable

- Loss and damages are real and significant. *Who pays*?
- Technology is not a magic fix.

  Example: machines for direct carbon capture may emit a good % of the extracted carbon

- Cities offer opportunity. Smart cities, transportation in high density population areas can have big benefits
- **The time for action is now**.

  We can still avoid the worst effects if concerted and significant action is taken now

AR6 Final Synthesis Report due end of 2022.

Political and Agency Leadership

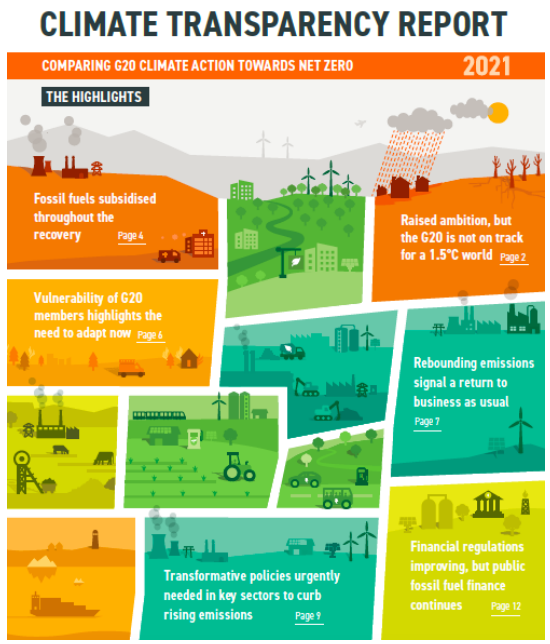
The evidence detailed by IPCC is a *code red for humanity:*

An *atlas of human suffering and a damning indictment of failed climate leadership*.

- *Nearly half of humanity is living in the danger zone – now.*
- *Many ecosystems are at the point of no return – now.*
- *Unchecked carbon pollution is forcing the world's most vulnerable on a frog march to destruction – now*."

UN Secretary-General António Guterres
August 9, 2021

G20 Countries



75% Global Greenhouse Gas Emissions

For a 67% chance of limiting global warming to 1.5°C it is necessary to limit carbon emissions to 400 $GtCO_2$

This is 10 years of emissions at 2020 levels

Current National Determined Contribution(NDC) Targets will result in 2.7°C increase in global temperature by 2100.

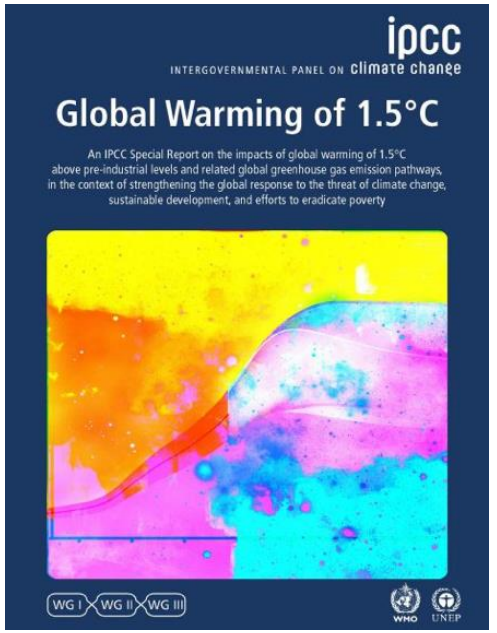
In 2020, under COVID, the world saw a 6% reduction in GHG emissions over 2019 levels but an increase in 2021.

The Good News

European Commission - Statement

Statement by President von der Leyen at the joint press conference with President Sassoli and Prime Minister Costa on the EU's political priorities under the Portuguese Presidency

Brussels, 20 January 2021



Joint Statement:
The United States and China are committed to cooperating with each other and with other countries to tackle the climate crisis, which must be addressed with the seriousness and urgency that it demands.

April 17, 2021 and November 10, 2021
President Xi Jinping and President Biden

Climate change: EU to cut CO2 emissions by 55% by 2030

13 hours ago

Climate change

Renewable energy, like wind power, is gradually replacing coal in many EU countries

The EU has adopted ambitious new targets to curb climate change, with a pledge to make them legally binding.

BBC: April 21, 2021

UN CLIMATE CHANGE CONFERENCE UK 2021

IN PARTNERSHIP WITH ITALY

Conference of Parties (COP26) Goals

1. Secure global net zero by mid century - keep 1.5°C within reach
2. Adapt to protect communities and natural habitats
3. Mobilize finance. - EQUITY. Countries most affected did least to cause problem
4. Work together to deliver

.org

Climate Tipping Points

Global

Greenland Ice Sheet Collapse
West Antarctic Ice Sheet Collapse
Amazon Rainforest dieback
Boreal Permafrost Collapse
Atlantic Circulation Collapse
Arctic Winter Ice Sheet Collapse
East Antarctic Ice Sheet Collapse
Low Latitude Coral Reef Die-offs

Regional

Boreal Permafrost abrupt thaw
Mountain Glacier loss
Sahel and W. Africa Monsoon (greening)
Southern Boreal Forest dieback
Northern Boreal Forest expansion

Armstrong McKay et al., Science. September 9, 2022

Vancouver, Canada
November 20, 2021

Rescuing cows that were stranded in a flooded barn in Abbotsford. Jennifer Gauthier/Reuters

Coquihalla Highway 5 was damaged by mudslides near Coldwater River Provincial Park in British

Zhengzhou, China
22nd July 2021

Wading through a flooded road in Zhengzhou, China, on Thursday. More rain is in the forecast after days of torrential downpours in the region. Aly Song/Reuters

NOAA NIDIS Drought.gov
National Integrated Drought Information System

24th March 2022

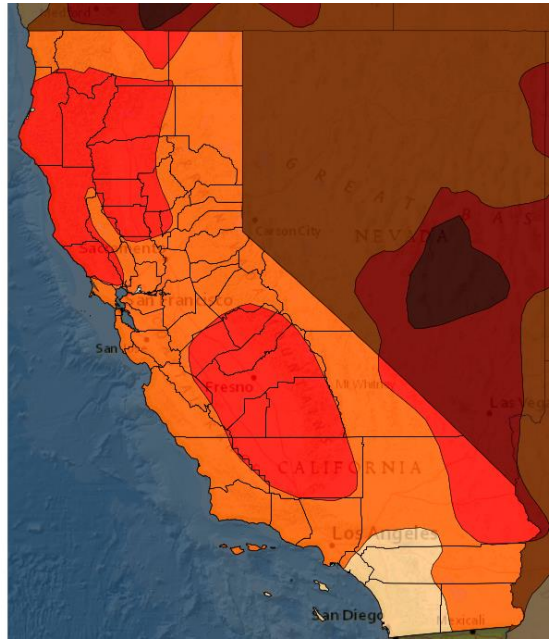
impacts are not exhaustive, they can help provide a clearer picture of drought in California.

D0 - Abnormally Dry — 100.0% of CA (D0–D4)
- Soil is dry; irrigation delivery begins early
- Dryland crop germination is stunted
- Active fire season begins

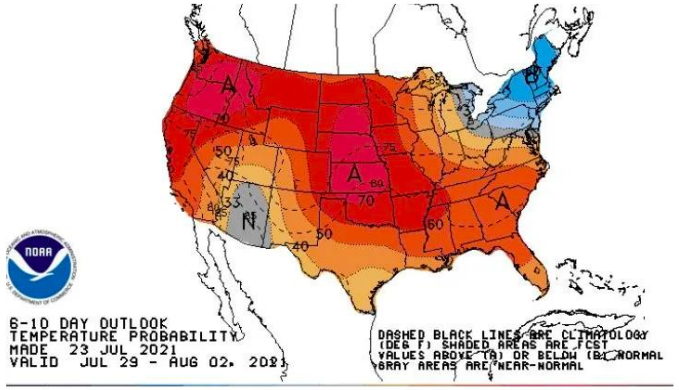
D1 - Moderate Drought — 100.0% of CA (D1–D4)
- Dryland pasture growth is stunted; producers give supplemental feed to cattle
- Landscaping and gardens need irrigation earlier; wildlife patterns begin to change
- Stock ponds and creeks are lower than usual

D2 - Severe Drought — 93.7% of CA (D2–D4)
- Grazing land is inadequate
- Fire season is longer, with high burn intensity, dry fuels, and large fire spatial extent
- Trees are stressed; plants increase reproductive mechanisms; wildlife diseases increase

D3 - Extreme Drought — 37.7% of CA (D3–D4)
- Livestock need expensive supplemental feed; cattle and horses are sold; little pasture remains; fruit trees bud early; producers begin irrigating in the winter
- Fire season lasts year-round; fires occur in typically wet parts of state; burn bans are implemented
- Water is inadequate for agriculture, wildlife, and urban needs; reservoirs are extremely low; hydropower is restricted



Heat Dome: 24th July 2021



Erfstadt-Blessam, Germany
16th July 2021

Before

After

Source: Google Earth/@BezRegKoeln

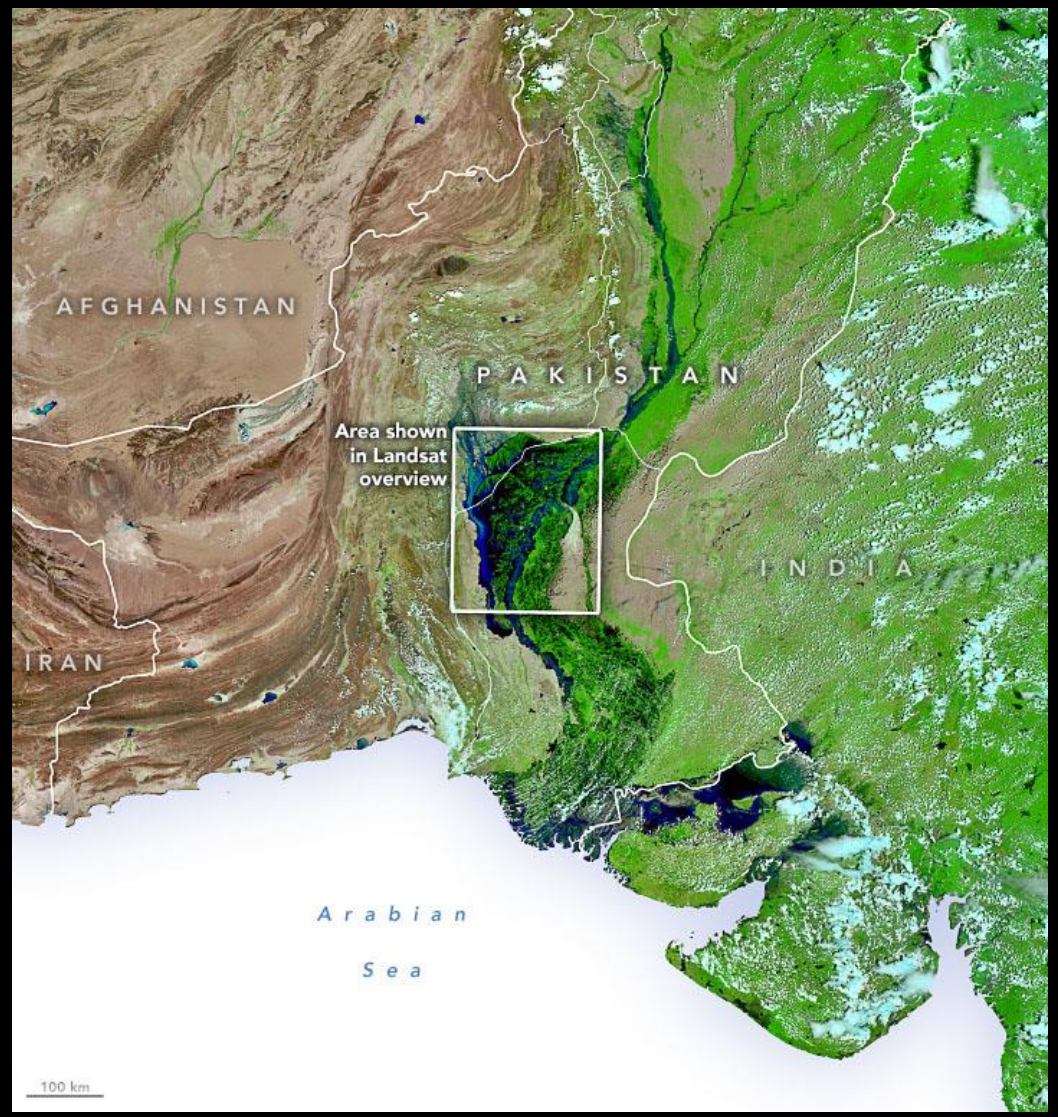
Sindh Province

Pakistan

August 2022

NASA Earth Observatory

https://earthobservatory.nasa.gov/



Hurricane Ian

September 2022

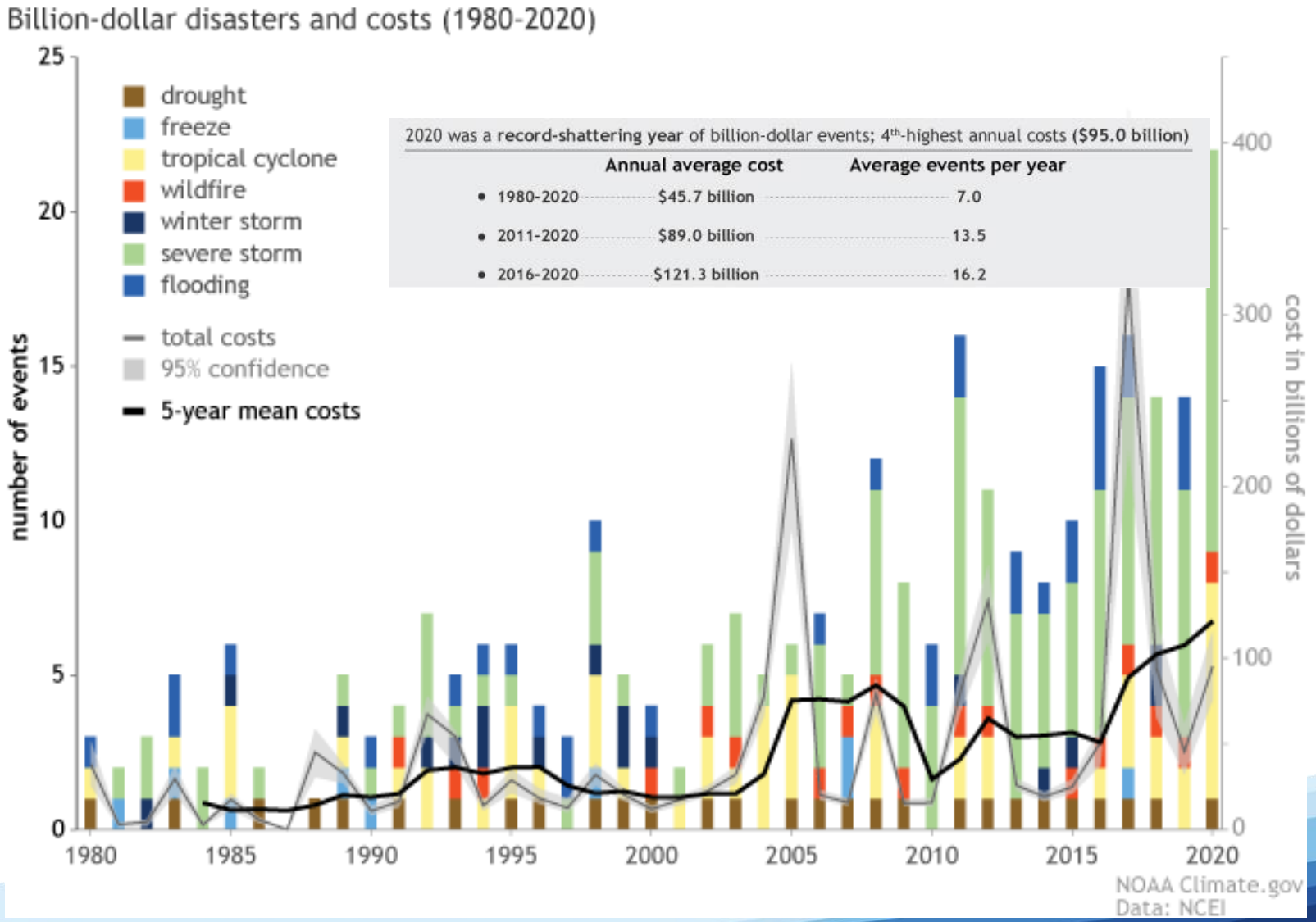
September 2022
NASA Earth Observatory
https://earthobservatory.nasa.gov/

Hurricane Ian
Photos courtesy of NY Times

City of Naples Police Department

NOAA: US Billion-Dollar Climate and Weather Disasters

www.climate.gov



Common Myths on Social Media

- Global warming is a result of fluctuations in the sun's energy
- The sun's energy goes through cycles [True]

BUT:

- A weaker phase in the sun's energy is expected to cause a 0.1-0.2^{o}C change later this century
- Entire atmosphere is affected by sun's fluctuations
- The stratosphere (closest to the sun is cooling)
- Atmosphere closest to the earth is warming (heat normally released to stratosphere is trapped)

Common Myths on Social Media

- Global warming is a good thing

- Extreme cold weather kills more people than extreme warm weather (True – through 2019)

But:

- Heat deaths are projected to increase
  (example: 2021 Heat Dome North America)
- More extreme flooding, droughts, famine
- Low-lying countries like the Maldives face extinction

Common Myths on Social Media

- Climate change action will result in a decline in standard of living. Fossil fuels are essential for economic growth
- Industrial revolution – enabled society to manufacture and innovate [True]

