

Strategies and Tools for Adaptive, Collaborative Water Management in the Era of Climate Change

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What is Adaptive Management (AM)?

a rigorous approach for designing and implementing management actions

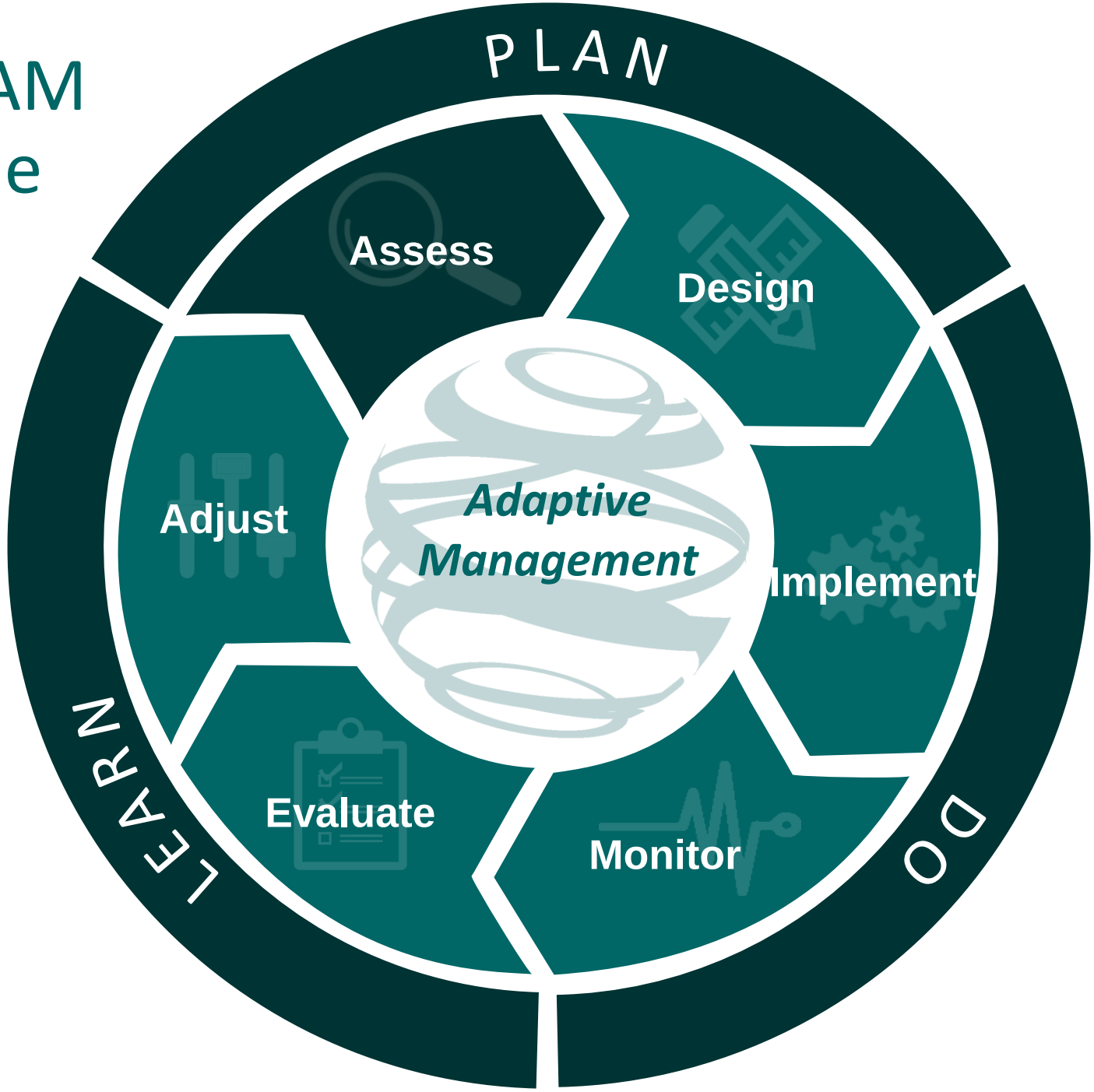
to

maximize learning about critical uncertainties that affect decisions

while simultaneously

striving to meet multiple management objectives

The AM cycle


PLAN
Assess
Design
Implement
DO
Monitor
Evaluate
LEARN
Adjust
Adaptive Management

Era of climate change

***Era:* a long and distinct period of history with a particular feature or characteristic**.

Warmer and wetter

Loss of glaciers and snowpack

Warmer and drier

Major latitudinal shifts in species

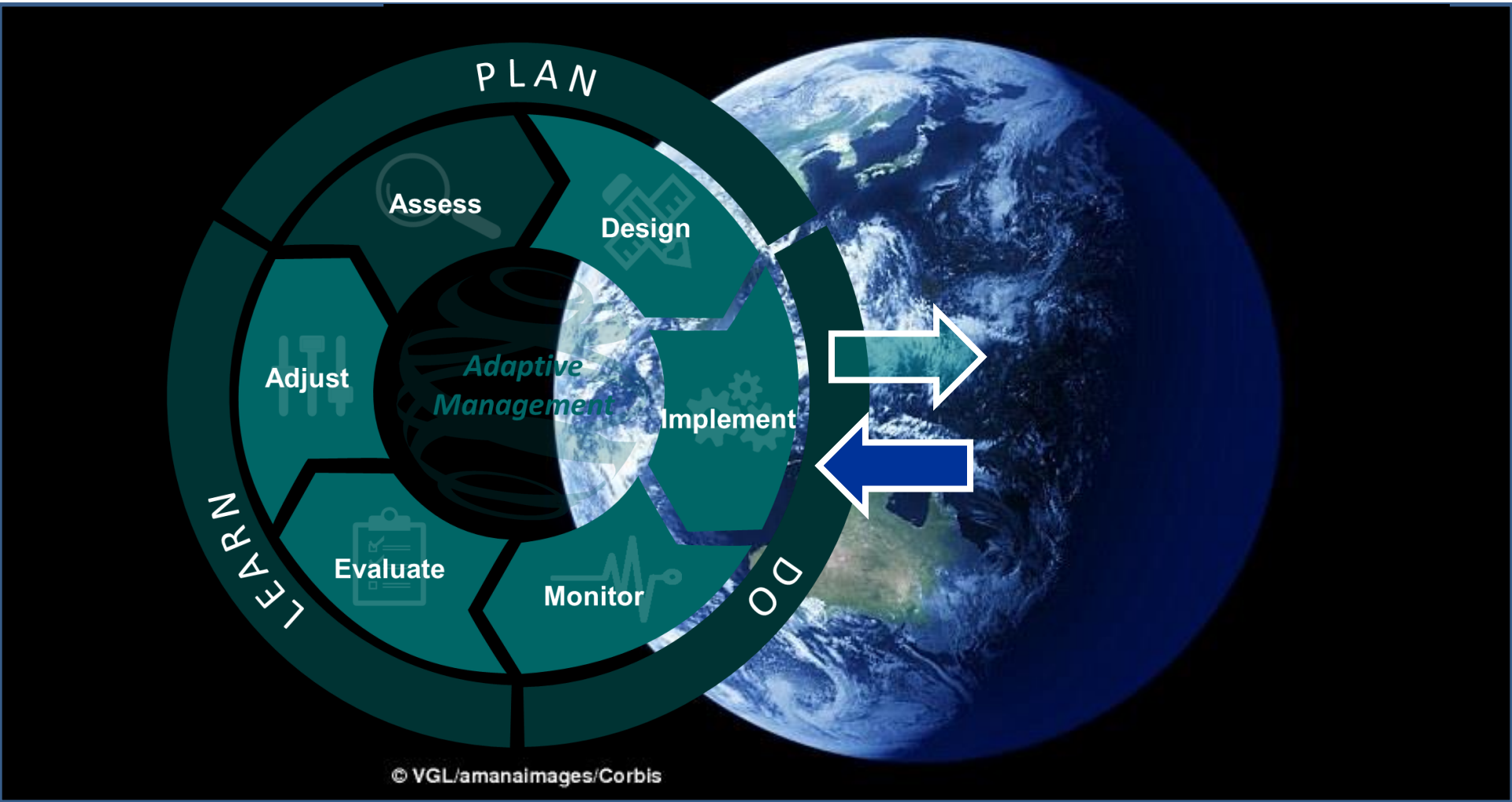
Increased pests, pathogens, and invasive species

A highly uncertain future

Greater year to year variability

Greater within year variability

What's the overlap between **Adapt**ive Management and Climate Change **Adapt**ation?