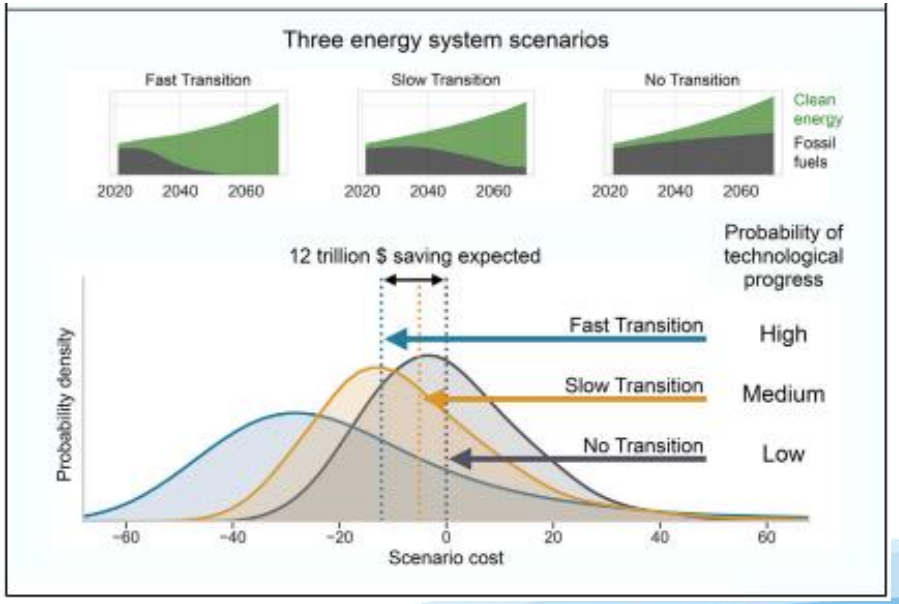
BUT:

- Renewable electricity is now cheaper than coal, oil and gas in some regions. Innovations in energy storage are emerging.
- Global economy could shrink by 18% due to natural disasters and more extreme temperatures if no significant changes by 2050
- University of Oxford paper, September 2022

Poorest communities and countries are the most vulnerable

Transition to Green Energy

- Oil & gas costs have not changed much when adjusted for inflation
- Renewables cost is decreasing
- Fossil fuel to green energy could save $12 trillion by 2050



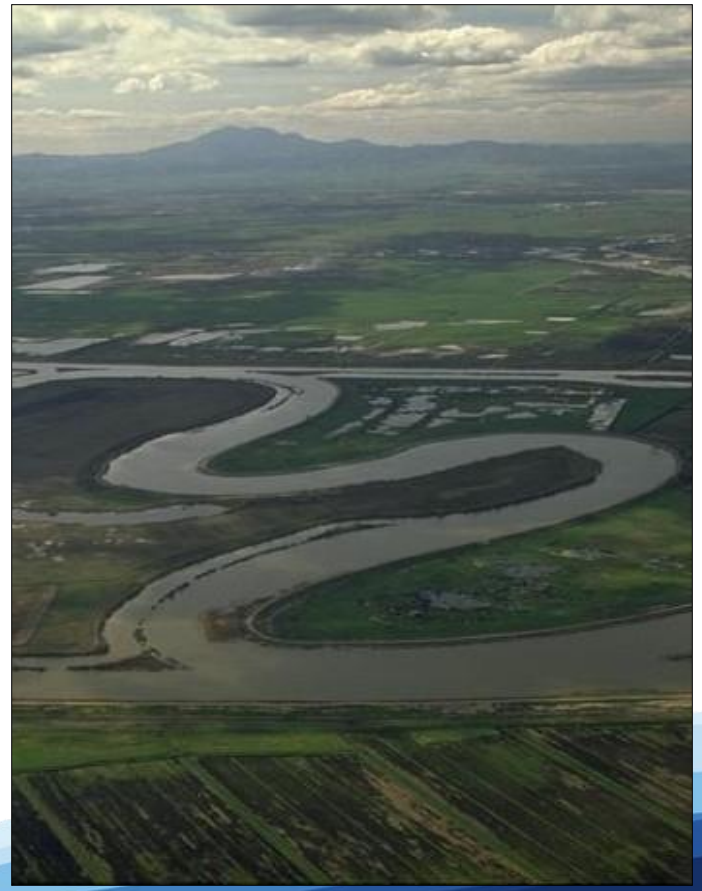
Way, R., Ives, M. C., Mealy, P., & Farmer, J. D. (2022). Empirically grounded technology forecasts and the energy transition.
Joule, 6(9), 2057–2082. https://doi.org/10.1016/j.joule.2022.08.009

Photo credit: Jane Thomas, Integration and Application Network (ian.umces.edu/media-library

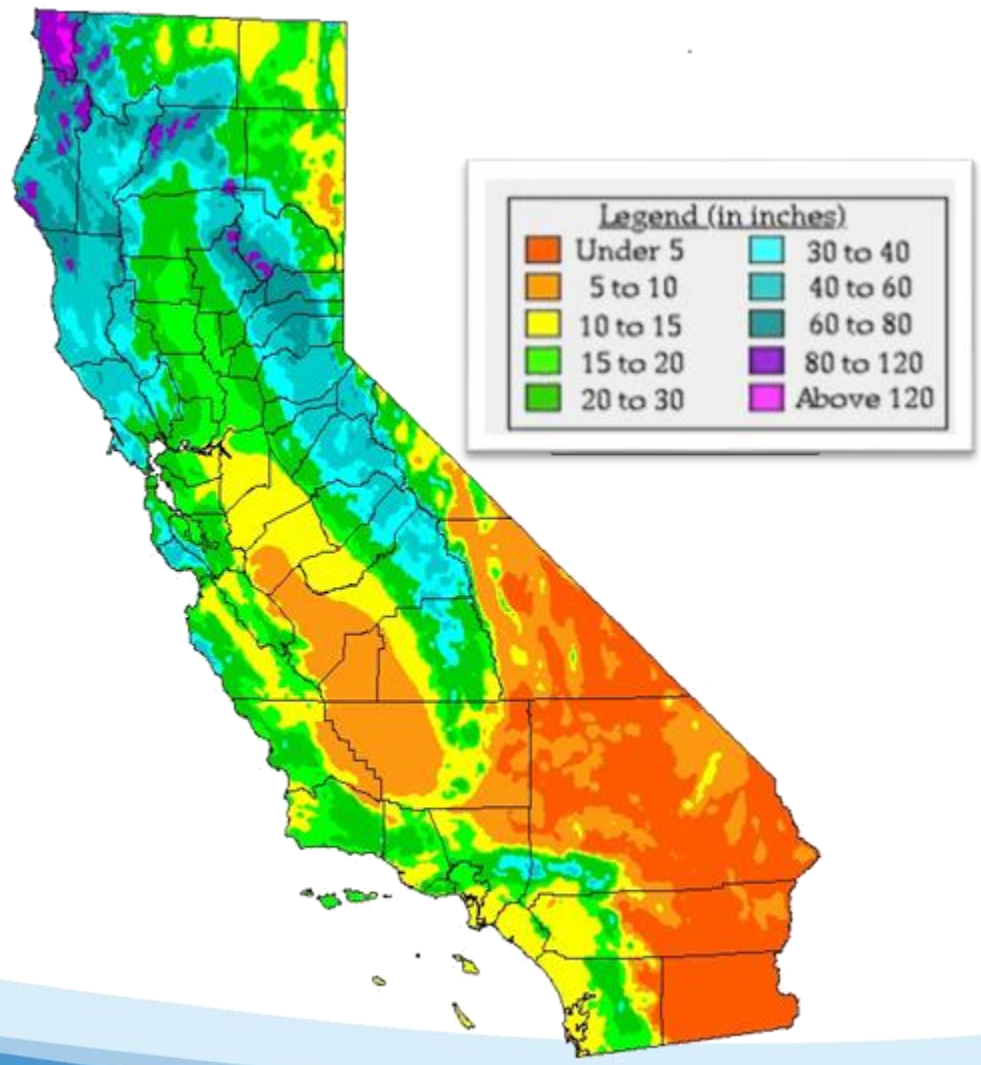
Managing our Environment for the Future

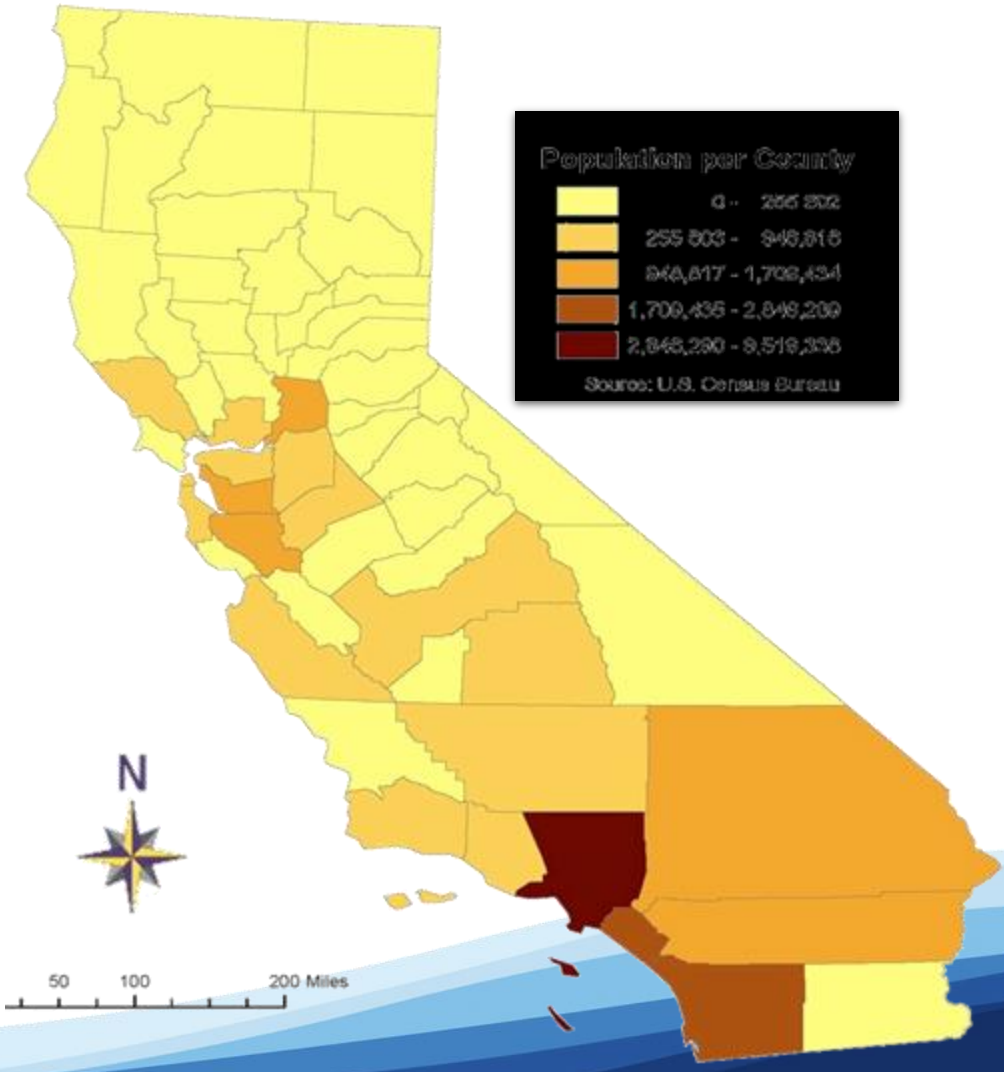
'*Drivers of complexity*' will include:

- Climate Change
- Population Growth
- Land Use Change
- Relative Sea Level Rise
- Catastrophic Events in Stressed Eco-Systems (floods, earthquakes, droughts, contaminant spills)
- Invasive Species
- Emerging contaminants

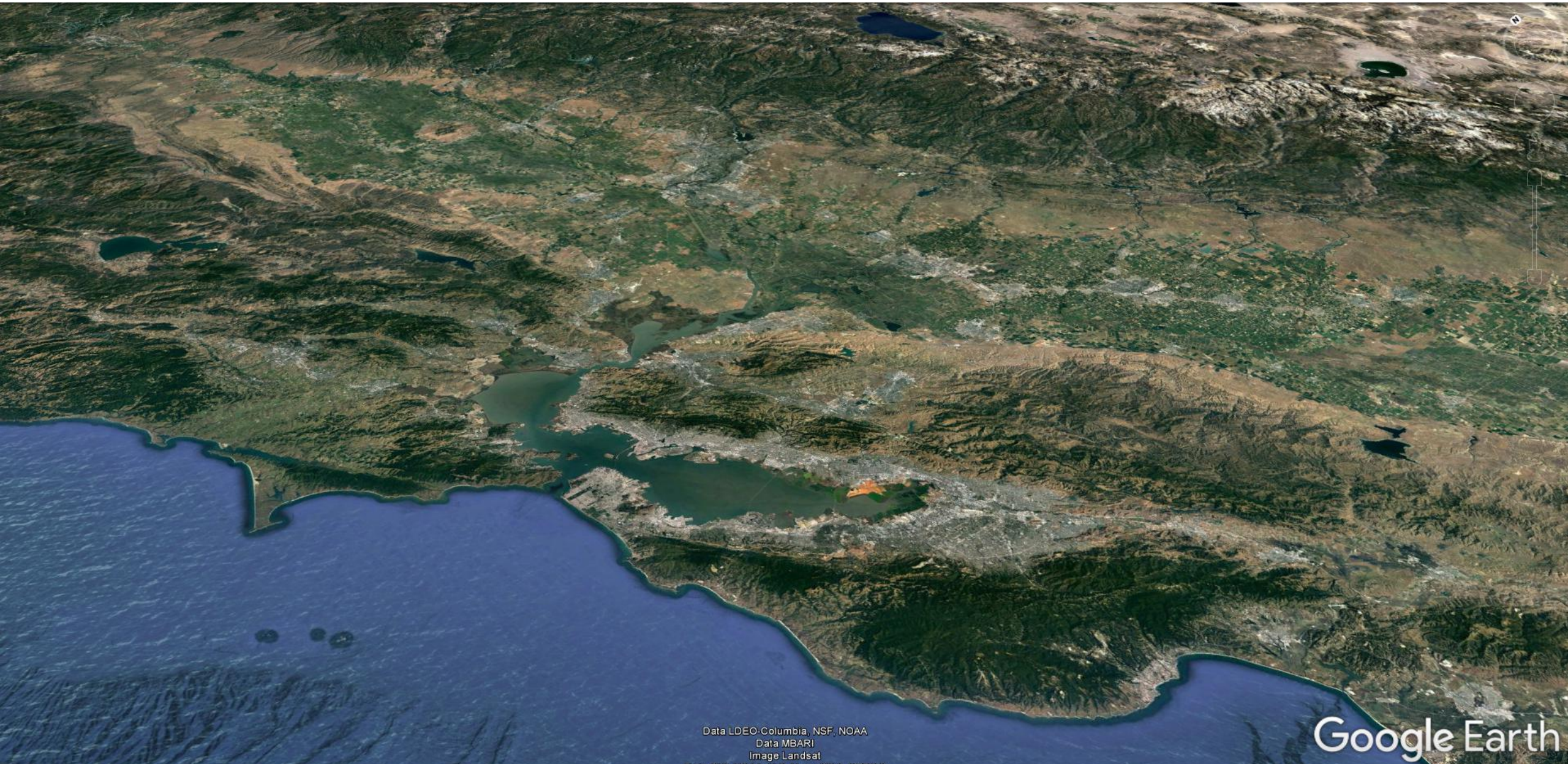


California Precipitation and Population





San Francisco Bay Delta

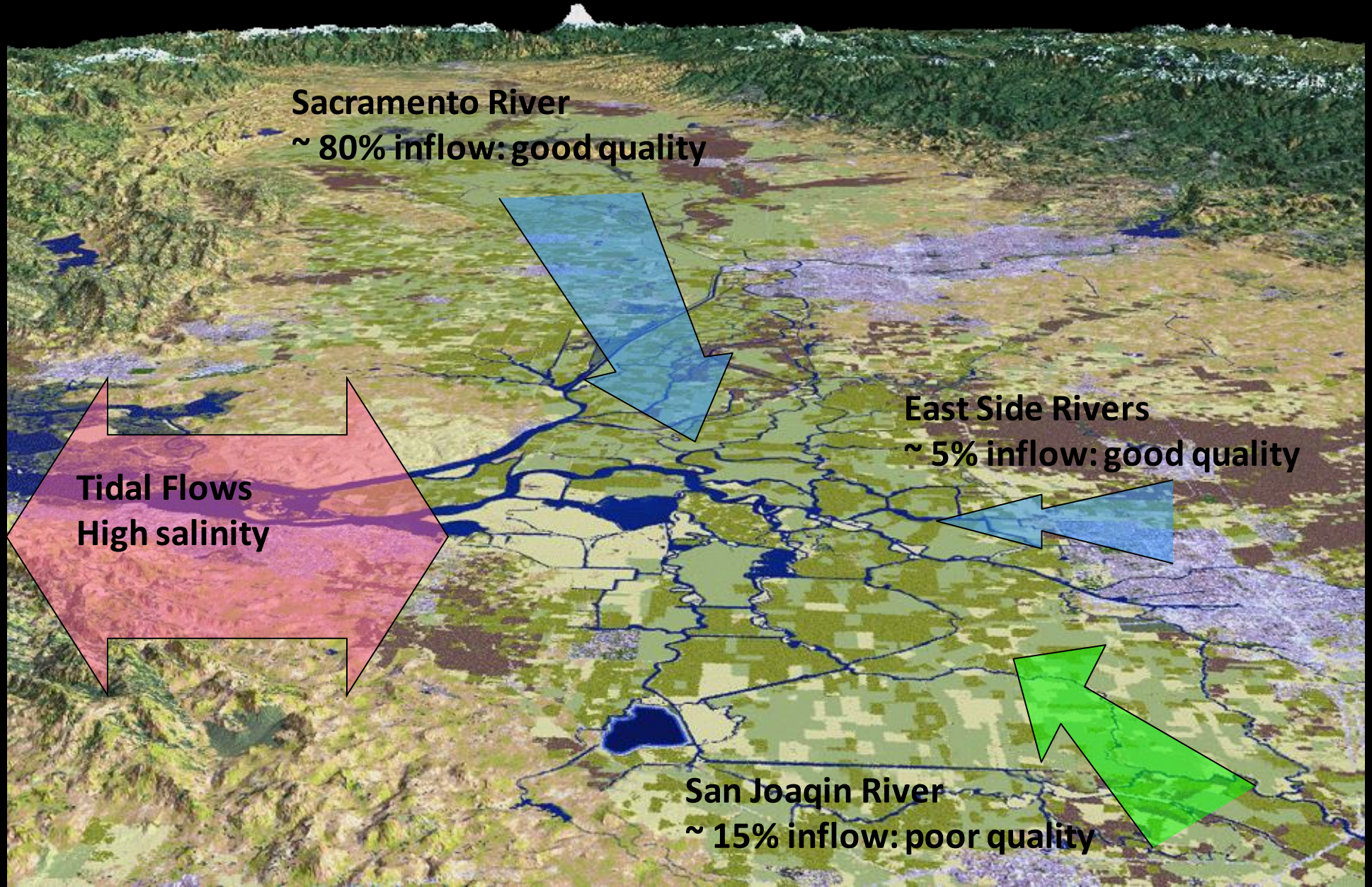


The Water Problems facing California

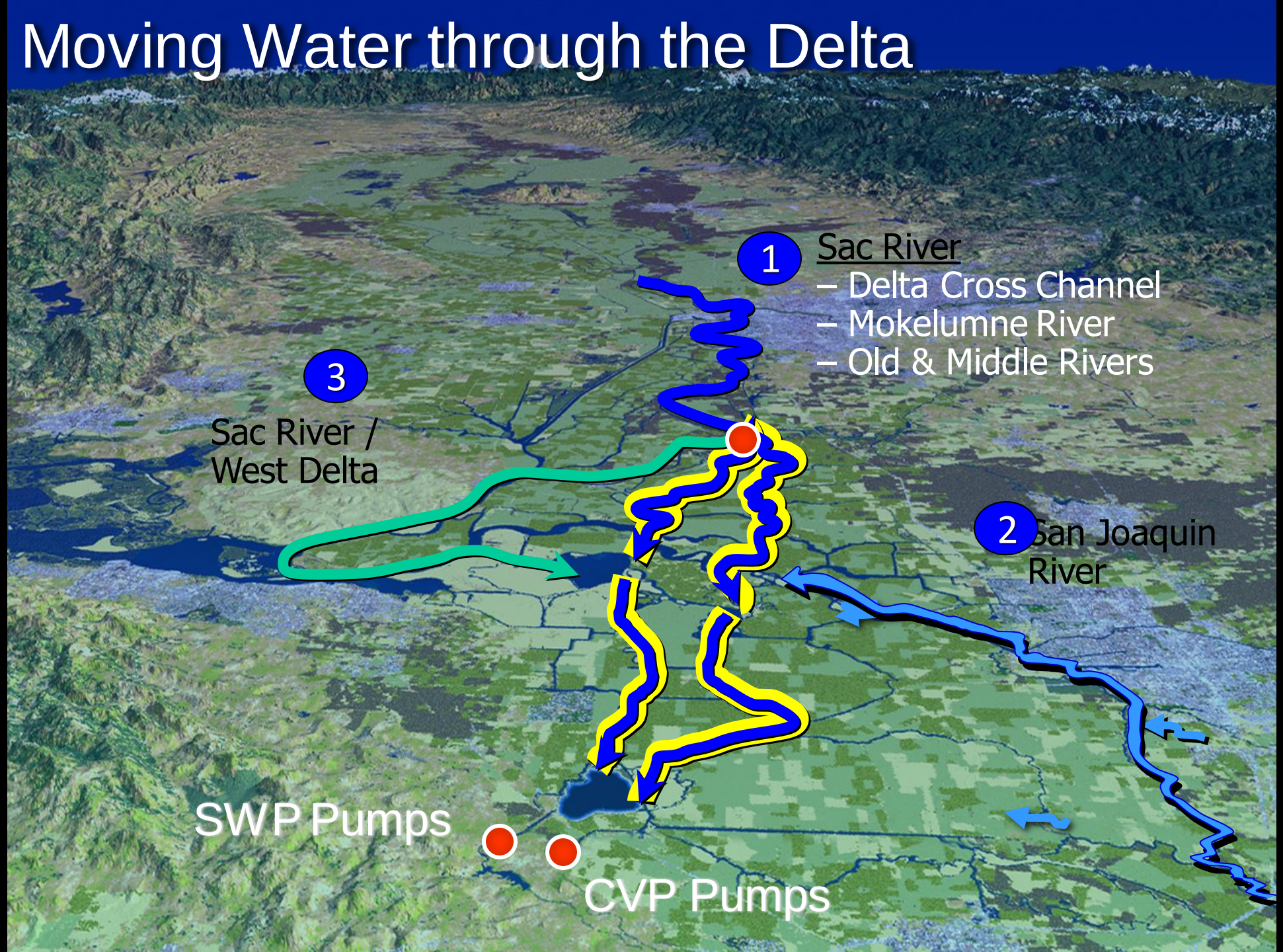
- → 2/3 of California residents rely on Delta water
- → Irrigates up to 4 million acres of California farmland

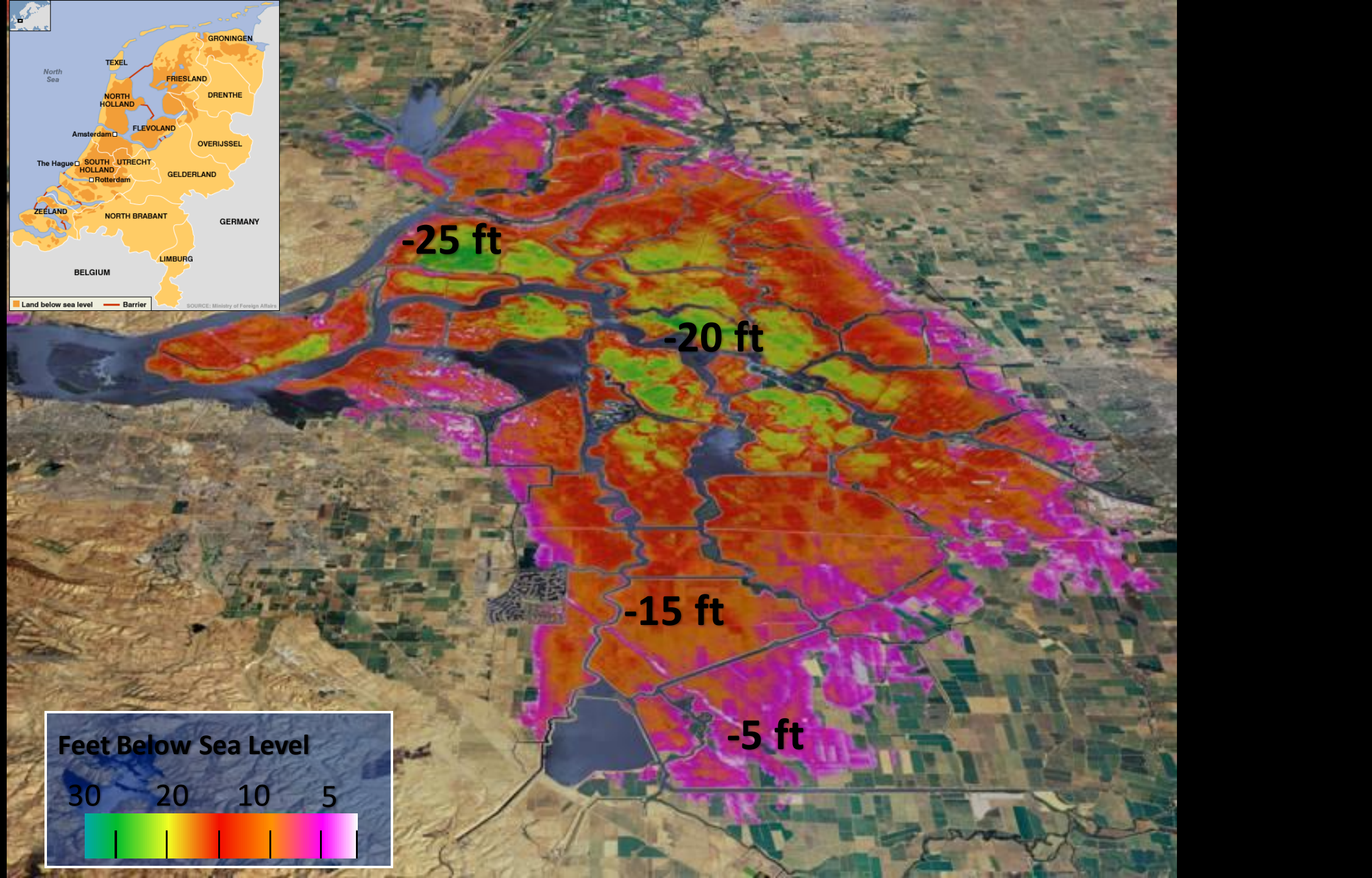
- → 80% of California's commercial fishery species rely on the Bay-Delta
- → Habitat for 700 species, including 50+ threatened or endangered
- → Hotspot for biodiversity
- → Greatest loss of biodiversity

Delta Inflows



Moving Water through the Delta

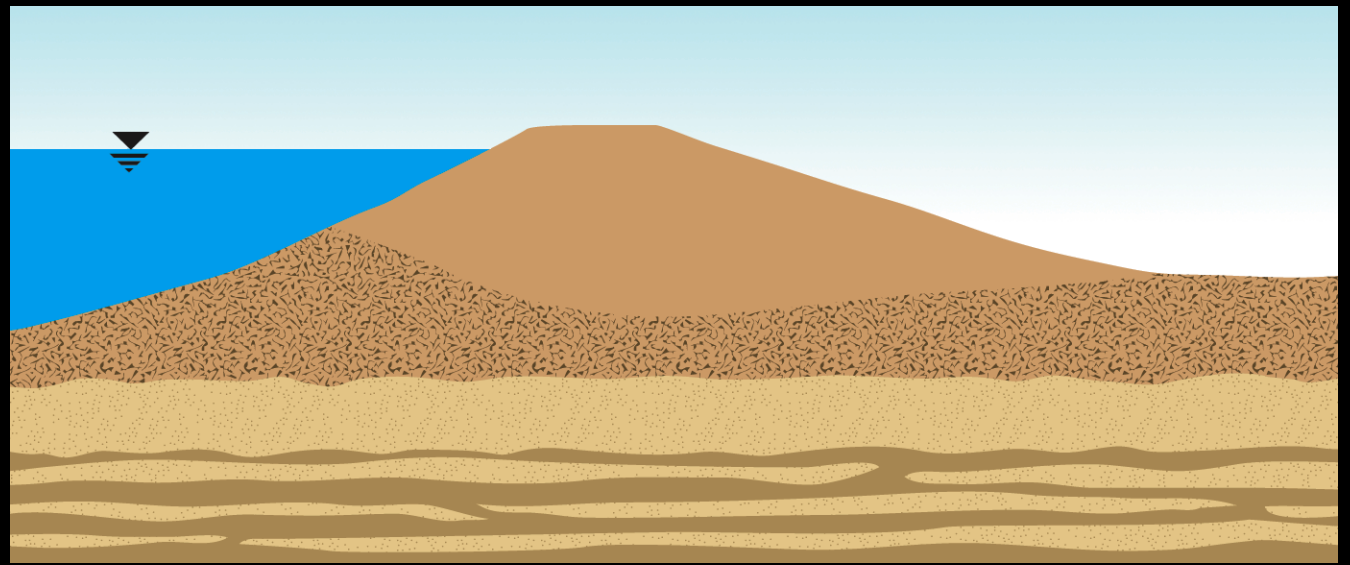



GRONINGEN
TEXEL
North Sea
FRIESLAND
DRENTHE
NORTH HOLLAND
FLEVOLAND
Amsterdam
OVERIJSSEL
The Hague
SOUTH HOLLAND
UTRECHT
GELDERLAND
Rotterdam
ZEELAND
NORTH BRABANT
GERMANY
LIMBURG
BELGIUM
Land below sea level
Barrier
SOURCE: Ministry of Foreign Affairs
-25 ft
-20 ft
-15 ft
-5 ft
Feet Below Sea Level
30
20
10
5