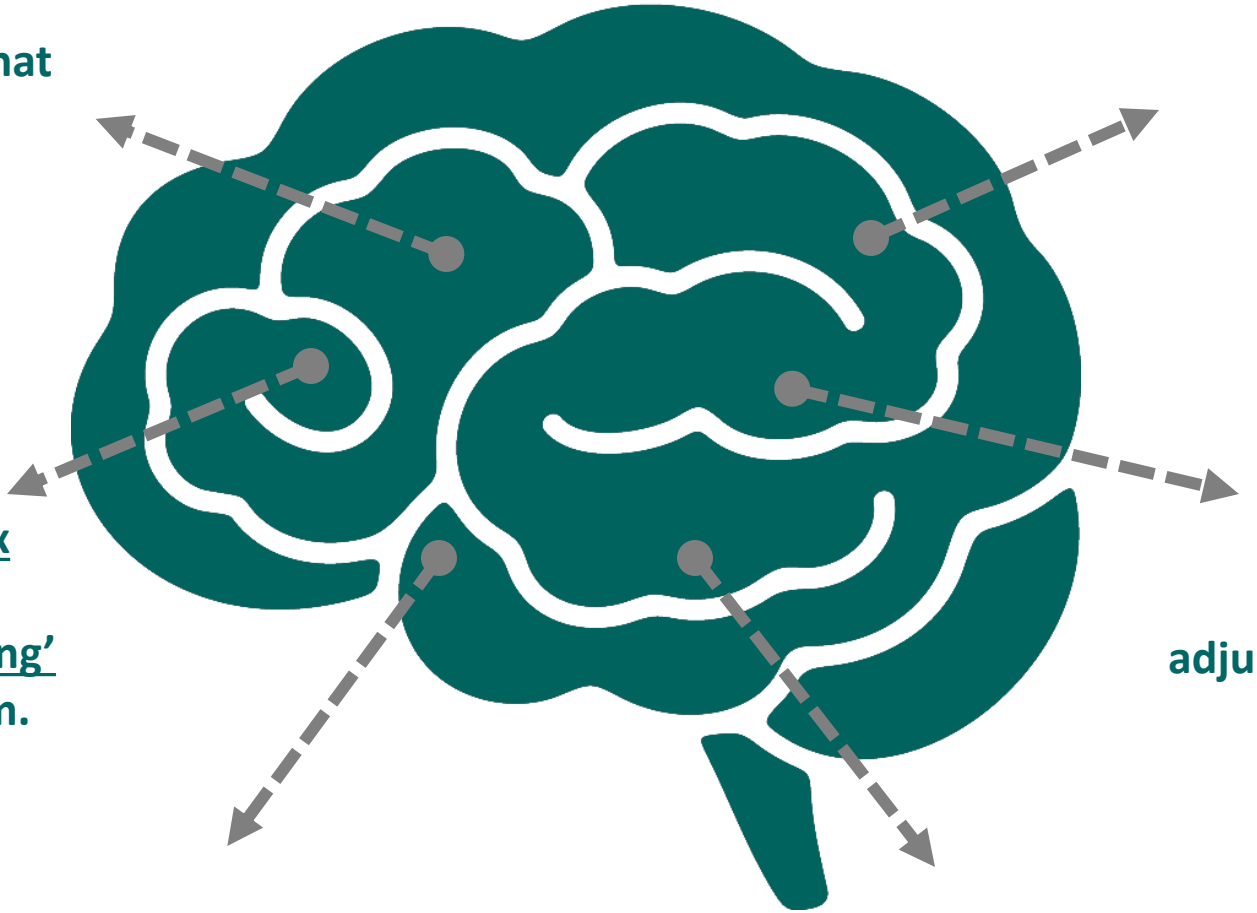
Oroville Dam, spillway damage, 2017

In a highly uncertain future, predict-then-act models are no longer appropriate

Calgary flood, 2013

Key Point 1: Climate change demands an AM Mindset…

Focus on uncertainties that have the most influence on decisions.



Use collaborative processes for resolving uncertainties

Isolate complex issues and use 'systems thinking' to analyze them.

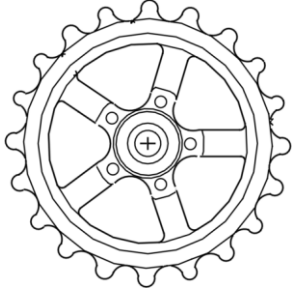
Commit to monitoring, learning, and adjusting actions – backed by organizational culture

Be clear about objectives.

Implement contrasting interventions to test hypotheses and hasten learning

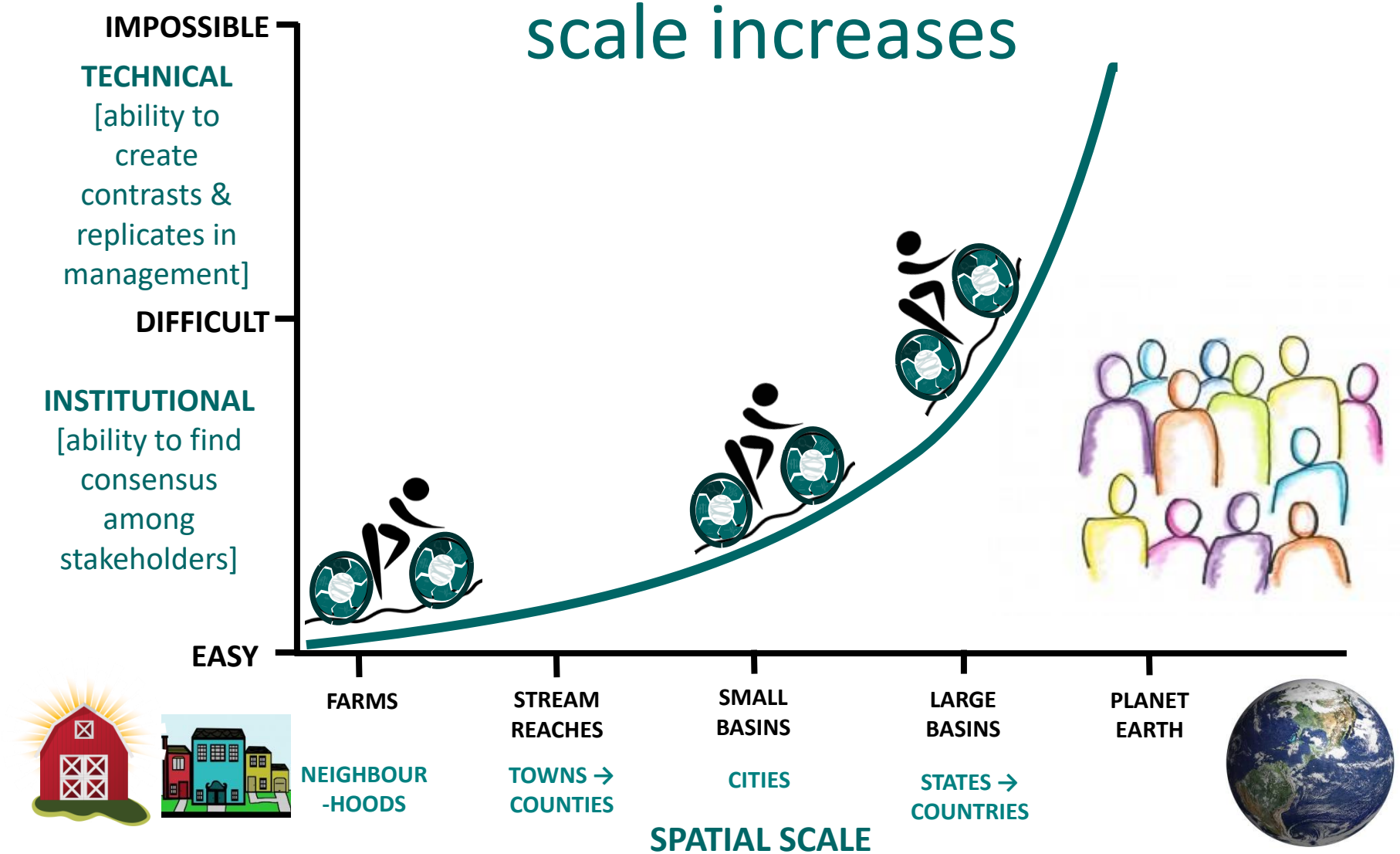
What does it take to keep the AM learning cycle moving forward, at different scales, under climate change?

A lot of gears!



Technical Gears	Institutional Gears
Rigorous AM science	Trust
Thorough experimental design	Leadership
Strong contrasts, replication	Executive Direction / Authority
Targeted monitoring, *rapid* evaluation, real time tools	Collaboration within/across agencies & stakeholders
Science boiled down for decision makers	Excellent Organizational Structure

Key point 2: Both AM and adapting to climate change gets harder as the spatial scale increases



Key point 3: Climate change brings both challenges & opportunities for AM & human adaptation

Challenges	Opportunities
Flows of very high magnitude / duration flood people, destroy restoration sites	Habitat created & hypotheses tested by floods; *may* lead to long overdue improvements in floodplain mgmt.
Long, severe droughts limit range of feasible management actions	Droughts force long overdue efforts at water conservation & management.
Historical flow record inapplicable to the future; GCM runs too coarse	Combine bottom-up and top-down approaches to climate risk assessment
Stochastic events can suddenly turn normal years into extreme years	Real-time tools for flow management can mitigate risks and impacts
Climate change makes already difficult problems even harder	Exploring extreme scenarios may lead to more creative mgmt. approaches