Delta Levees

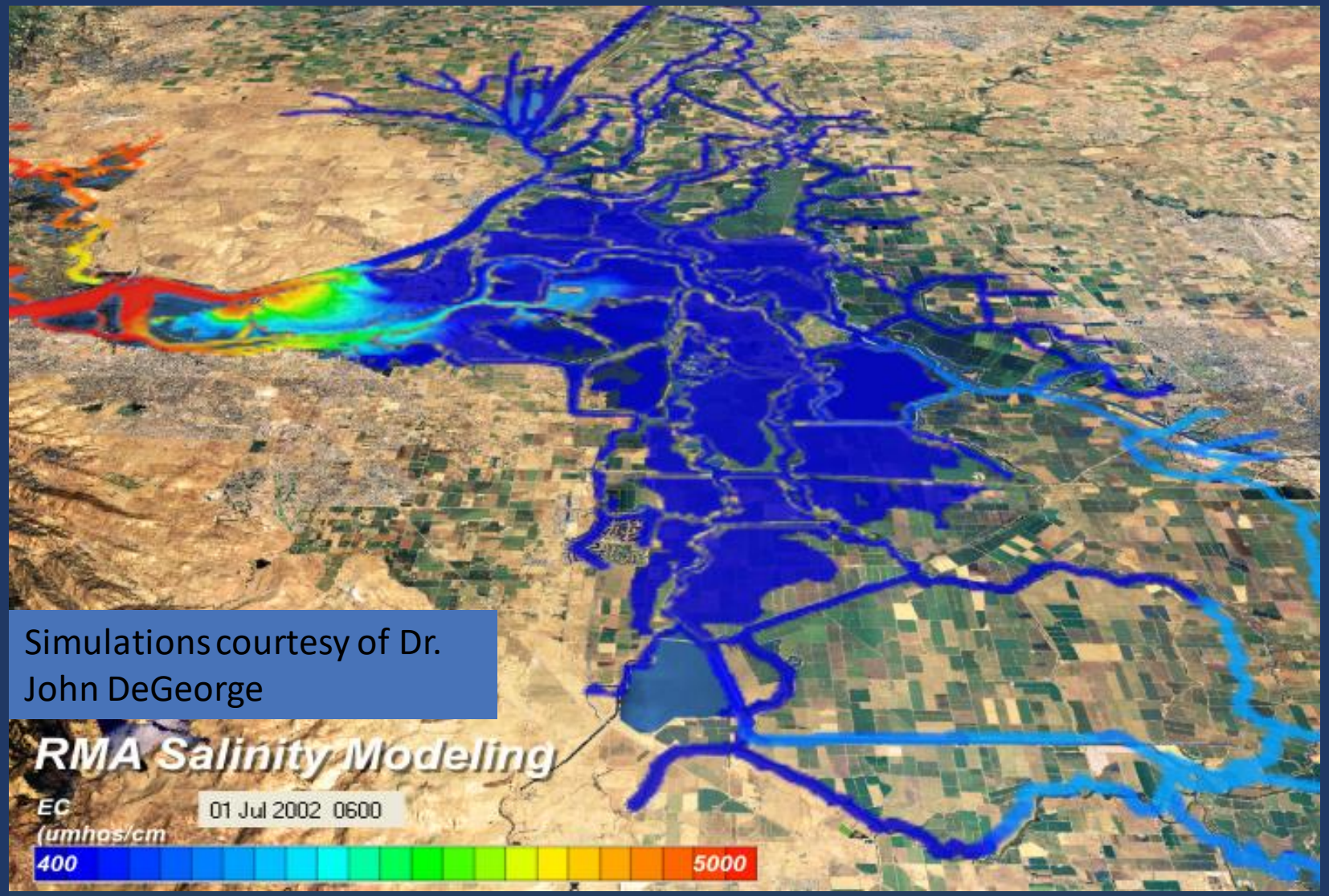
Prone to failures due to

Earthquakes
Seepage
Flood
Wave overtopping
Burrowing animals



6.5 Magnitude Earthquake

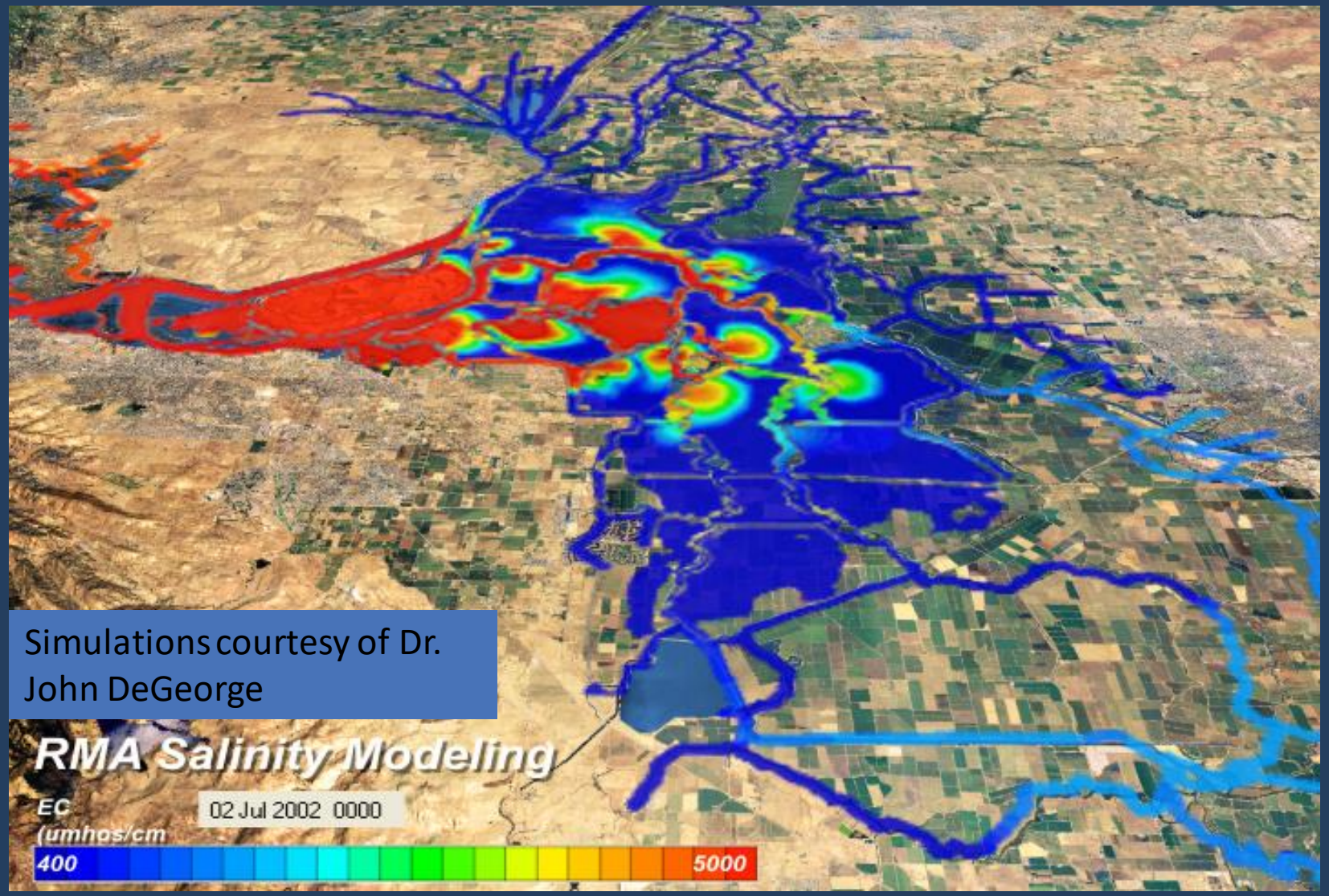
causing 20-Island Failure



0 – 6 hours: Islands flood with fresh water

6.5 Magnitude Earthquake

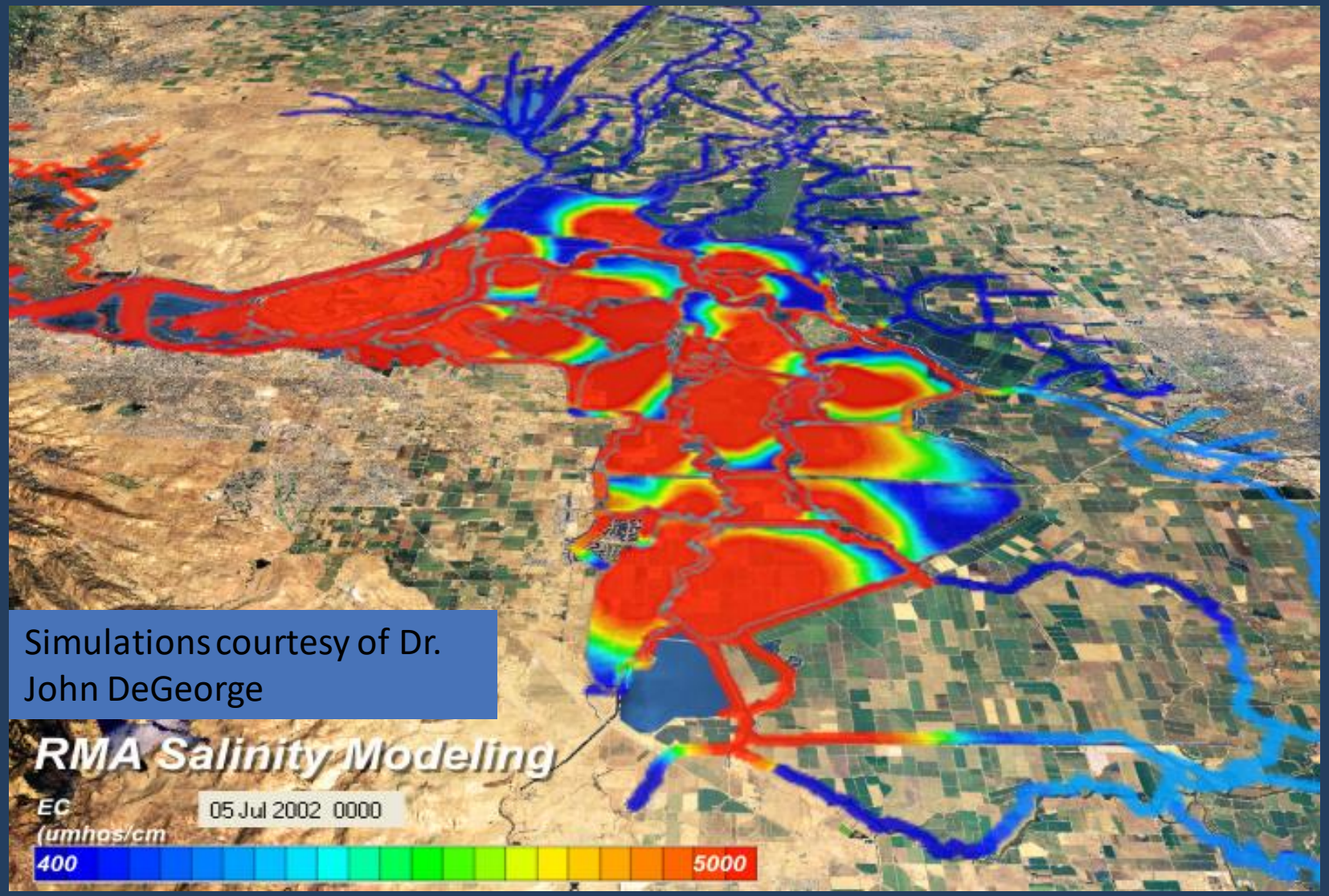
causing 20-Island Failure



12 – 24 hours: Salt water intruding into Delta

6.5 Magnitude Earthquake

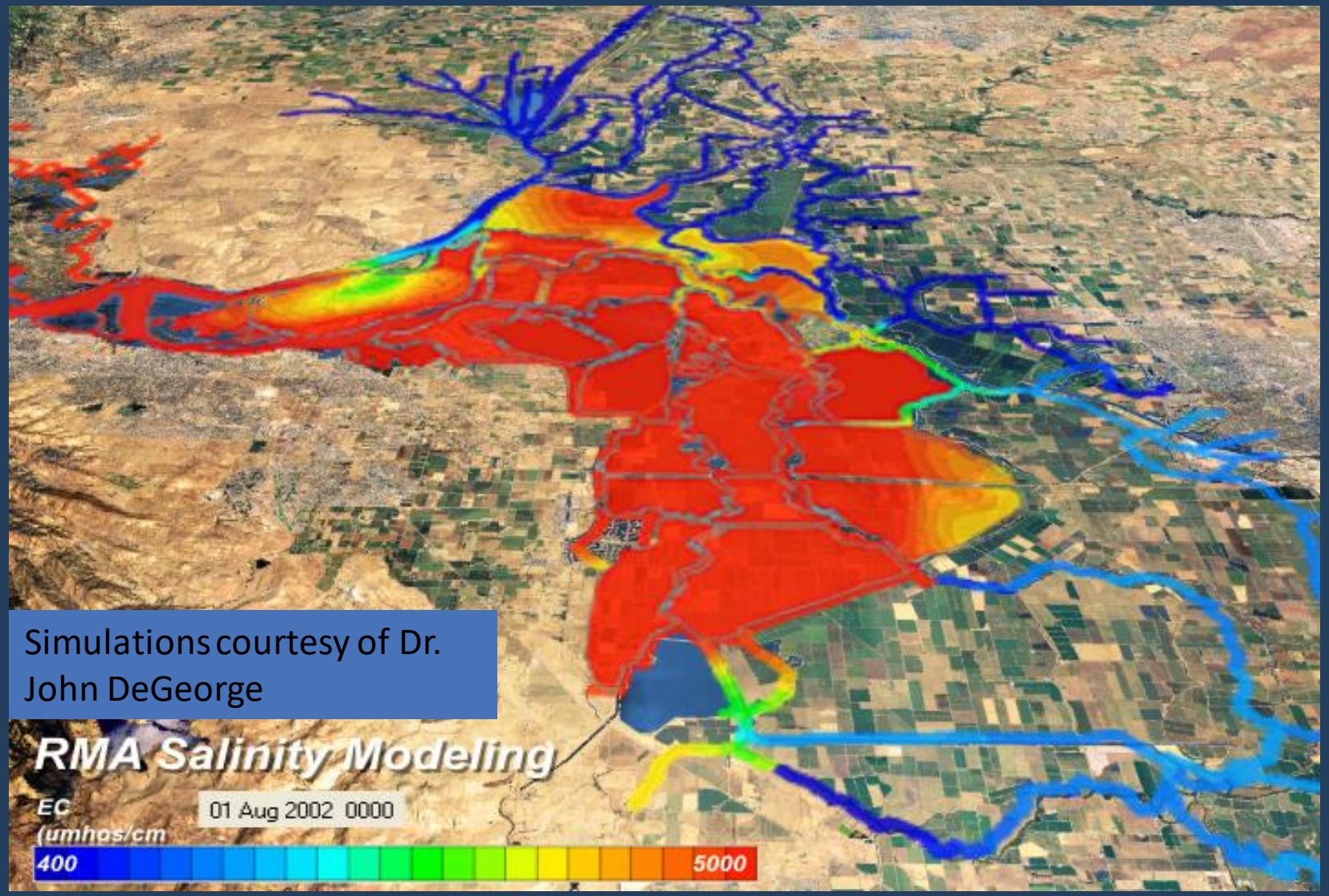
causing 20-Island Failure



1 – 7 days: Salt water throughout Delta

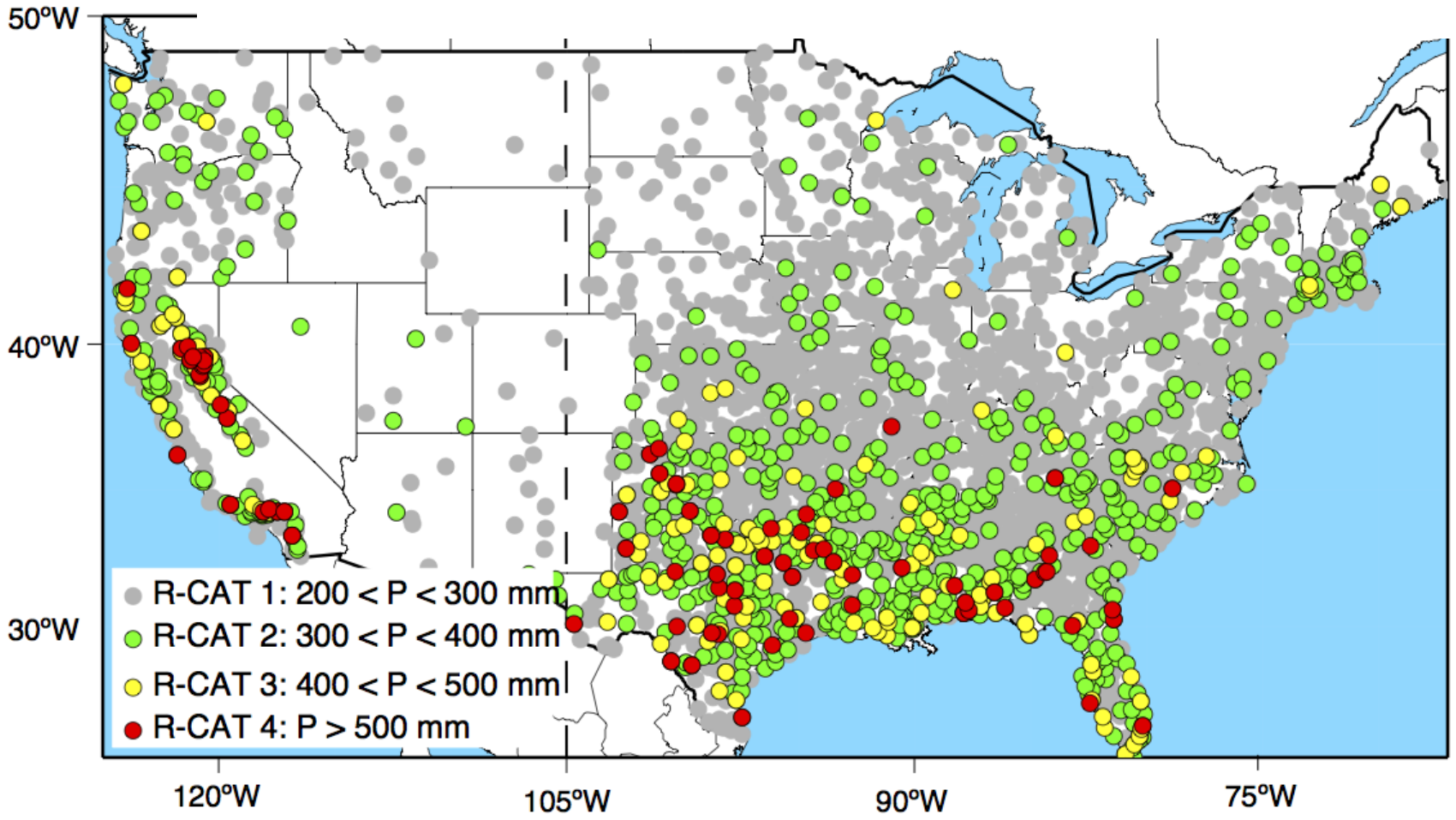
6.5 Magnitude Earthquake

causing 20-Island Failure



30 days: A saline estuary

Extreme Precipitation and Variability in Precipitation

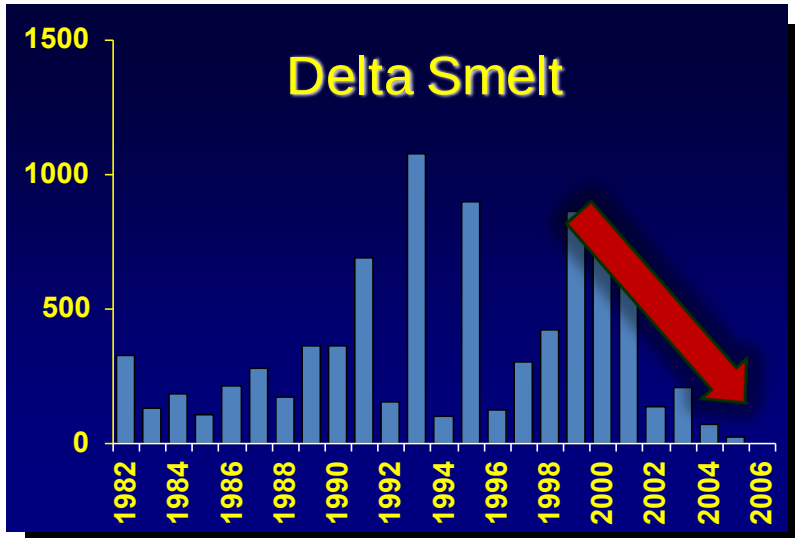


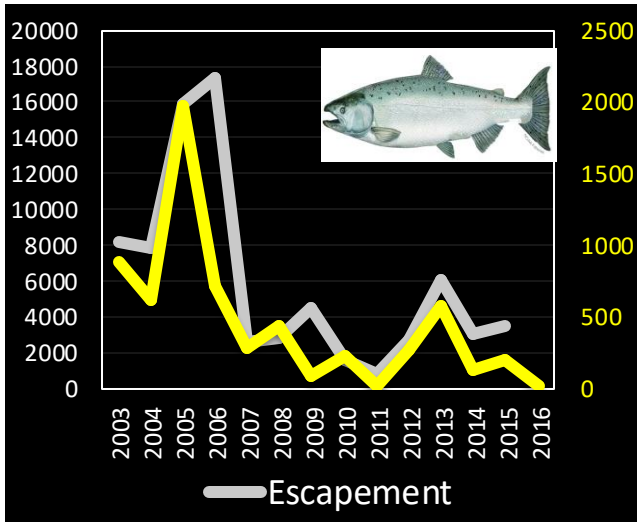
USGS science for a changing world

Southwest Climate Science Center

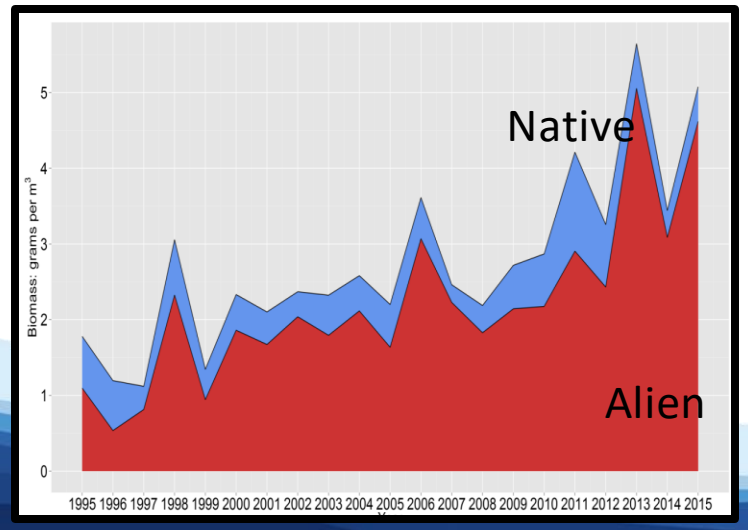
Ralph & Dettinger, BAMS, 2012

A Collapse in Delta Smelt





Chinook Salmon
Winter-Run and Spring Run



There are many other endangered species – many have conflicting needs (seasonally and spatially).

Who decides?

Green Sturgeon

Longfin Smelt

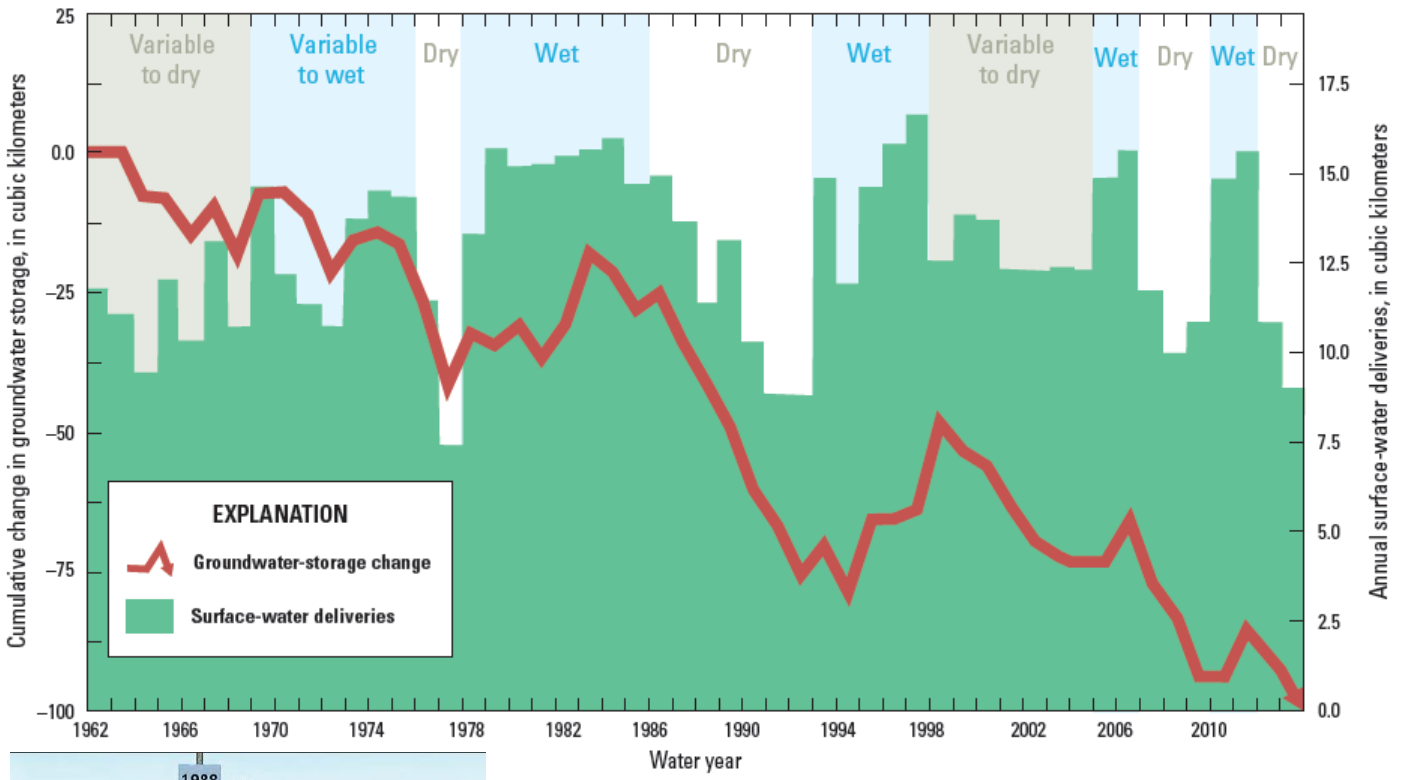
RESEARCH ARTICLE

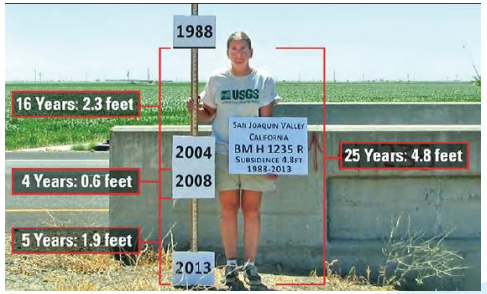
Unprecedented 21st century drought risk in the American Southwest and Central Plains

Benjamin I. Cook, Toby R. Ault, Jason E. Smerdon

- Drought of 2012-16
- Snowpack: one third of the historic lowest ever recorded
- 2015 allocation to urban users – 25%
- 2014 and 2015 allocation to agriculture through Central Valley Project - 0%
- Groundwater deficit in past decade: 45+ km^3

2012-16 Drought: Groundwater storage depletion and subsidence in the California Central Valley





Source: USGS, 2016

2009 State of California Legislation
The Coequal Goals

- "'Coequal goals' means the two goals of providing a **more reliable water supply for California** and **protecting, restoring, and enhancing the Delta ecosystem**. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place." *(California Water Code §85054).*

DELTA STEWARDSHIP COUNCIL

Delta Science Program

[Established by the Delta Reform Act]

Mission: To provide the best possible, unbiased scientific information for water and environmental decision-making in the Bay-Delta system

- ***Support and facilitate*** research
- ***Synthesize*** scientific information
- ***Facilitate*** independent peer review
- ***Coordinate*** science
- ***Communicate*** science

Even the simple questions are complex!

What do we mean by natural flows in such a complex and irreversibly altered system?

Yarnell, S.M., G.E. Petts; J.C. Schmidt, A.A. Whipple, E.E. Beller; C.N. Dahm; P. Goodwin; J.H. Viers, 2015. *Functional Flows in Modified Riverscapes: Hydrographs, Habitats and Opportunities* BioScience 2015. doi: 10.1093/biosci/biv102

Restoration to Managing for Novel Ecosystems

We need to understand "novel ecosystems" that sustain critical functions under conditions that are now irreversibly different from how species evolved.

Resilient or sustainable ecosystems are not necessarily desirable ecosystems.

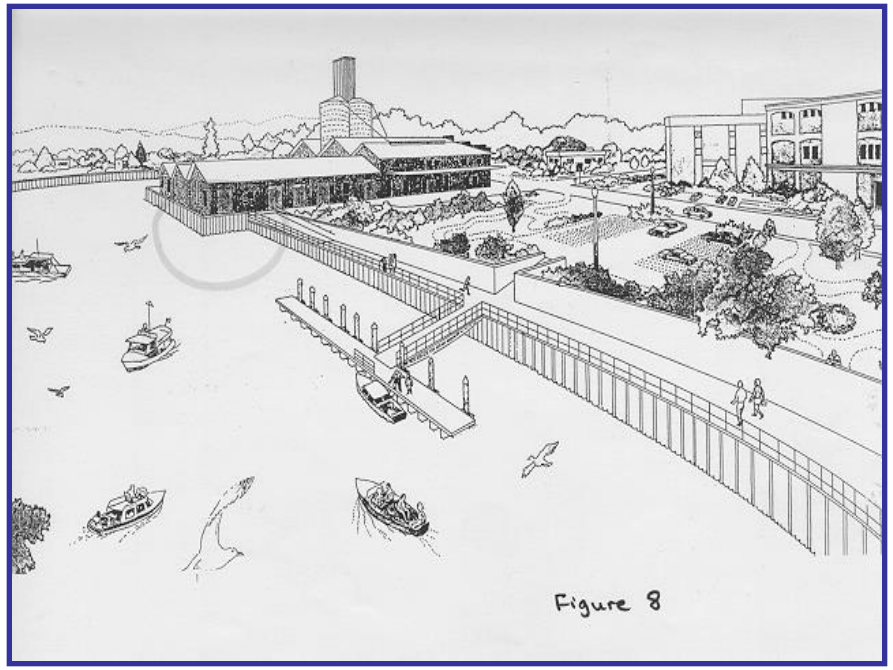
Peter B. Moyle, 2016

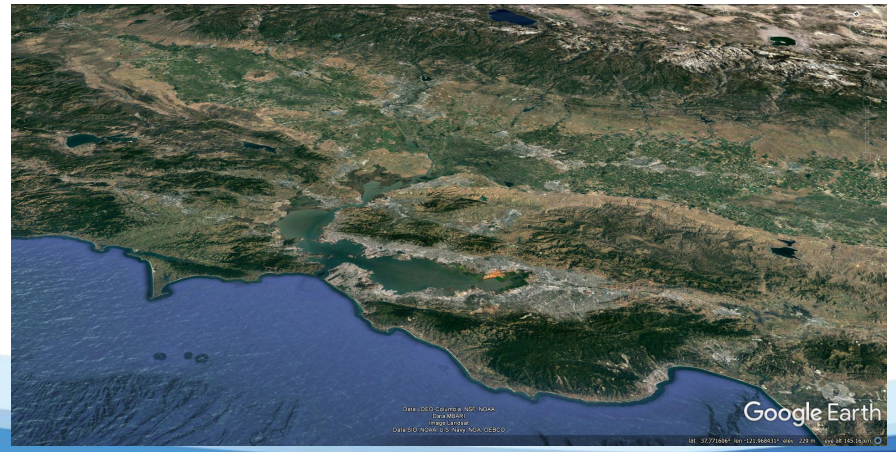
A Restoration Success Story – the Napa River Basin

27 major floods in past 120 years

County Courthouse, Napa - 1896

The Napa Living River Strategy



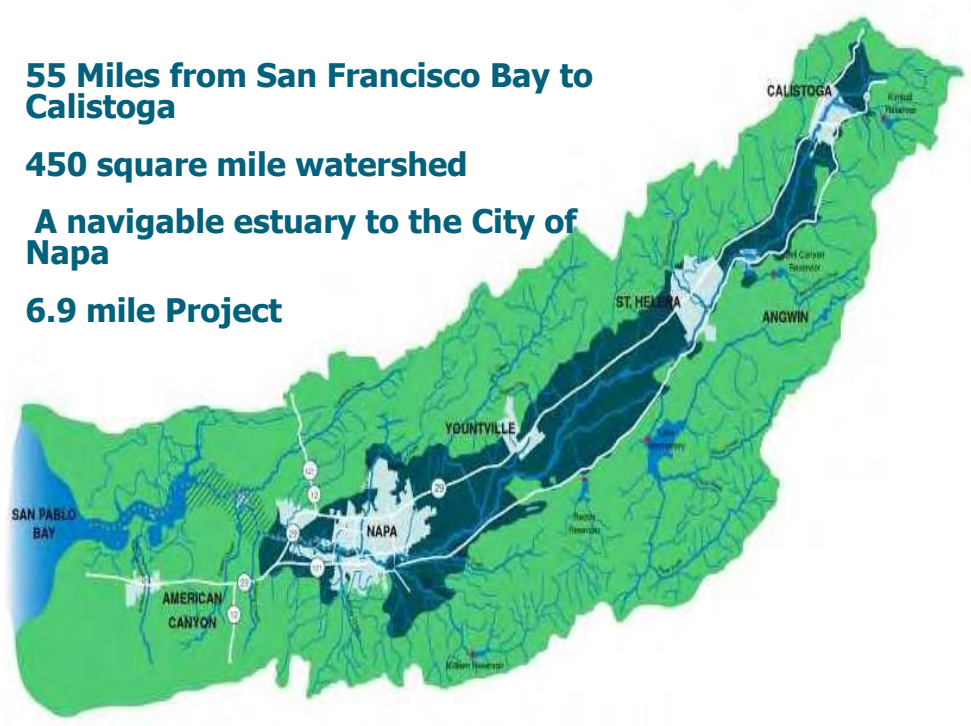


55 Miles from San Francisco Bay to Calistoga

450 square mile watershed

A navigable estuary to the City of Napa

6.9 mile Project

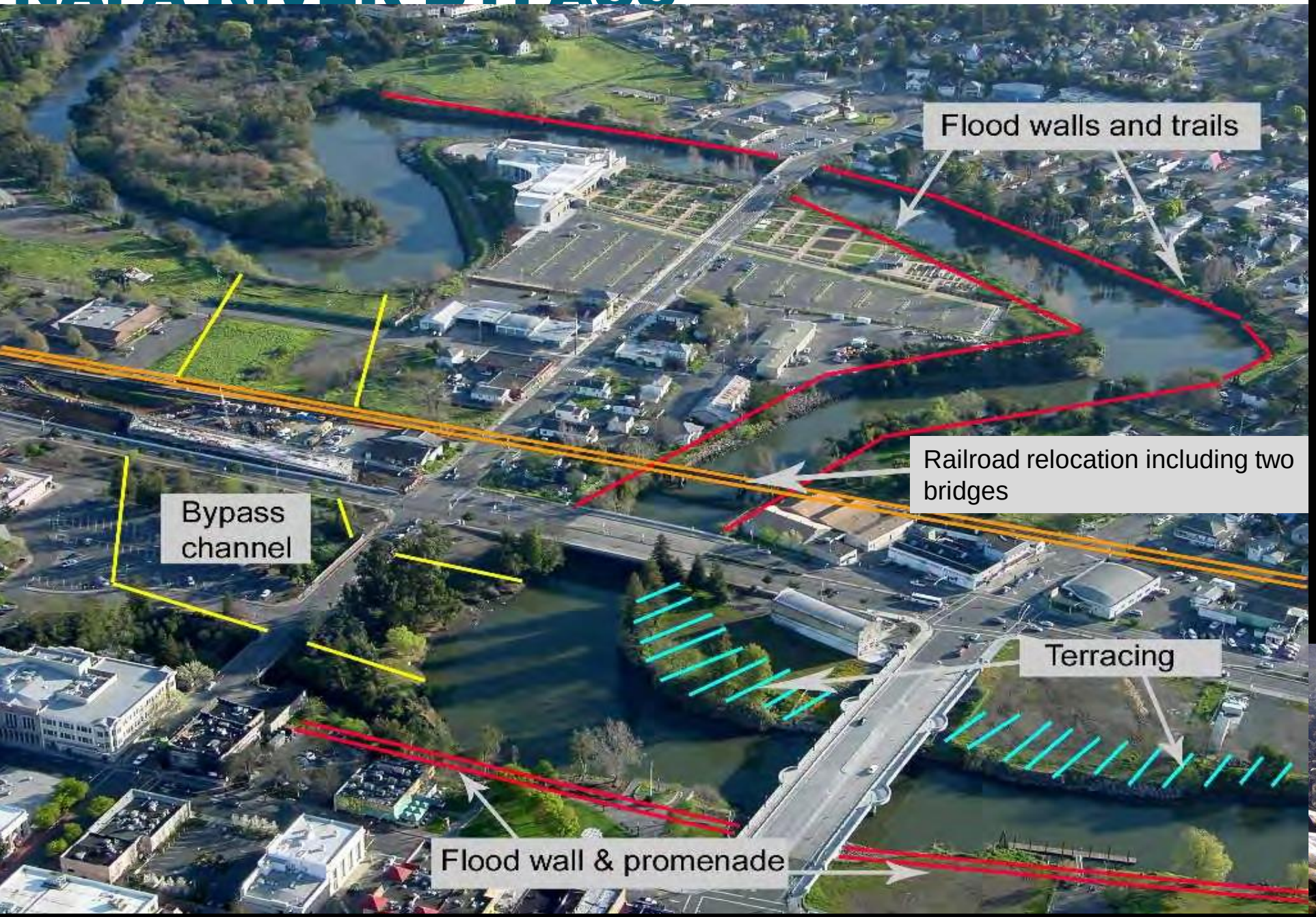


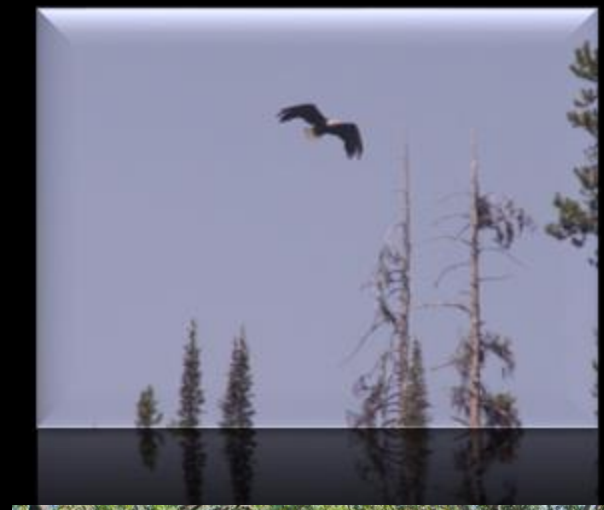
COMMUNITY COALITION FORMED

27 local stakeholder groups and 24 agencies

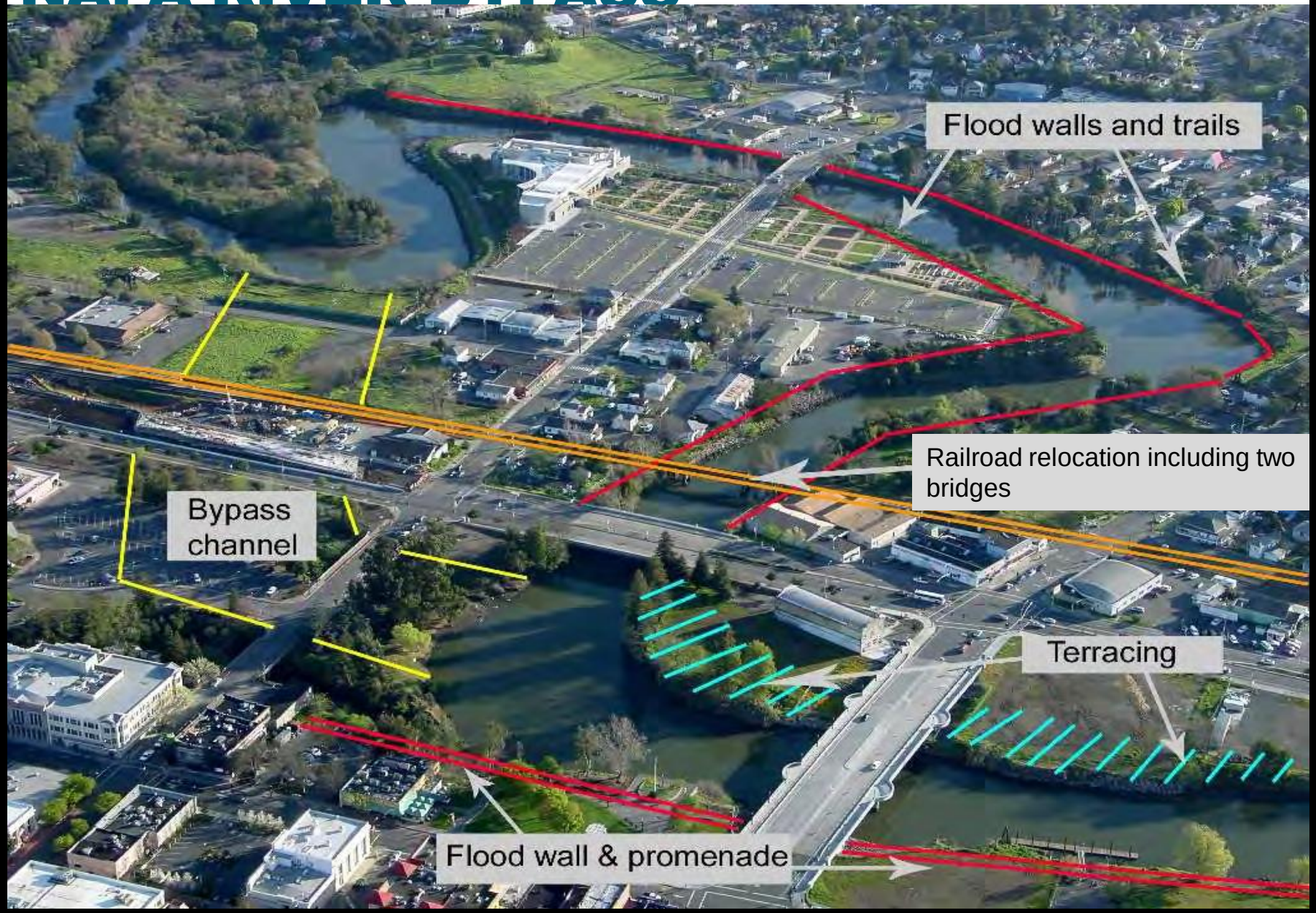
Creation of 659 acres of wetland, mudflat and open water

NAPA RIVER BYPASS





NAPA RIVER BYPASS



NAPA RIVER BANK BEFORE PROJECT

NAPA RIVER BANK AFTER

Napa Floodplain Restored

California Drought 2012-16

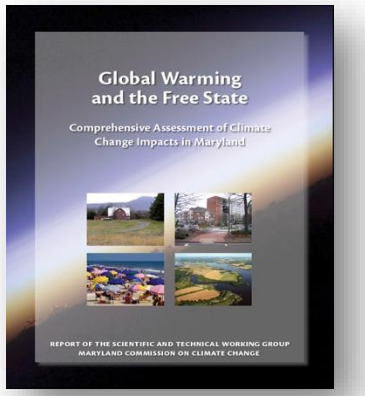
2017 Wettest Winter in Recorded History with no flooding in Napa

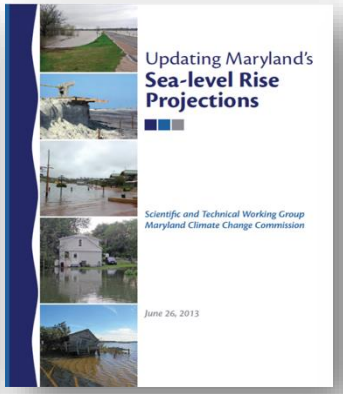
Very dry summer

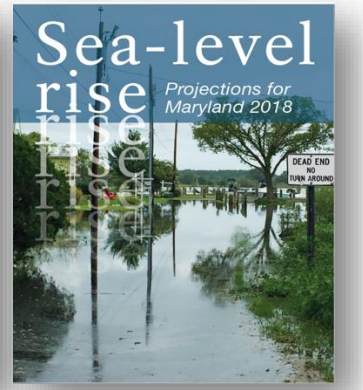
Fundamental Question: Will the ecosystem recover or was the fire a tipping point?