5 Recent River Basin AM projects (2000-2017)

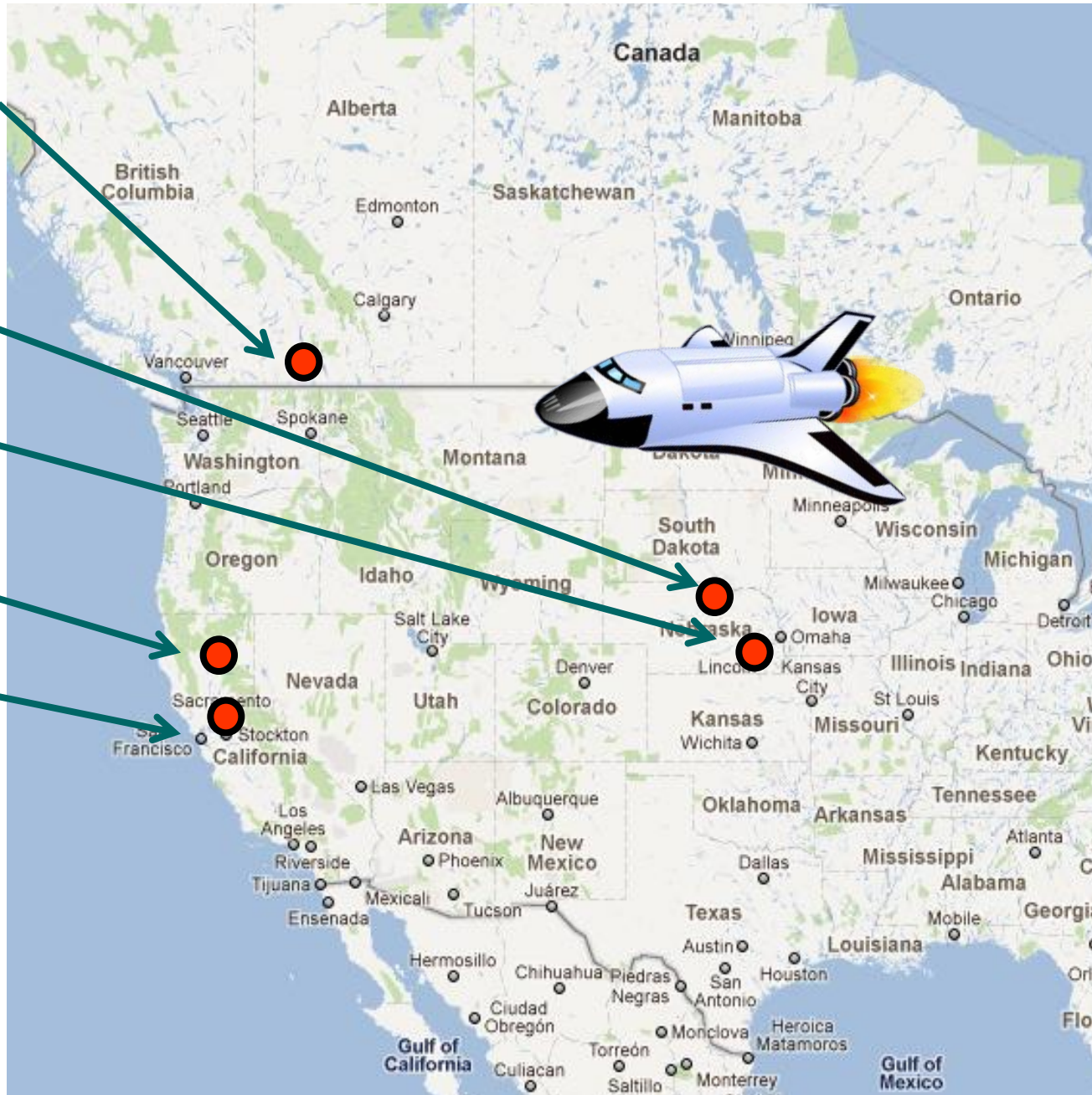
Okanagan (BC, WA)

Missouri
(MT, WY, CO, ND, SD, NE, KA, MO, IO)

Platte (NE, WY, CO)

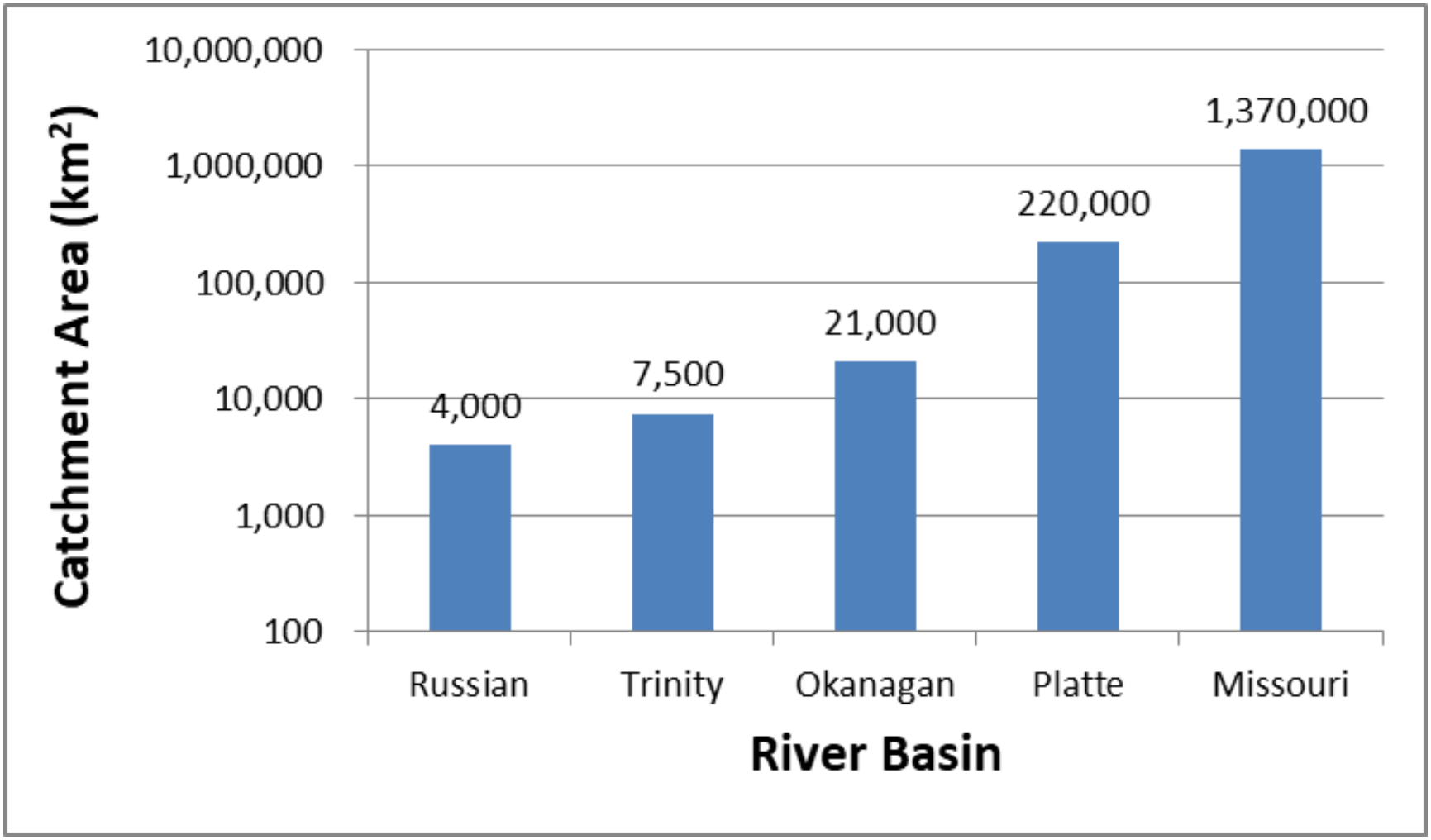
Trinity (CA)

Russian (CA)



Basin areas vary from 4,000 to 1,370,000 km^2

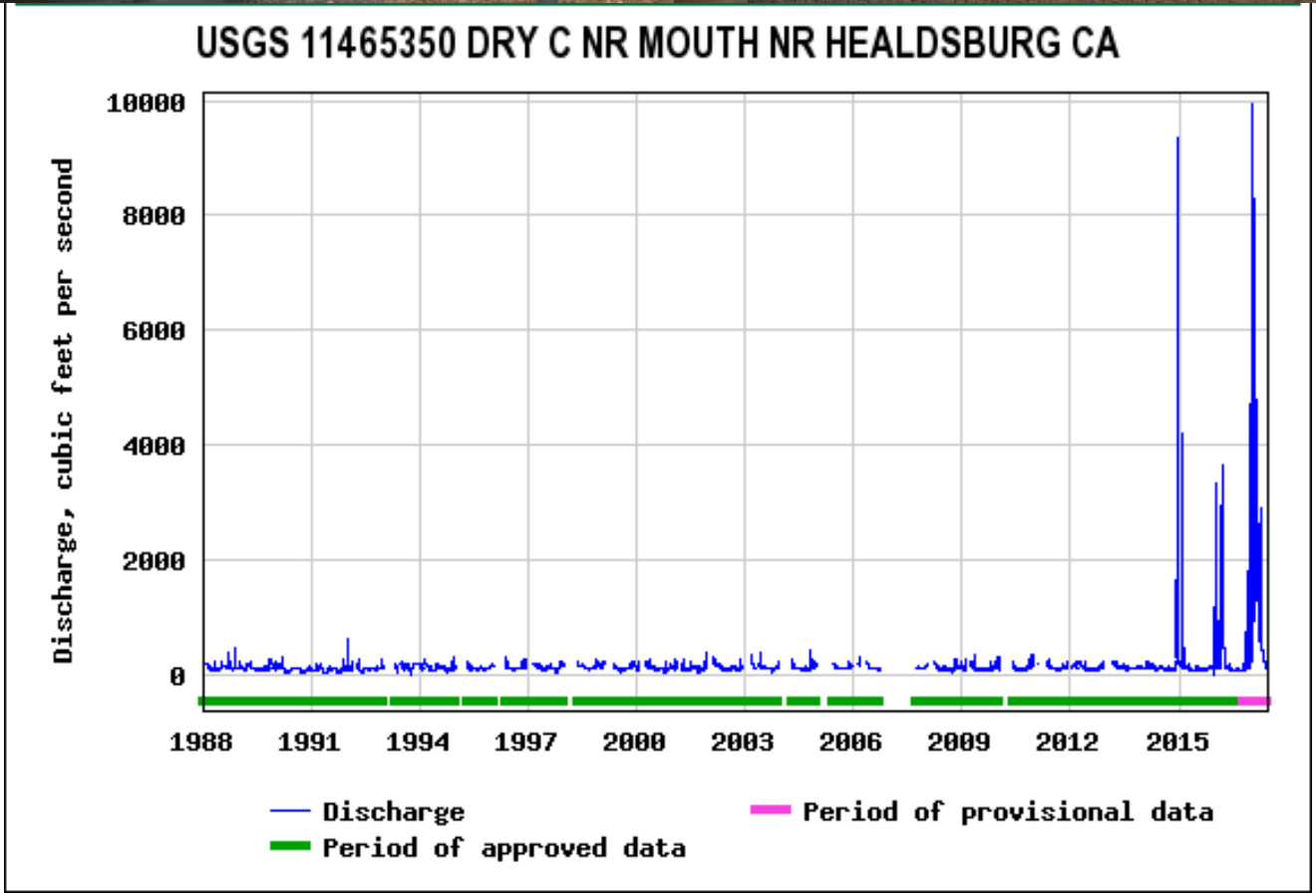
(2.5 orders of magnitude)



Russian River (4000 km^2)

Recover endangered California coho and Chinook by restoring off-channel habitat in 6 miles of a tributary called Dry Creek


Maidu
Grinding
Stones
.25 miles
KEEP


USGS 11465350 DRY C NR MOUTH NR HEALDSBURG CA
Discharge, cubic feet per second
10000
8000
6000
4000
2000
0
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
Discharge
Period of approved data
Period of provisional data

How the project weathered high water

Designed by Interfluve, Inc.

http://www.scwa.ca.gov/drycreek/

SONOMA COUNTY WATER AGENCY

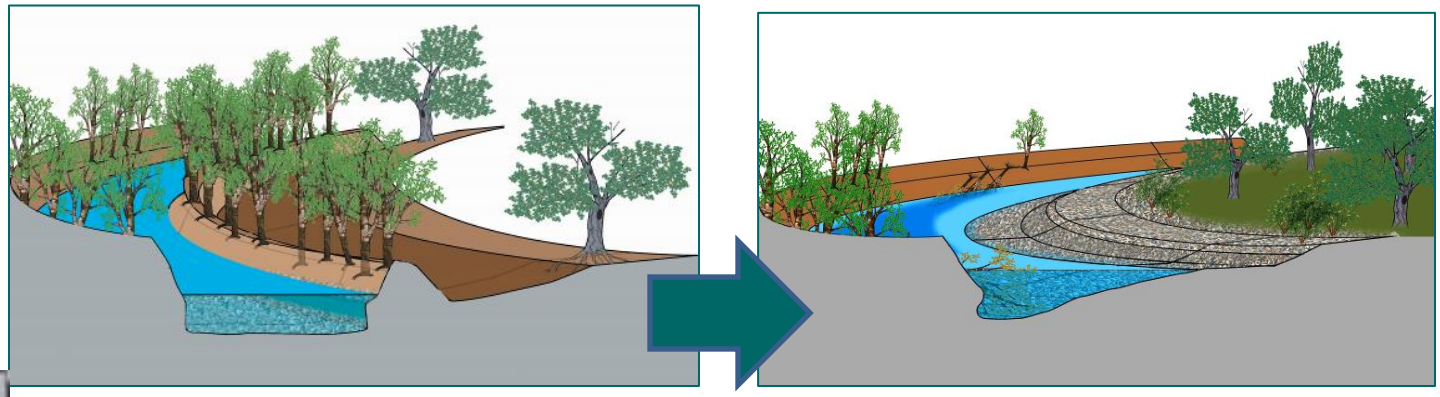
December High Water at Orsi property

Designed by ESA, Inc.

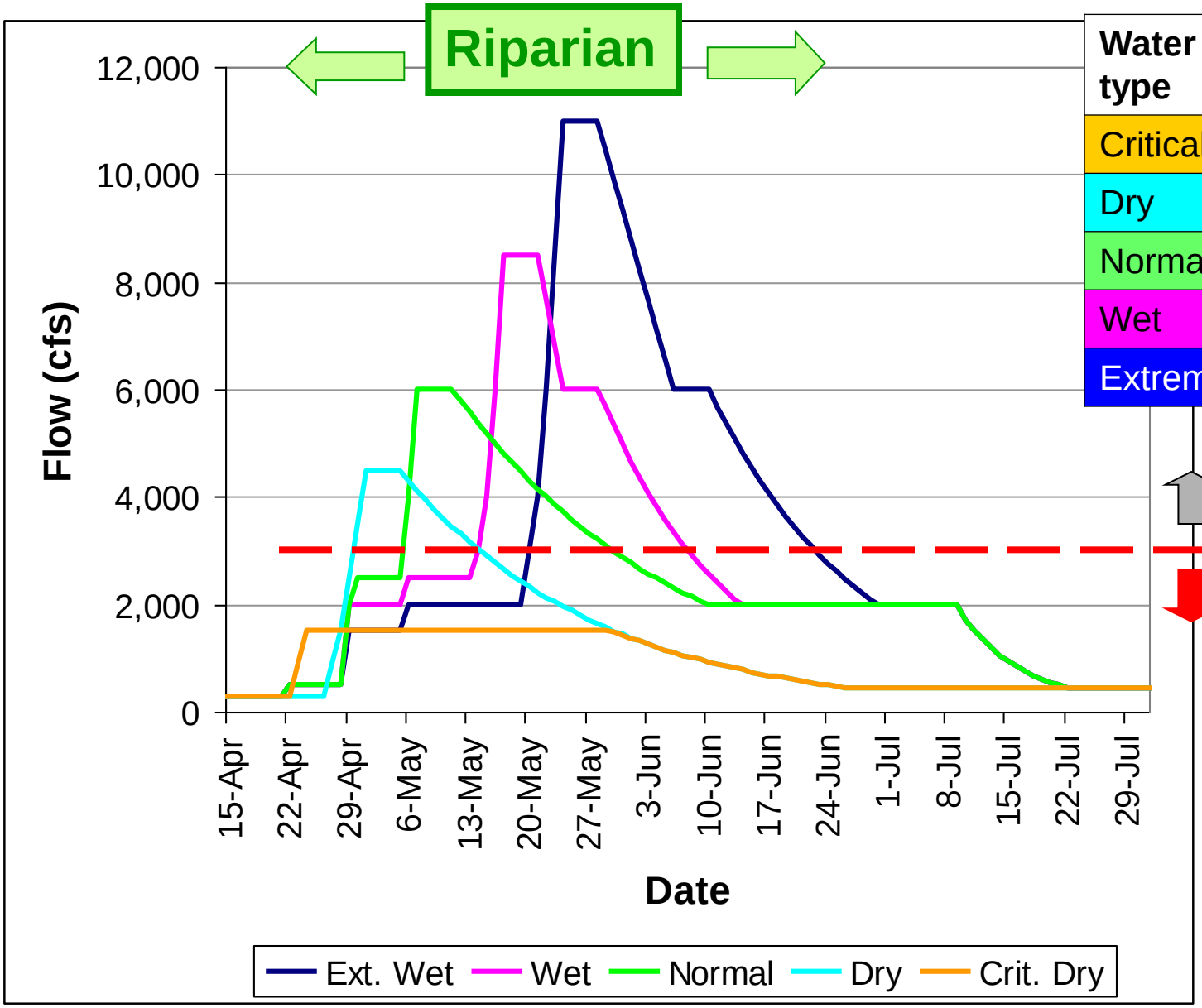
Trinity River (7,500 km^2)

Restore habitat forming processes in 40 miles of river to support salmon by channel rehabilitation, flow manipulation, adding gravel

Restoration strategy defined in a 2000 Record of Decision (ROD)



Water year flow allocations & strategies

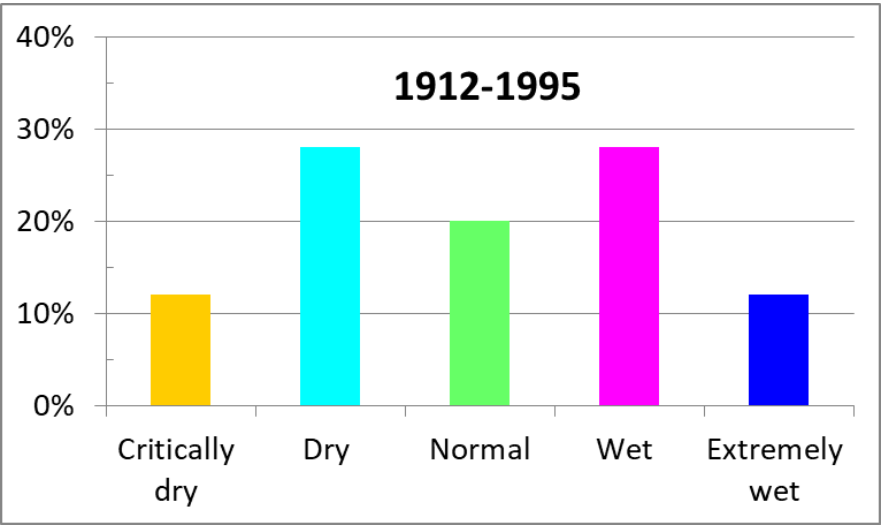


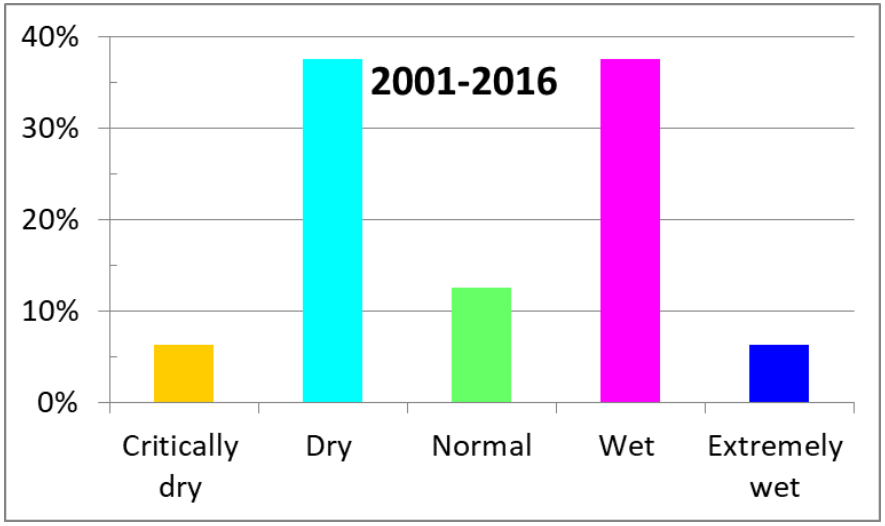
Water year type	ROD Volume (AF)
Critically dry	369,000
Dry	453,000
Normal	647,000
Wet	701,000
Extremely wet	815,000