Photo Source: Atlantic Monthly, Getty Images

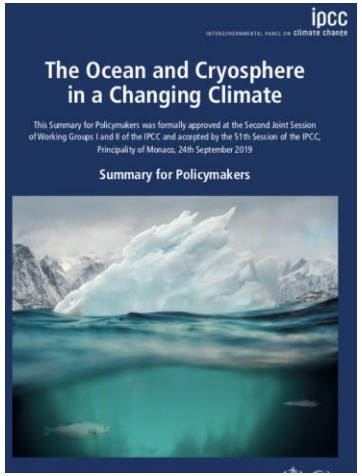
Sea Level Rise in Chesapeake Bay



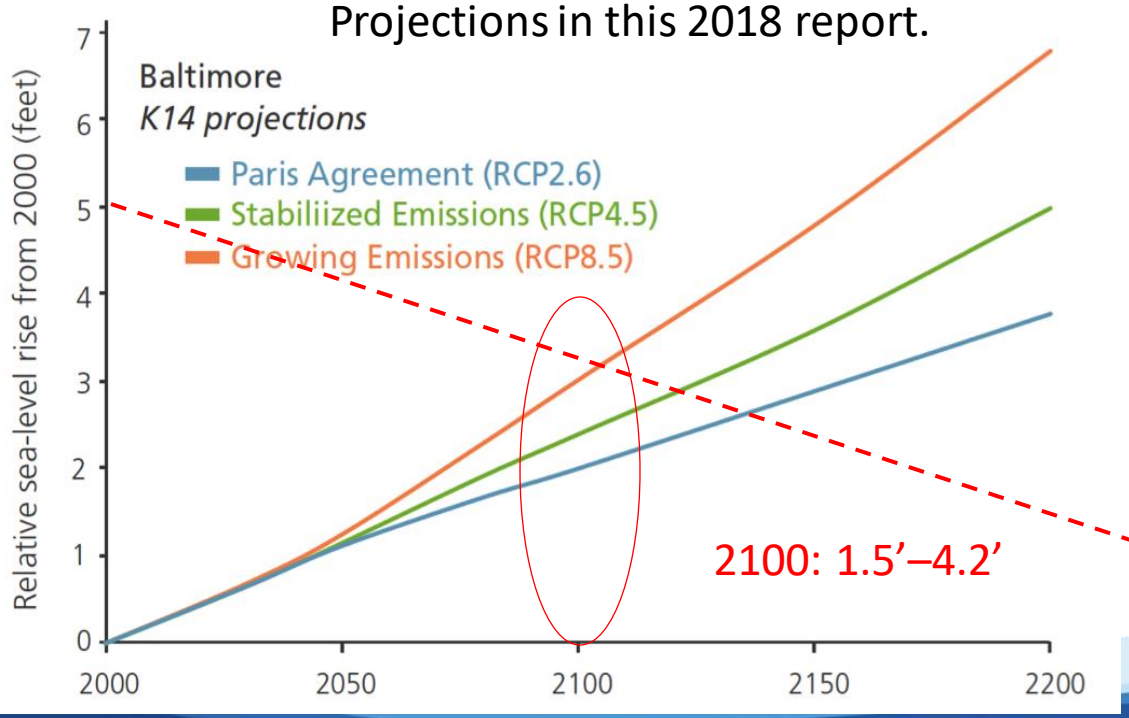




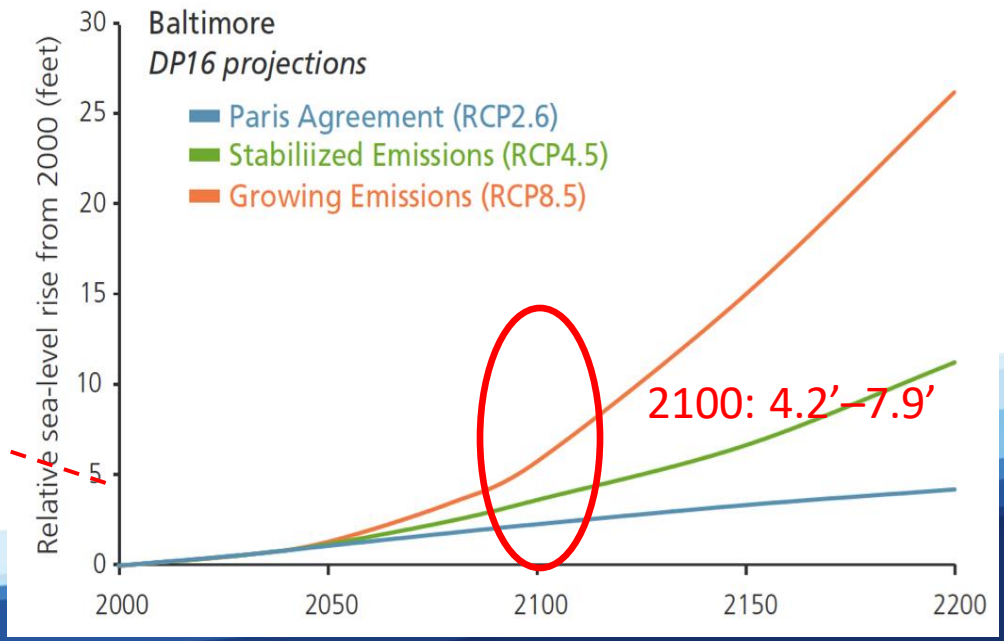
2008 2013 2018



Projections in this 2018 report.



Projections with more rapid ice loss.

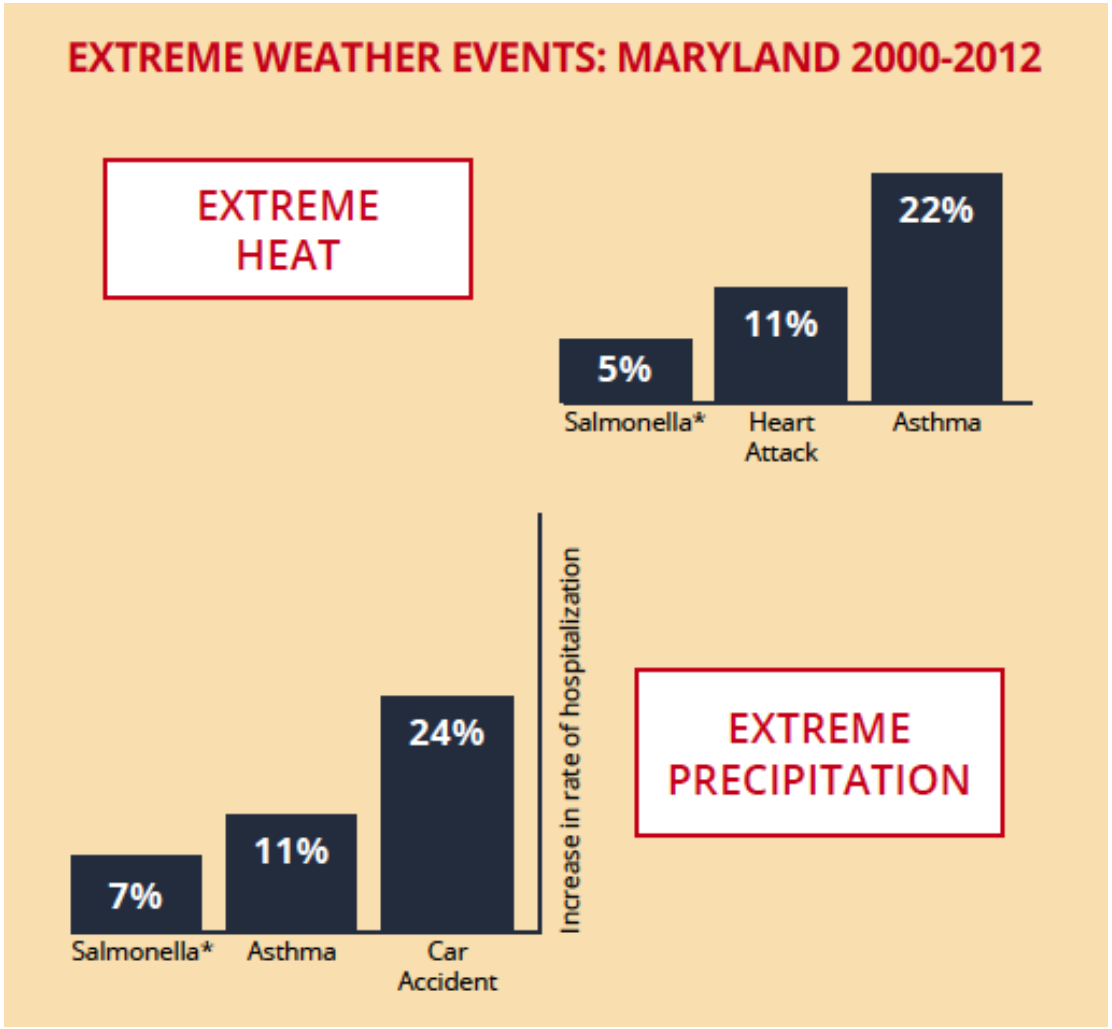


High Tide in Dorchester County

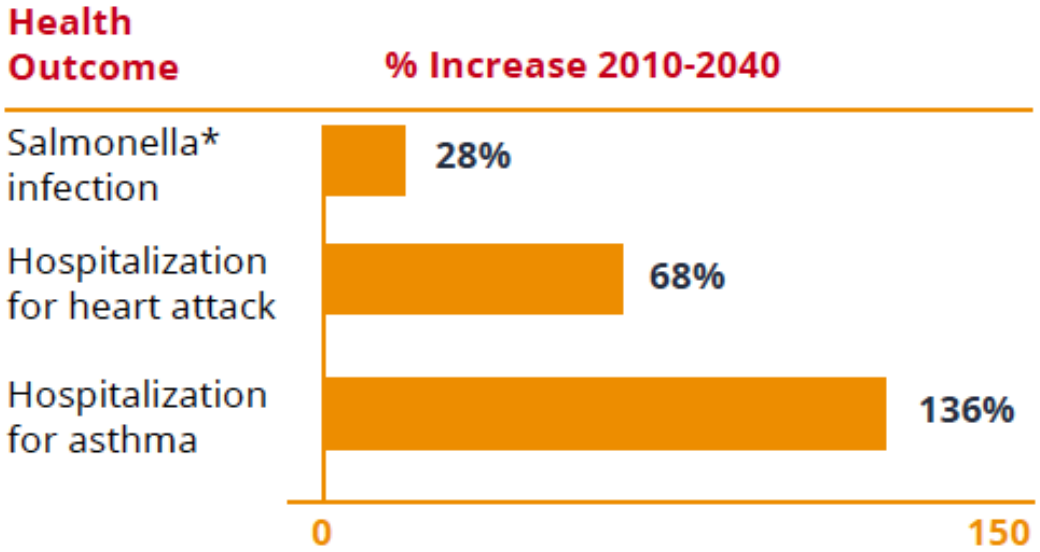
Source: Hightidedorchester.org

IAHR.org

Health Consequences in Maryland



Projected change in negative health outcomes by 2040 during extreme heat events in Maryland during summer months: [2]



2 Data compiled from the *Maryland Climate and Health Profile Report*, April 2016, Maryland Institute for Applied Environmental Health - University of Maryland School of Public Health, College Park.

MARYLAND
Department of the Environment

- Climate Change Home
- Commission Annual Report
- Agencies Annual Climate Change Reports
- Adaptation and Resiliency Working Group
- Education, Communication, Outreach Working Group
- Mitigation Working Group
- Scientific and Technical Working Group
- MCCC Home

Climate Change Fact Sheets

Available in 2 languages:

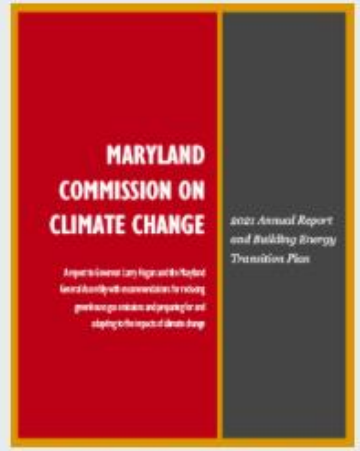
Please choose English or Spanish.

Open #mainSlideShow on this page in a new tab

Maryland Commission on Climate Change

Members

Annual Reports



The 2021 Annual Report Appendices

Upcoming Meetings & Events

Meetings are held virtually unless otherwise noted. Dates and times are subject to changes. Marylanders are invited to attend.

https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Pages/index.aspx

Ecological engineering is defined as the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both. *Mitsch, 2012*

(www.ecoeng.org)

Engineering with Nature

(https://ewn.erdc.dren.mil)

Nature-Based Solutions

(https://www.iahr.org/index/detail/414)

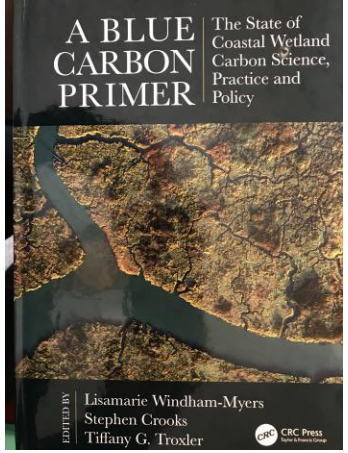
Carbon Sequestration and Tidal Wetlands

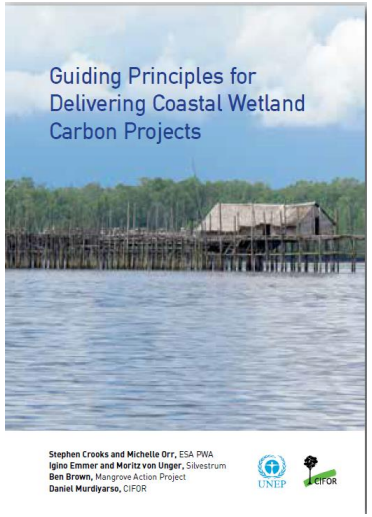
Stephen Crooks PhD
Silvestrum Climate Associates
Principal: Wetland Science & Coastal Management

Blue Carbon

Blue Carbon is defined as the carbon accumulating in vegetated, tidally influenced ecosystems such as tidal forests, tidal marshes and intertidal to subtidal seagrass meadows *(International Blue Carbon Working Group, 2015).*

Blue Carbon Ecosystems (BCEs) are defined as coastal wetland ecosystems with manageable and atmospherically significant carbon stocks and fluxes *(Windham-Myers et al., 2019).*





Building Blue Carbon Experience

Blue Carbon: Multiple Benefits

Benefits include:

- Carbon sequestration
- Coastal resilience
  - *- risk reduction to homes and infrastructure*
  - *- wetland and ecosystem function*
  - *- adaptation [time]*
- Water quality
- Recreation
- Aesthetics – living shorelines
- Agriculture

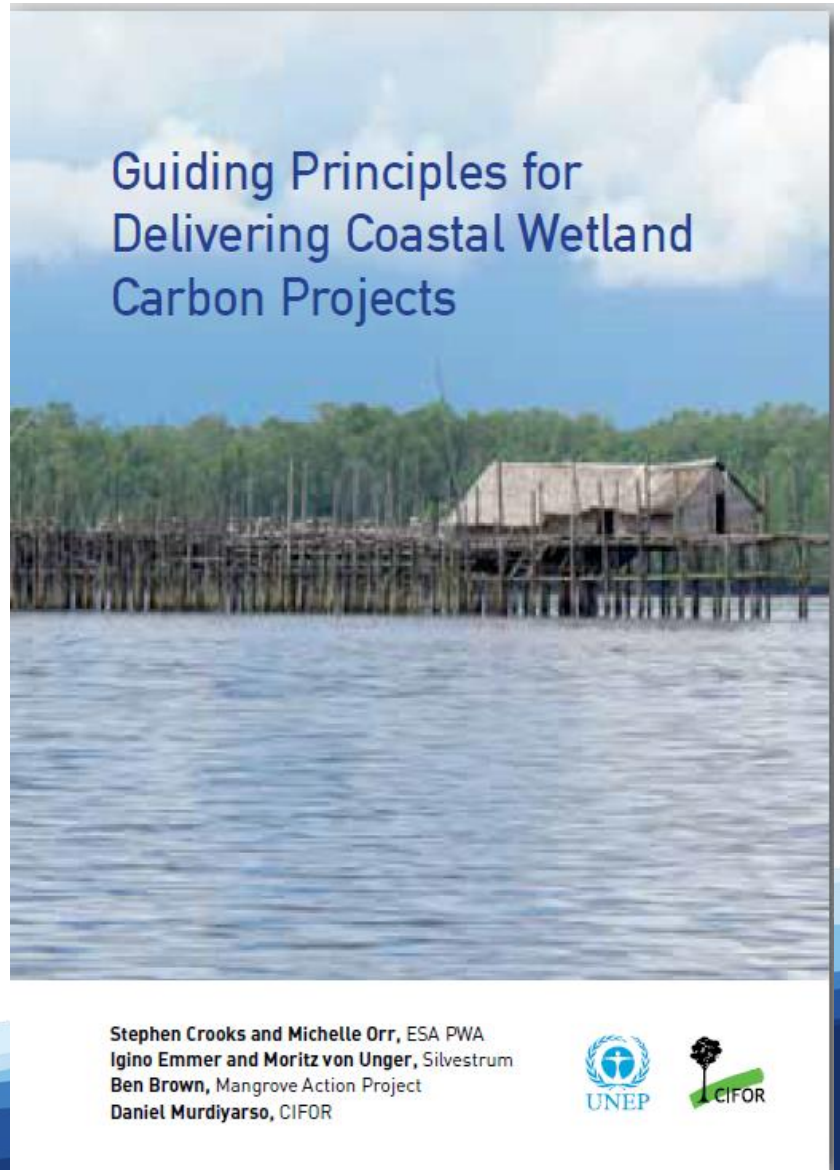
Multiple benefits = multiple funding sources