Geomorphic

Habitat / Temp

Pattern and *sequence* of water years may be changing

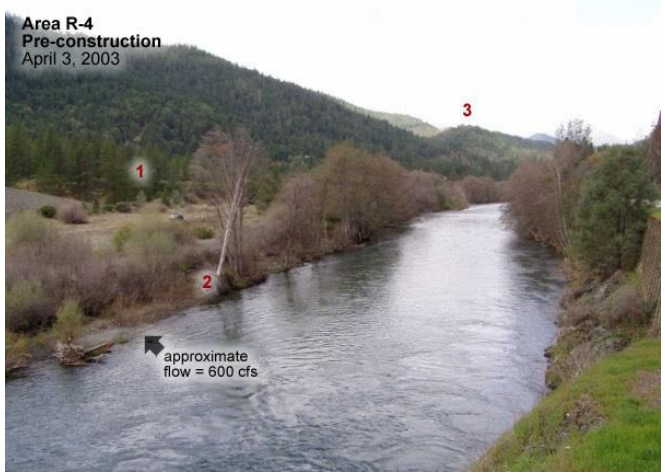




Challenges with more variable climate

- Multiple dry years in a row:
  - Maintaining sufficient water in upstream reservoirs
  - Preventing riparian encroachment
  - Maintaining river temperatures
- Wet years:
  - More rain and less snow changes hydrologic pattern from ROD
  - Big storms have widened channel, reducing velocities at a given flow

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Dry	Normal	Wet	Wet	Wet	Crit. Dry	Dry	Dry	Dry	Wet	Wet	Normal	Dry	Crit. Dry	Dry	Wet

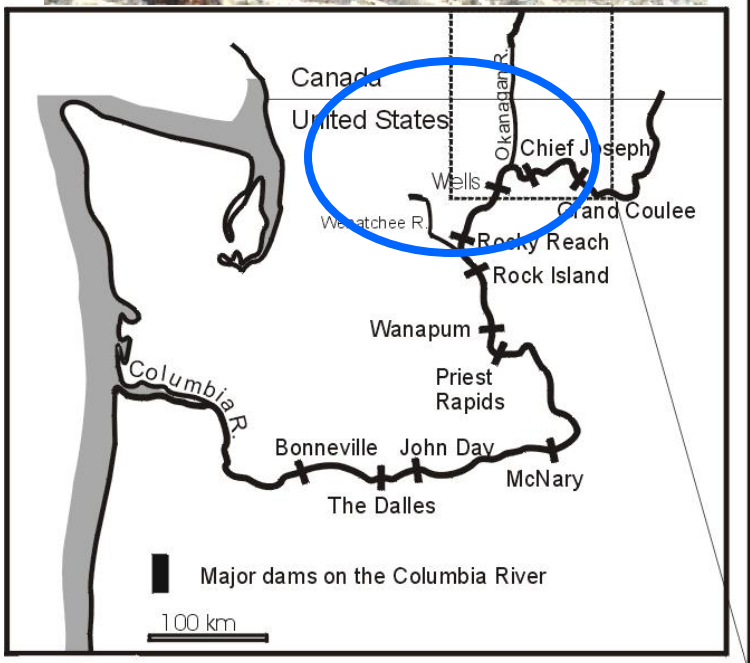


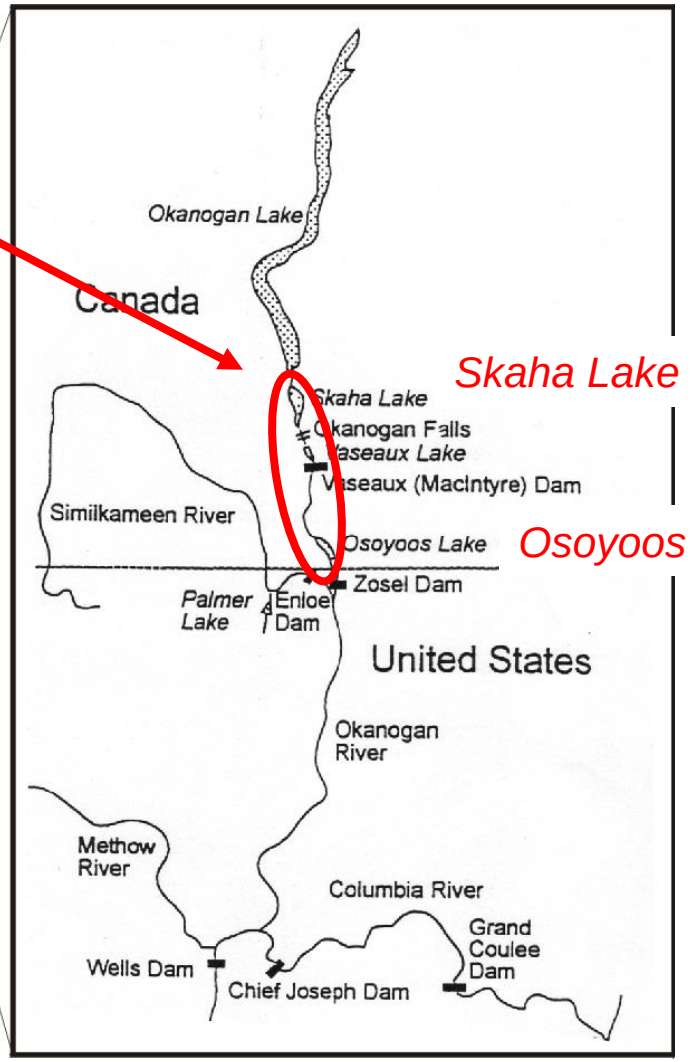
Taking Advantage of Wet Years

Adapting to Dry Years

Okanagan Basin (21,000 km^2)

Recover Okanagan sockeye by flow management, habitat restoration, re-introduction into Skaha Lake and hatchery supplementation

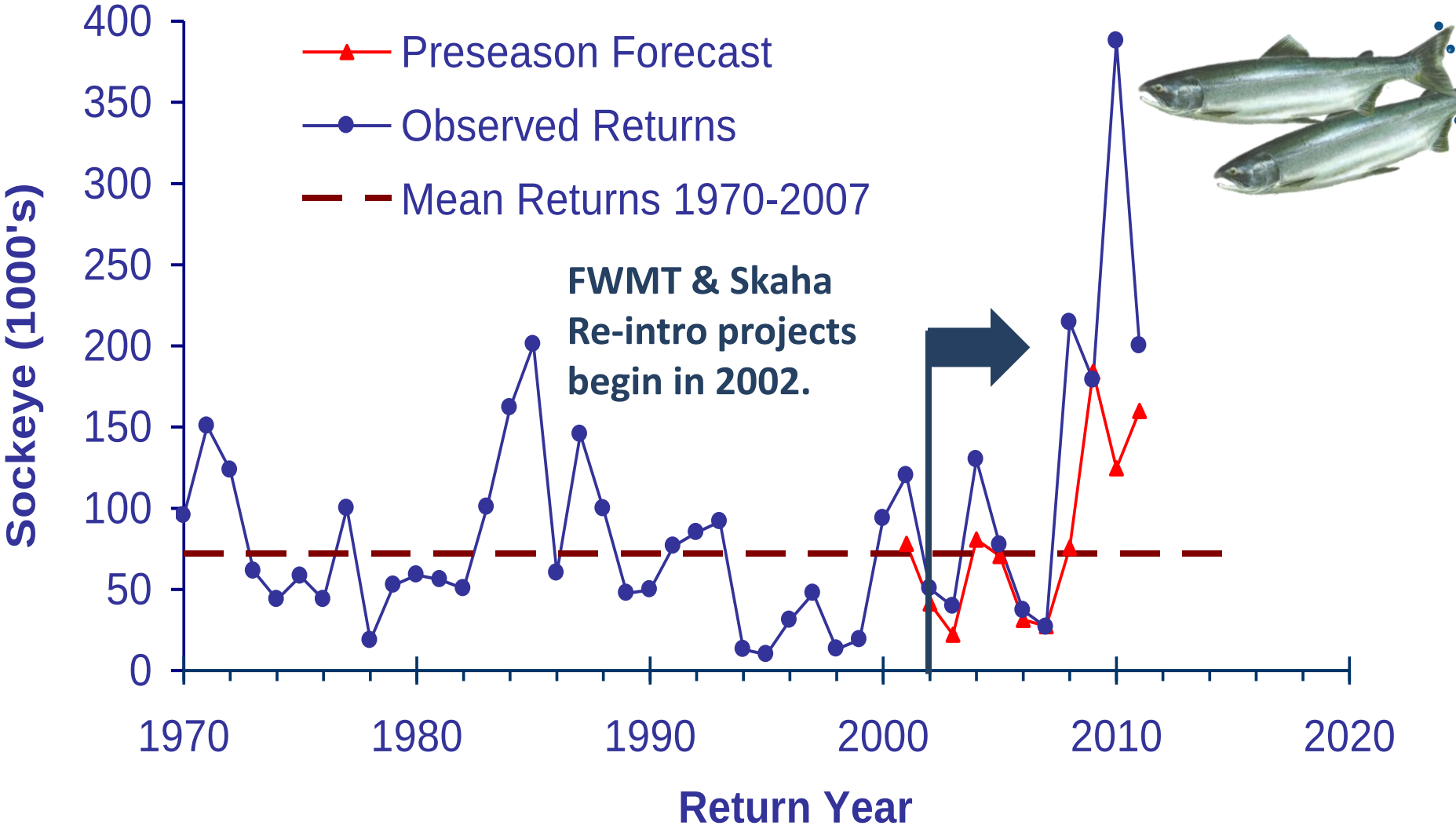




Skaha Lake

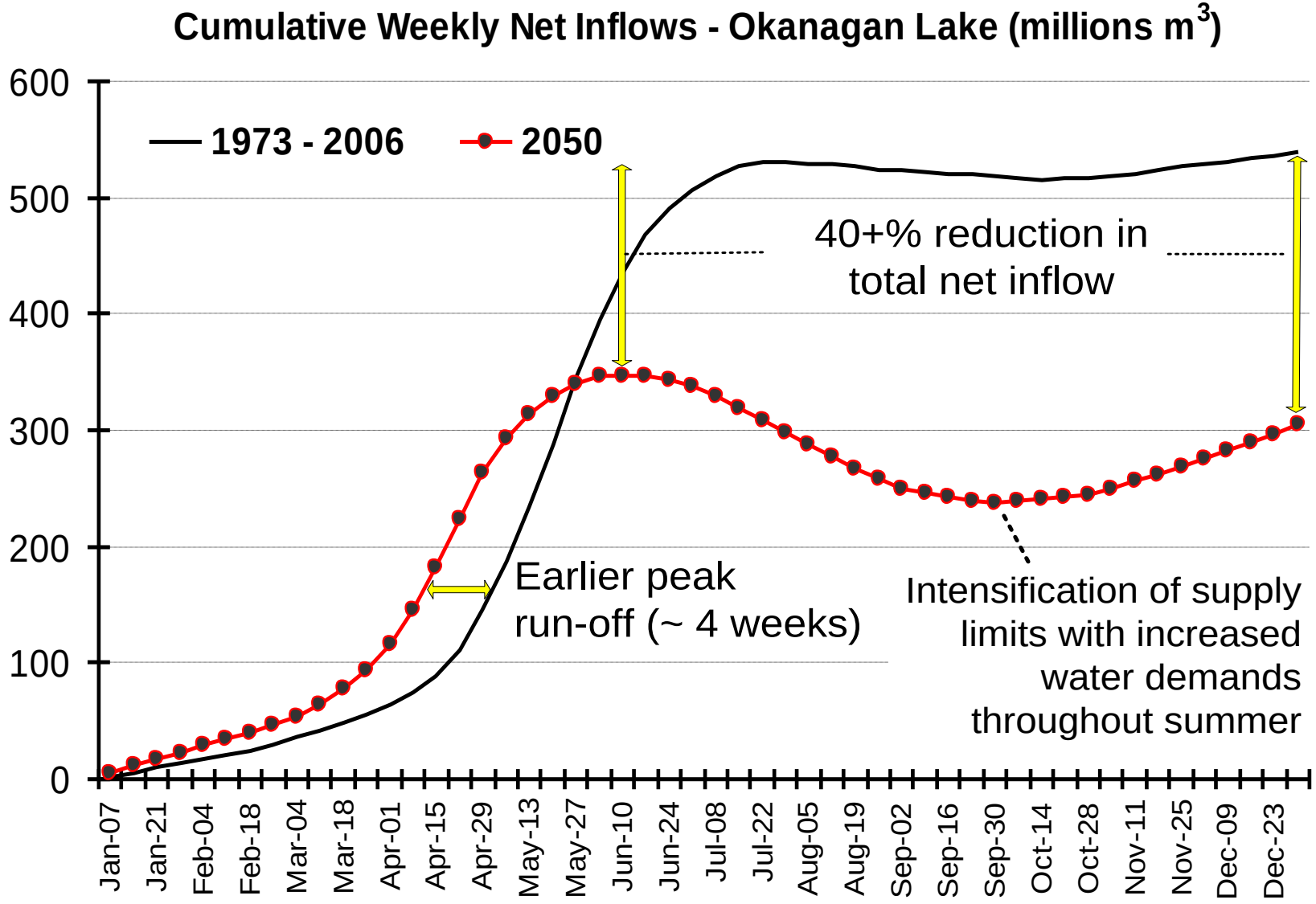
Osoyoos Lake

The good news: 600% increase in sockeye

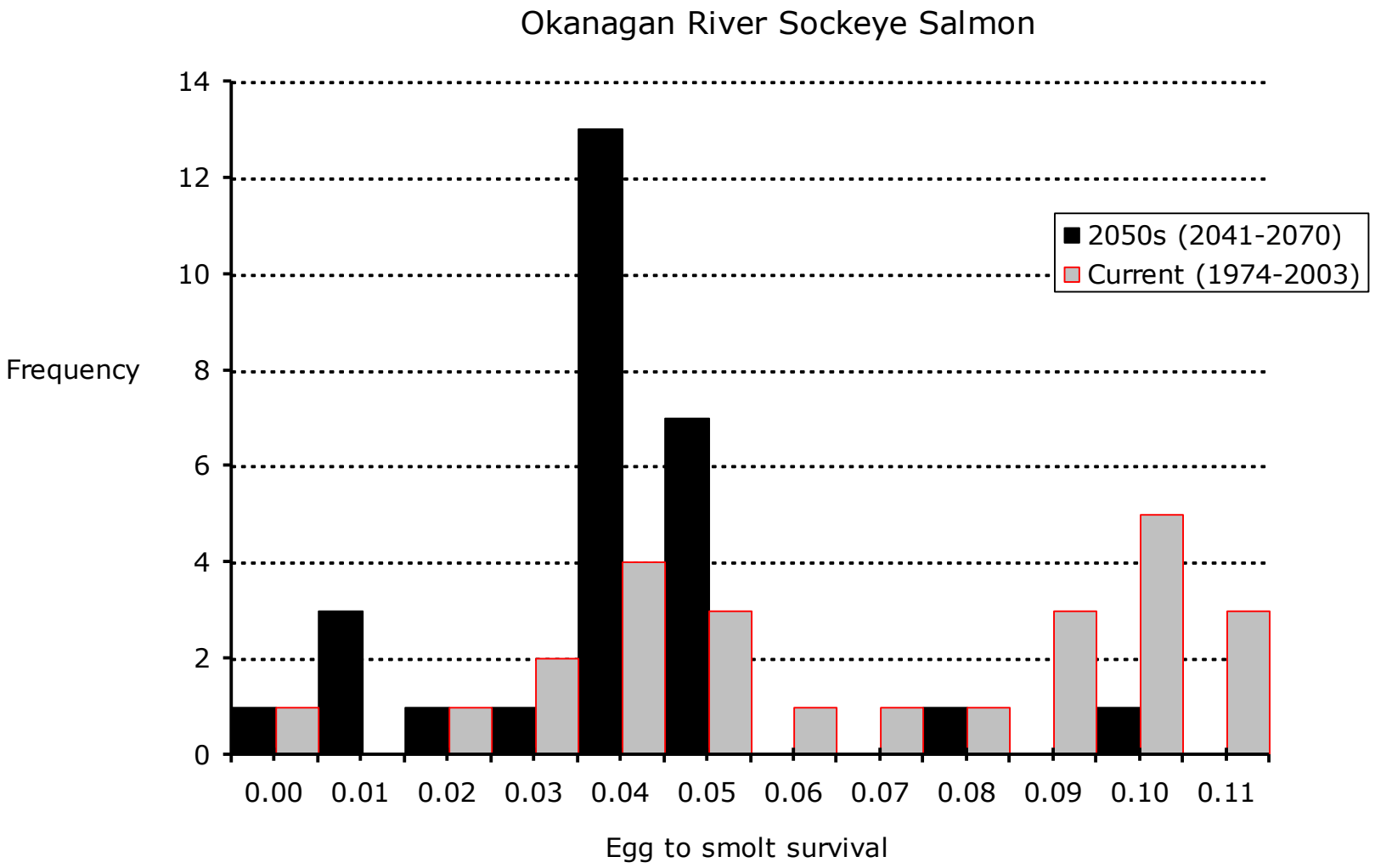


Kim Hyatt, DFO

The bad news (1): 2050 will be a lot drier

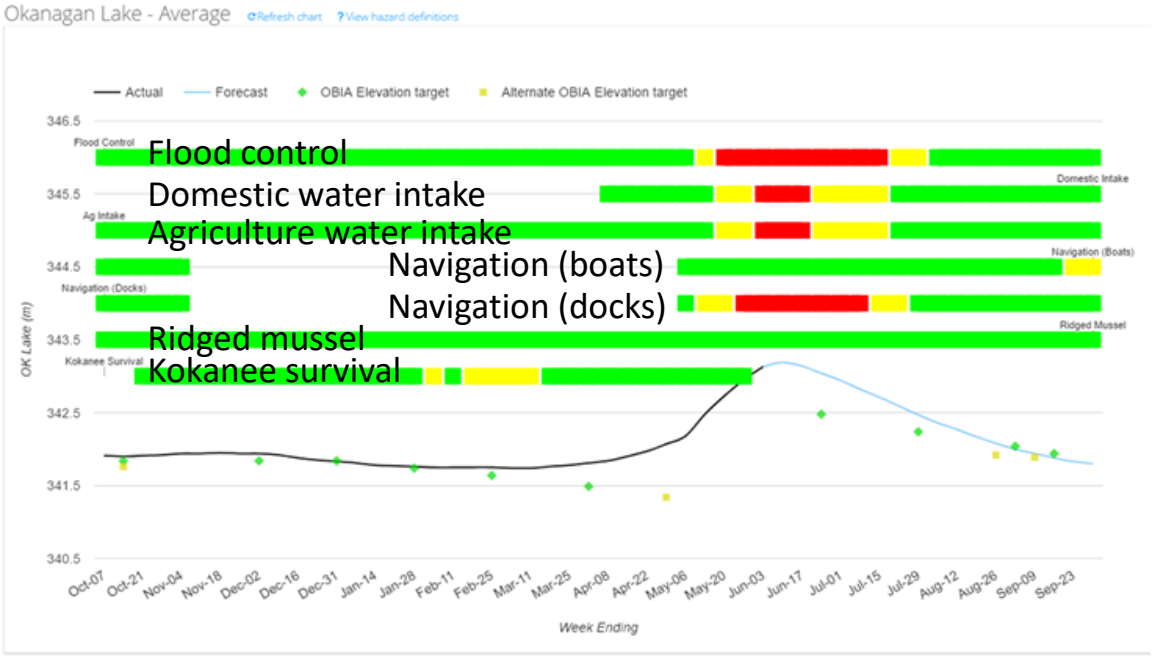


The bad news (2): egg to smolt survival is projected to decrease by 44% by 2050