Developing the Learning Curve

1. Recognize value of wetland management
2. Establish examples of good practice
3. Achieve multi-use functional landscape
4. Adaptation to climate change
5. Incorporate GHG fluxes and storage

Blue Carbon Interventions:

Policy adjustment
Management actions
Carbon finance projects



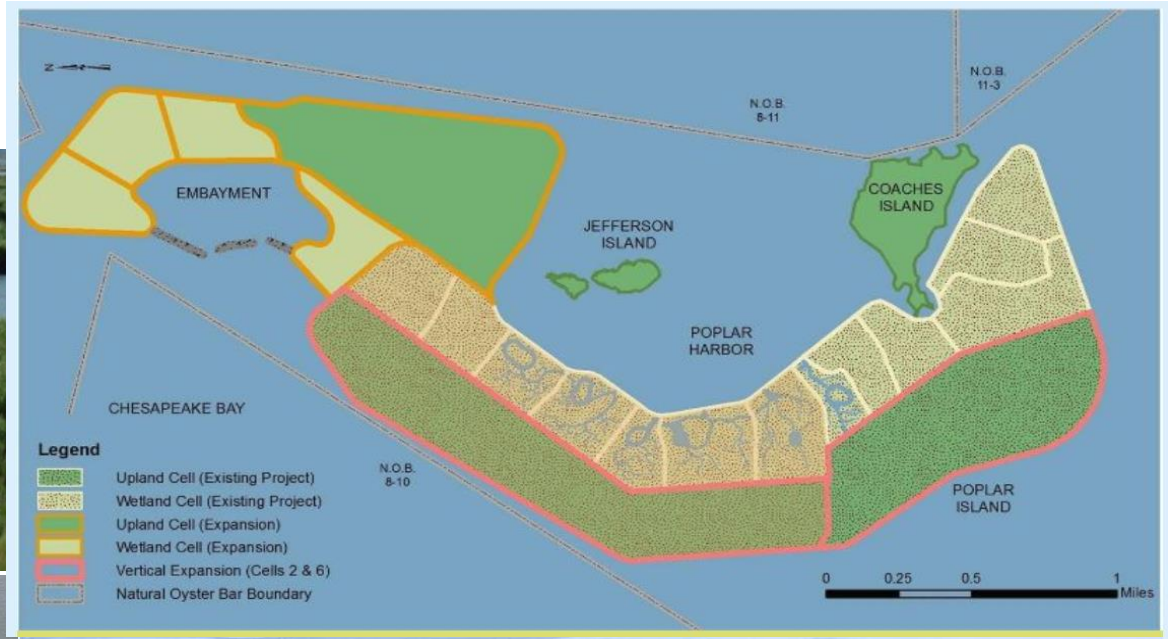
Poplar Island and Mid-Bay Islands
Maryland Dredge Material Management Program

SEDIMENT TO SOLUTIONS:
CHANNELING INNOVATION

MARYLAND DEPARTMENT OF TRANSPORTATION
MARYLAND PORT ADMINISTRATION

GreenPort of Baltimore

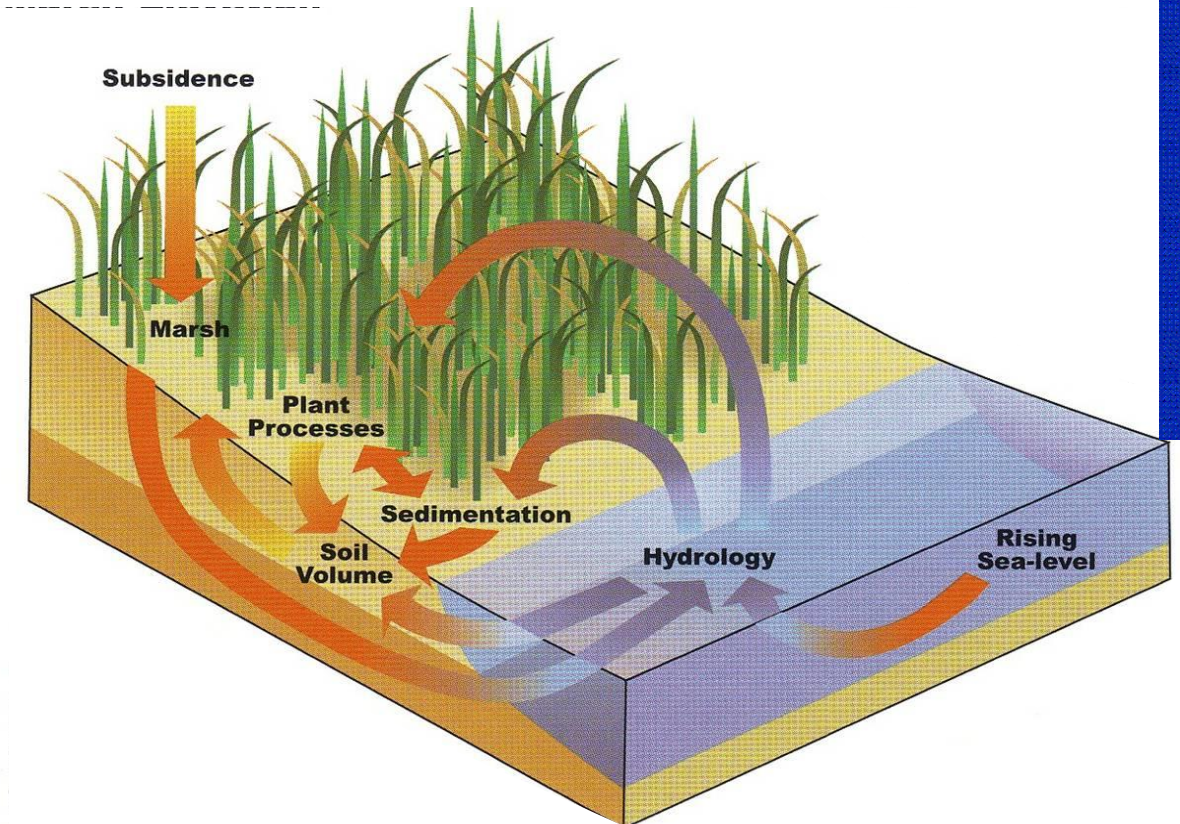
Poplar Island Expansion

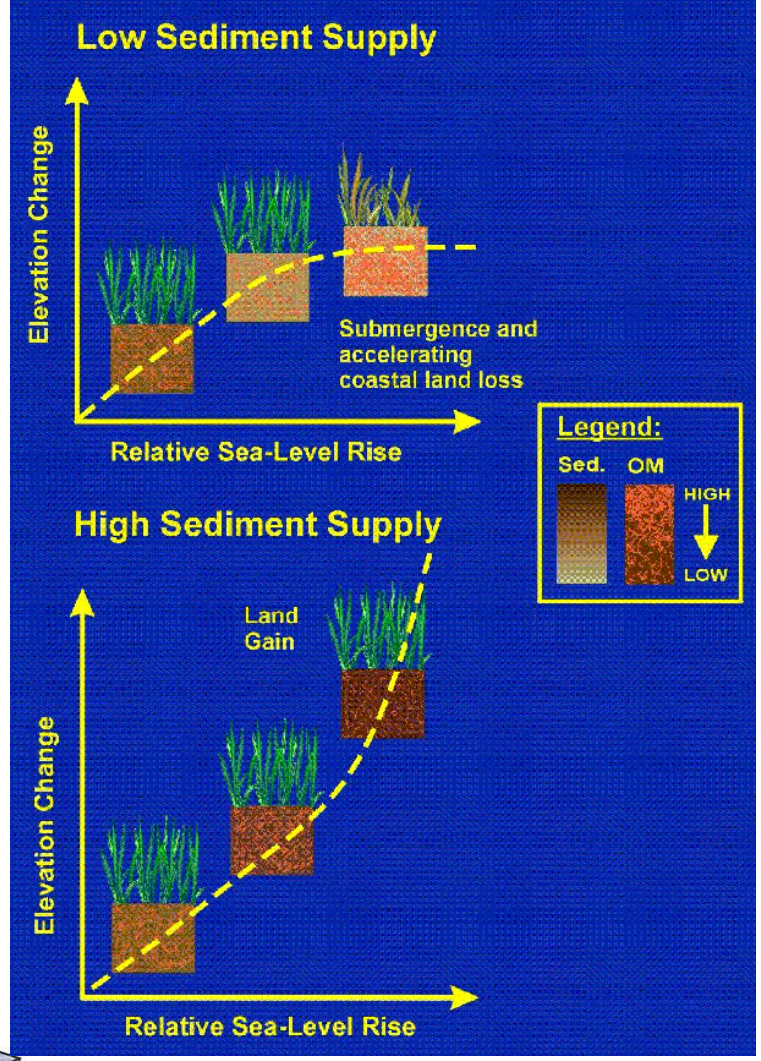


Coastal Wetlands and Sea-level Rise

Depends on:

- relative sea-level rise
- tidal hydrology
- sediment supply





Practical limits ?

1800

Tidal Marsh

Courtesy of Dr. Letitia Grenier

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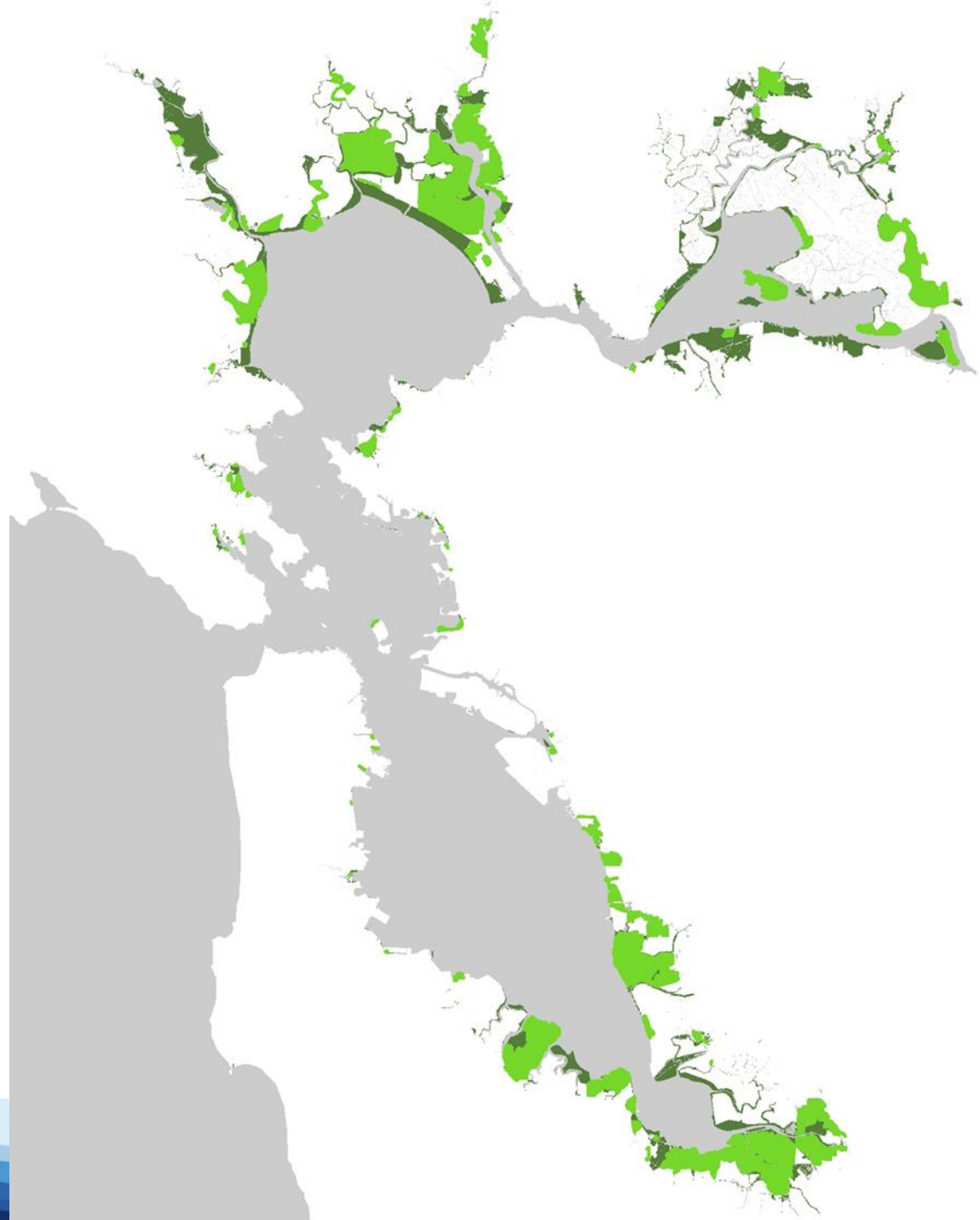
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER
4911 Central Ave, Richmond, CA 94804, p: 510-746-7334 f: 510-746-7300



FUTURE

Tidal Marsh

Restored Tidal Marsh

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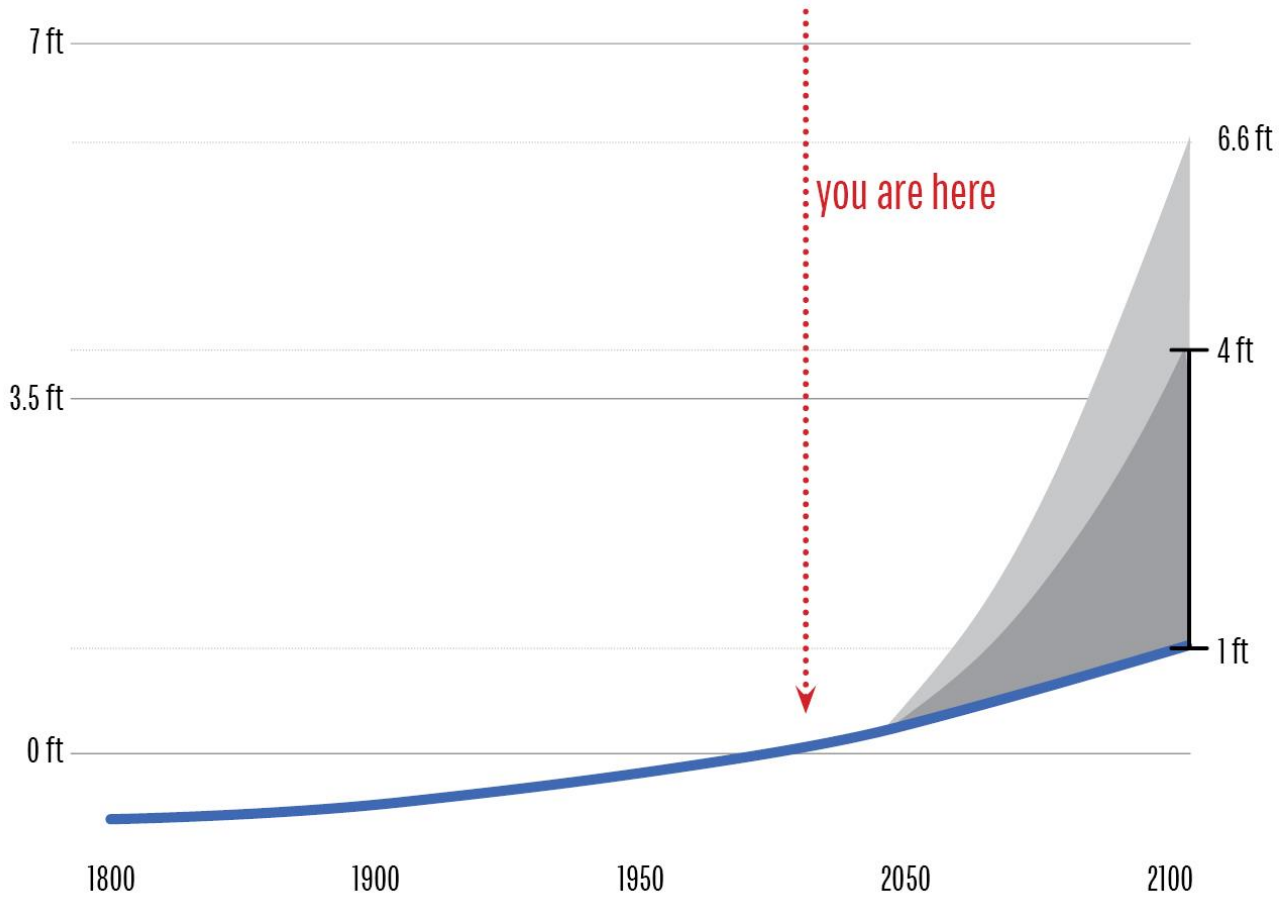
GLOBAL SEA LEVEL *change* SINCE 1800

Courtesy 3rd National Climate Assessment, 2014



The Baylands and Climate Change:
WHAT WE CAN DO

SPUR
16 Feb 2016
San Francisco, CA

LETITIA GRENIER
SAN FRANCISCO ESTUARY INSTITUTE

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SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