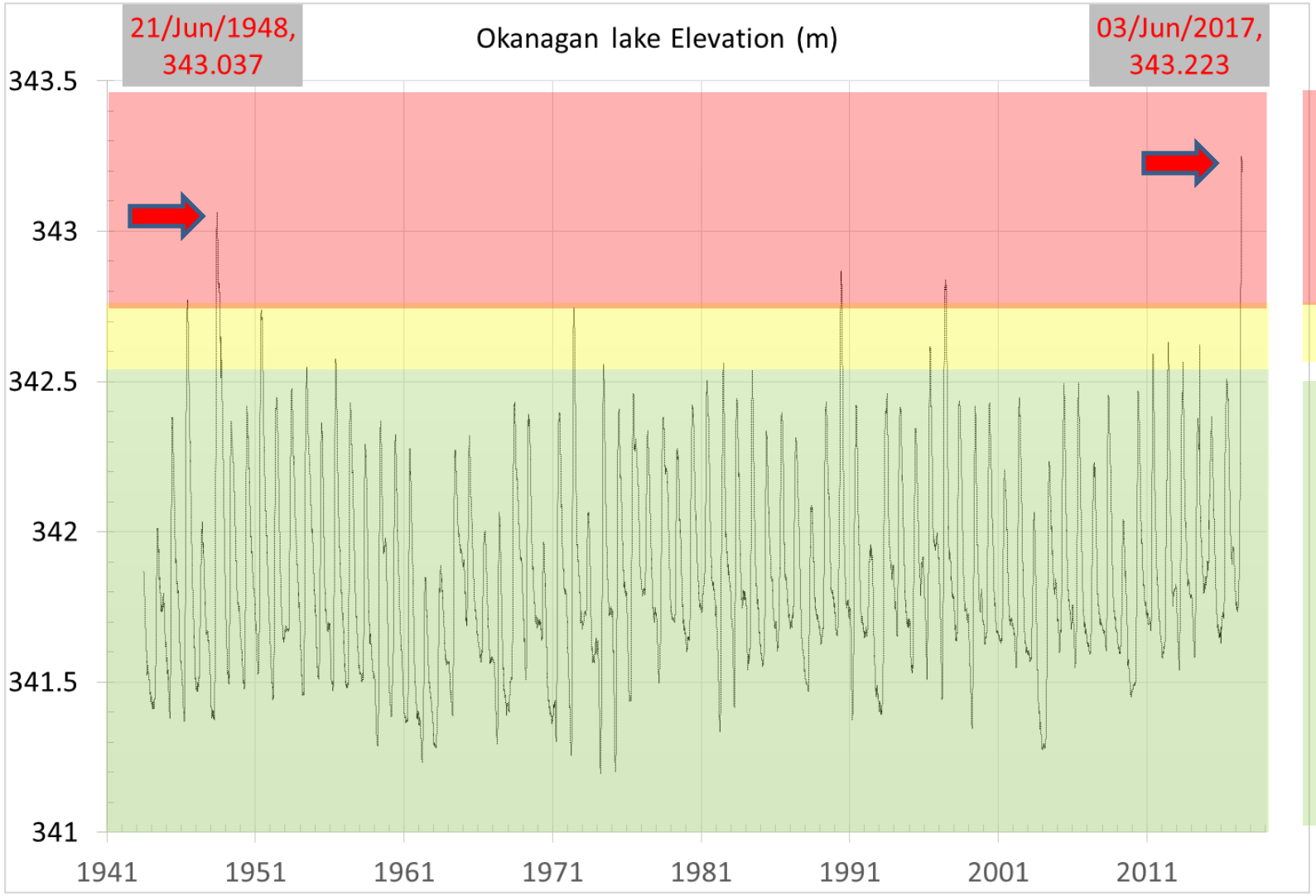


The bad news (3): record flooding in Okanagan Lake in May 2017

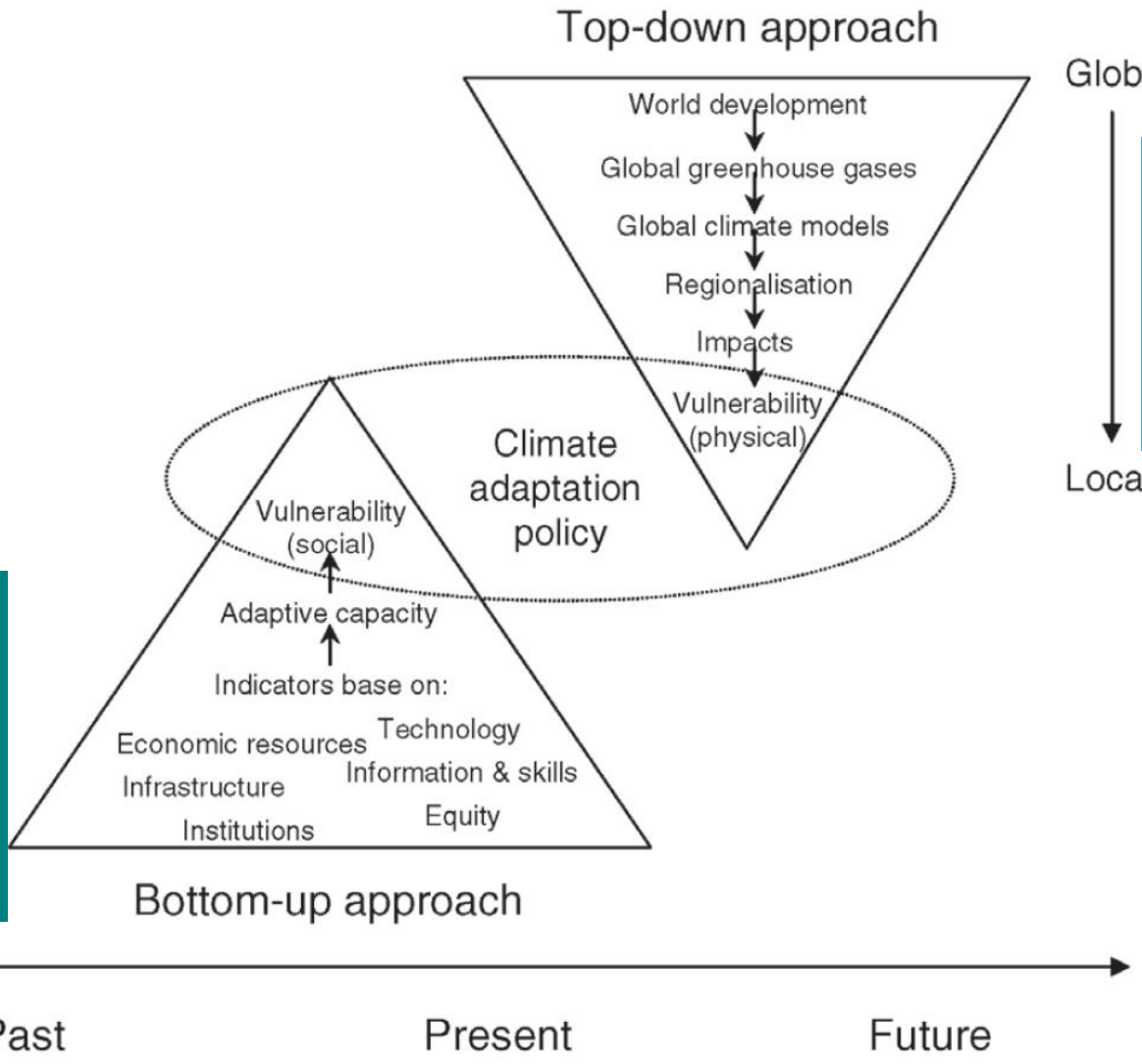
Date	Okanagan Basin Snowpack (% of Normal)
March 1	86%
April 1	105%
May 1	147%
June 1	228%



Vulnerability ranges for flooding in Okanagan Lake



Okanagan work combines both bottom-up and top-down approaches to AM and climate adaptation