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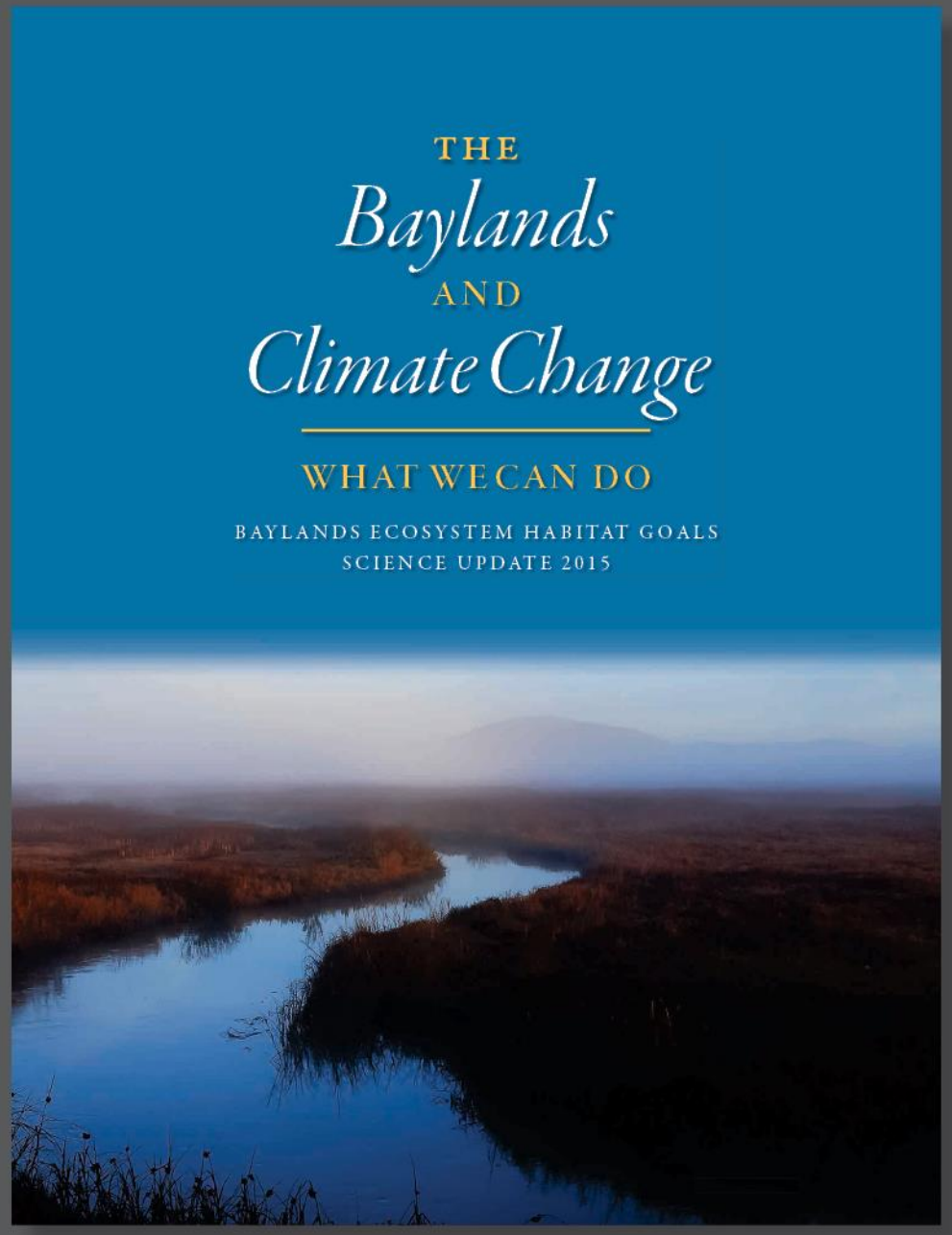

State of California
Coastal Conservancy

BAY AREA ECOSYSTEMS CLIMATE CHANGE CONSORTIUM

BAYLANDS GOALS 2015

- Science synthesis
- Effect of future change, especially climate and sediment supply, on the Baylands
- Goal is healthy ecosystem, providing a resilient shore for people and wildlife
- Recommendations and landscape visions for the next century

Shira Bezalel

WHAT WE CAN DO

- *Restore complete systems, including processes*
- *Restore soon, in areas marshes are likely to persist*
- *Plan for the Baylands to migrate*

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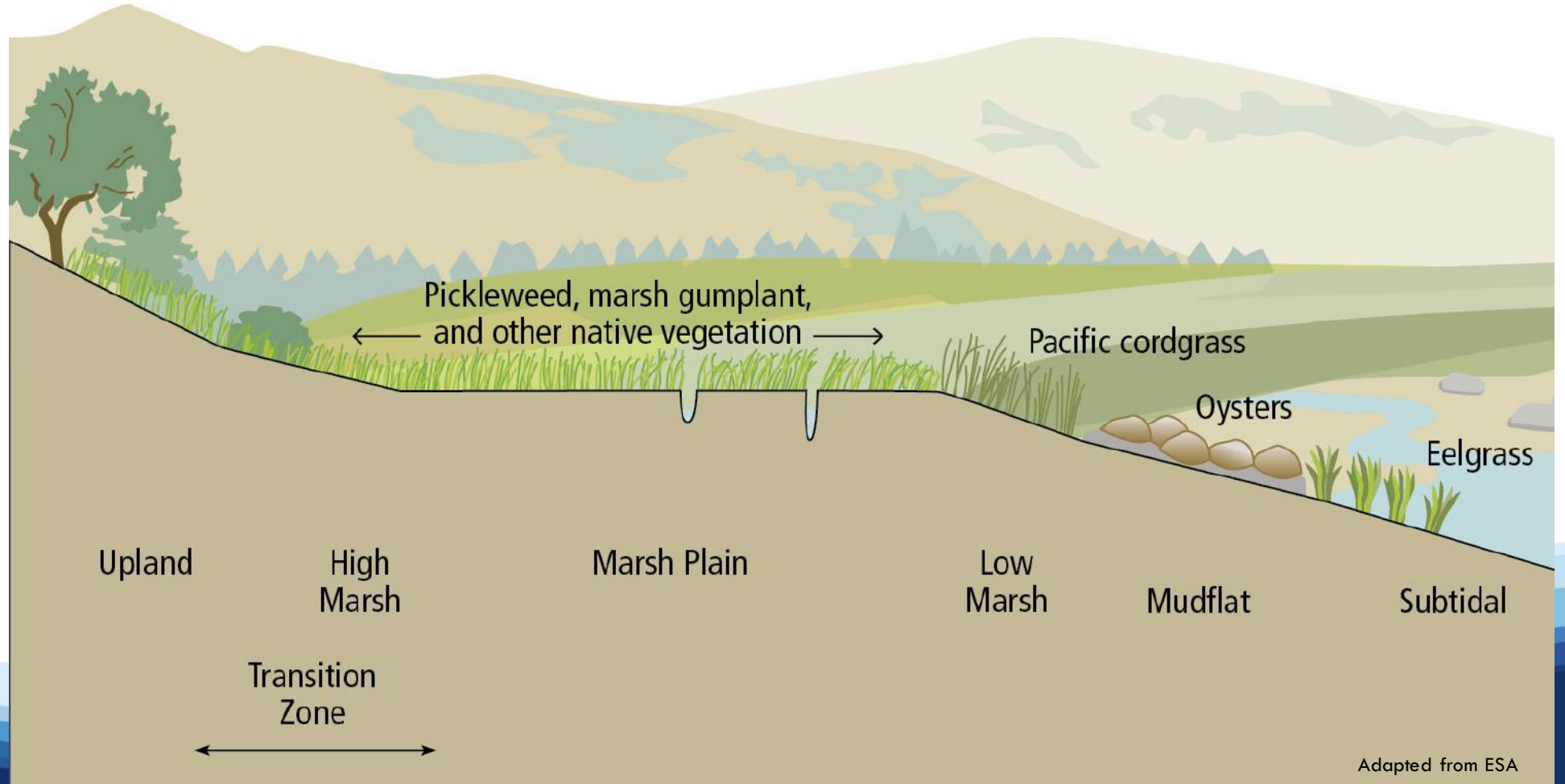
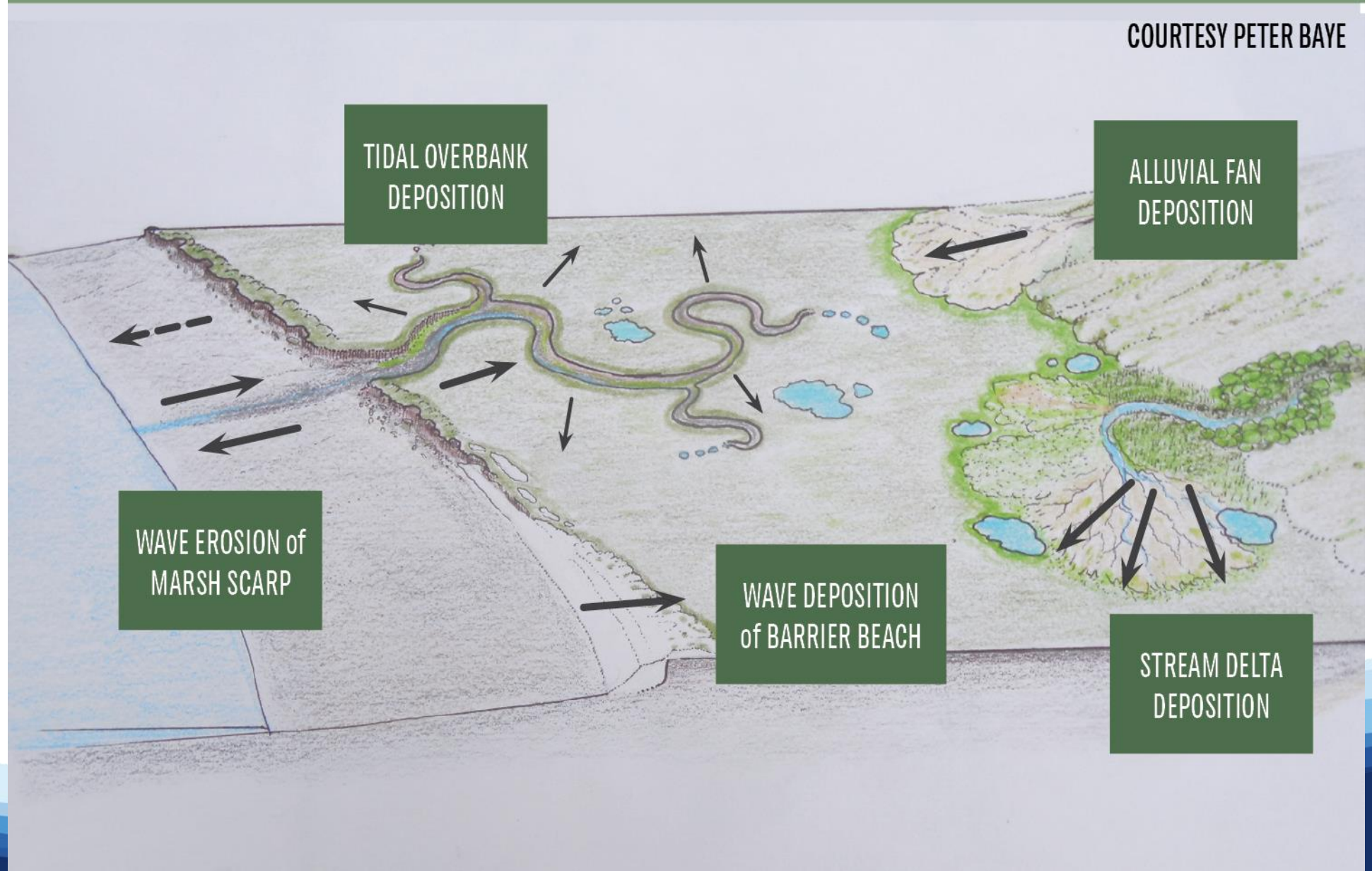
Restore COMPLETE SYSTEMS



Adapted from ESA

MEANS RESTORING PROCESSES NOT JUST PLACES



restore MARSHES BY 2030 IN AREAS WHERE THEY'RE LIKELY TO persist

Build up of sediment and vegetation takes time

Higher starting elevation means marshes survive sea-level rise for longer

PLAN FOR THE BAYLANDS TO *migrate*

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PLAN FOR THE BAYLANDS TO *migrate*

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PLAN FOR THE BAYLANDS TO *migrate*

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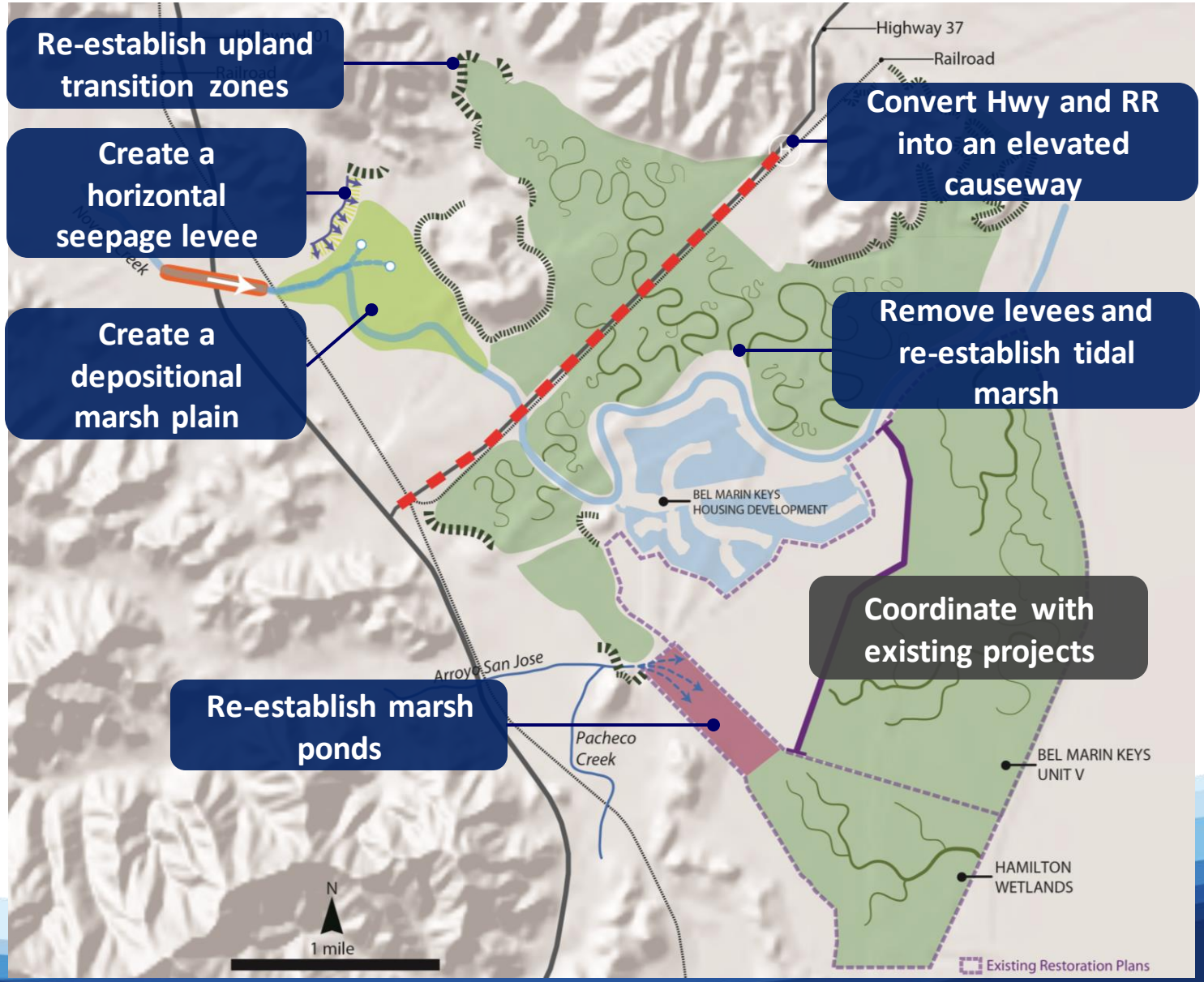
Novato Creek Baylands Long-term Vision



WE HAVE *choices to make*

Baylands Goals Science Update

www.BaylandsGoals.org

Nate Kauffman

IAHR.org

Adaptive Management

Example from Delta Stewardship Council, California

Provide unbiased and objective evidence for identifying and defining problems

Communicate limitations and opportunities of goals and objectives

Specify or develop appropriate conceptual and quantitative models; identify critical uncertainties; develop hypotheses; model alternative actions; identify data necessary to test hypotheses

Evaluate alternative actions using information from models and decision support tools (Box 3-2); use models to develop performance measures

Design and implement actions to test assumptions and predicted outcomes and reduce scientific uncertainties

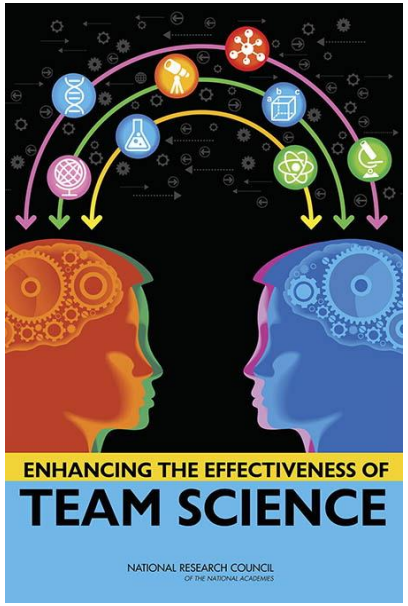
Use models and tiered management questions to design monitoring. Collect, manage and share data.

Analyze data, synthesize scientific information, and evaluate progress based on performance measures

Communicate new scientific understanding to decision-makers

Advise on selecting the next generation of follow-up actions

We are drowning in information, but starving for wisdom. The world will henceforth be run by synthesizers, people able to put the right information at the right time, think critically and make important decisions wisely.



E. O Wilson, 1978

SESYNC

At times of change, the learners will be the ones who will inherit the world, while the knowers will be beautifully prepared for a world that no longer exists.

Alastair Smith

This is the decade for action

- Opportunity to transition from a predicament to a crisis
- No magic bullet to solve the challenge
- No single entity will solve the challenge
- Innovation partnerships that are built on principles of economic outcomes, a just and equitable transition and engagement with marginalized social and business sectors
- Opportunities for win-win-win actions
- International Collaboration – professional communities such as IAHR

Thank you for your attention.