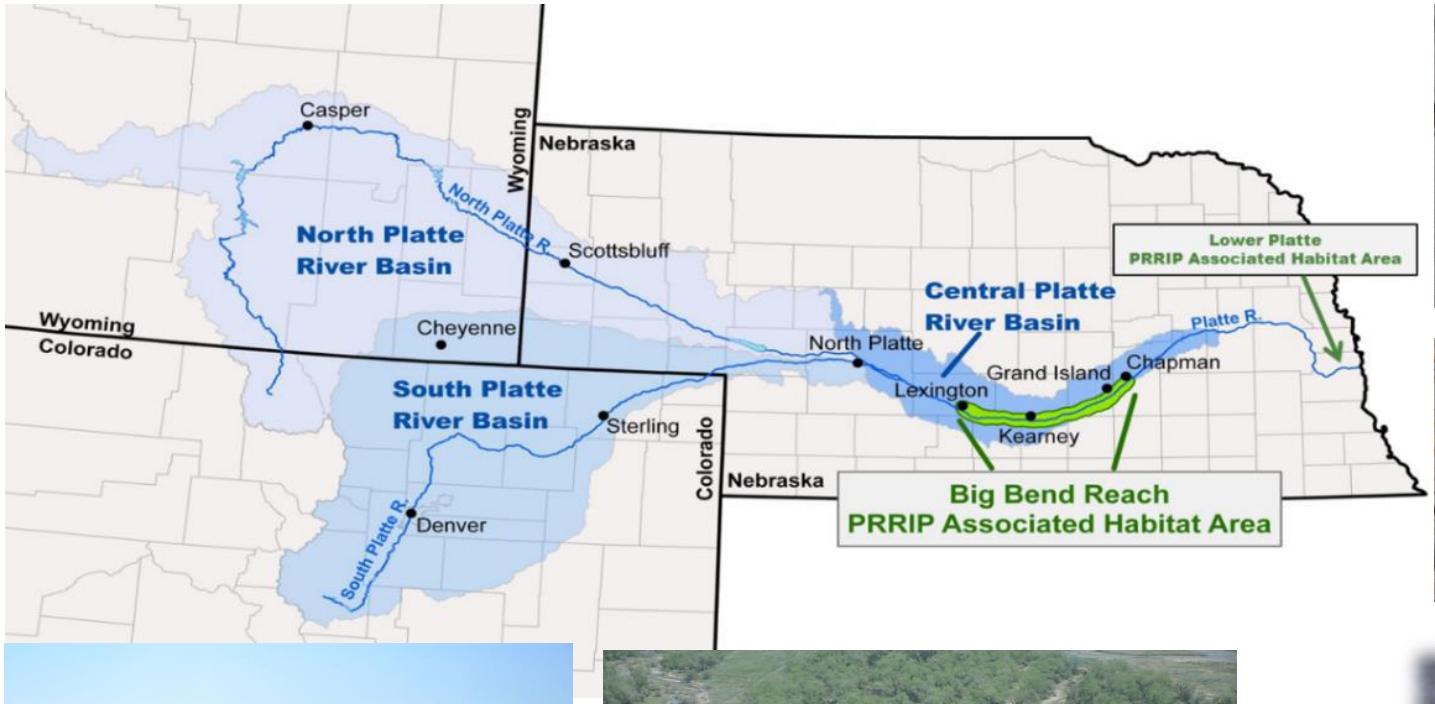
Vulnerability based on cause-effect prediction

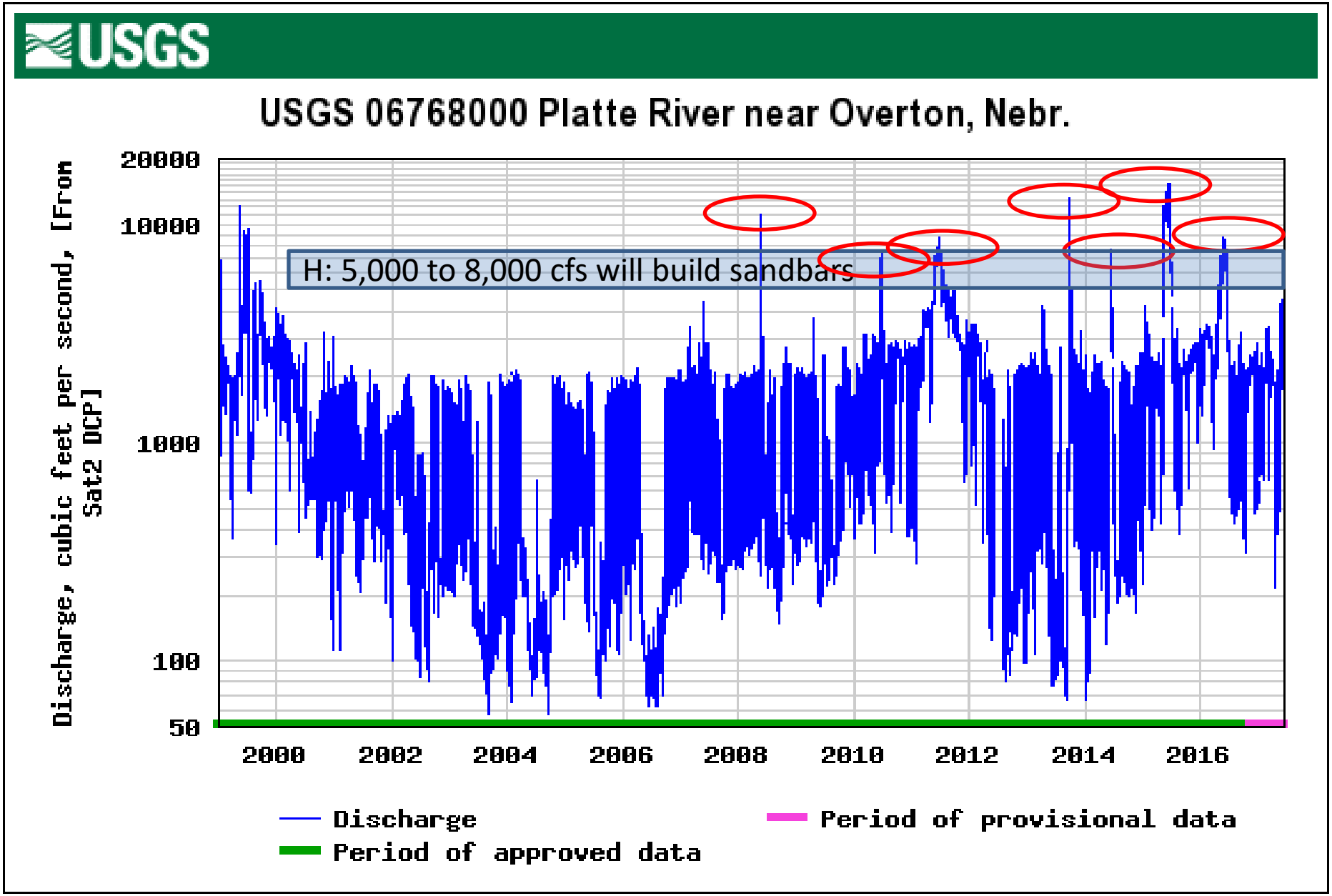
Vulnerability based on existing capacity and needs

From Dessai and Hulme 2004

Platte Basin (221,000 km^2)

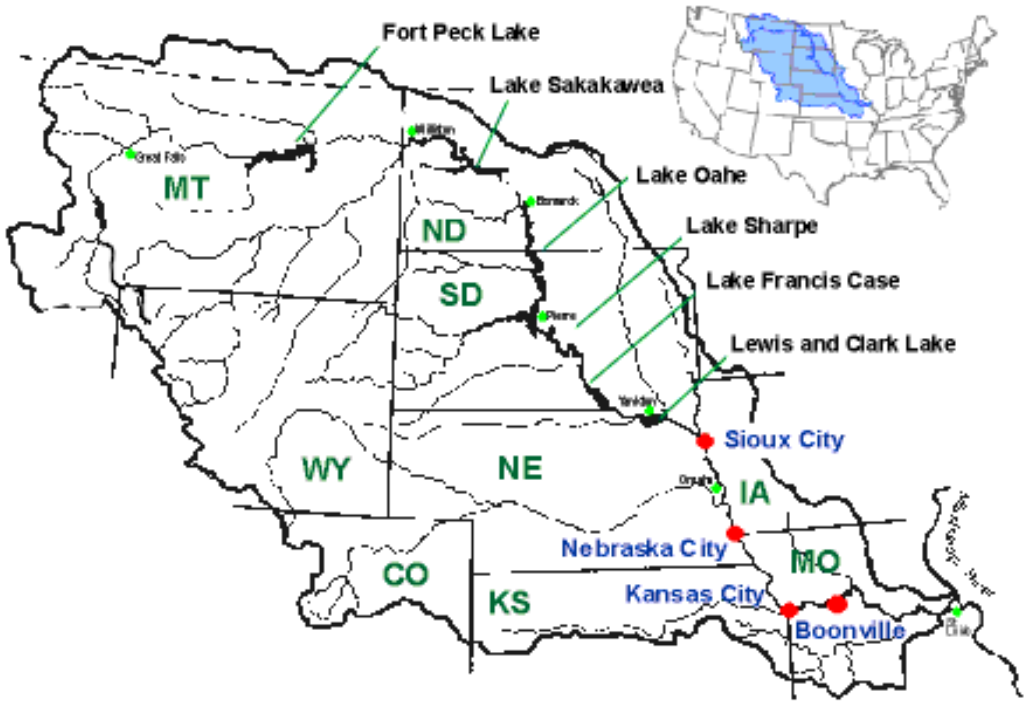
Recover piping plovers, least terns and whooping cranes by increasing nesting and roosting habitats, adding water and sand




USGS
USGS 06768000 Platte River near Overton, Nebr.
Discharge, cubic feet per second, [From Sat2 DCP]
20000
10000
1000
100
50
H: 5,000 to 8,000 cfs will build sandbars
2000
2002
2004
2006
2008
2010
2012
2014
2016
Discharge
Period of provisional data
Period of approved data

Missouri (1,370,000 km^2)

Recover piping plovers, least terns and pallid sturgeon by building habitat and *possibly* changing flows



The challenge: meeting species needs and "human considerations"

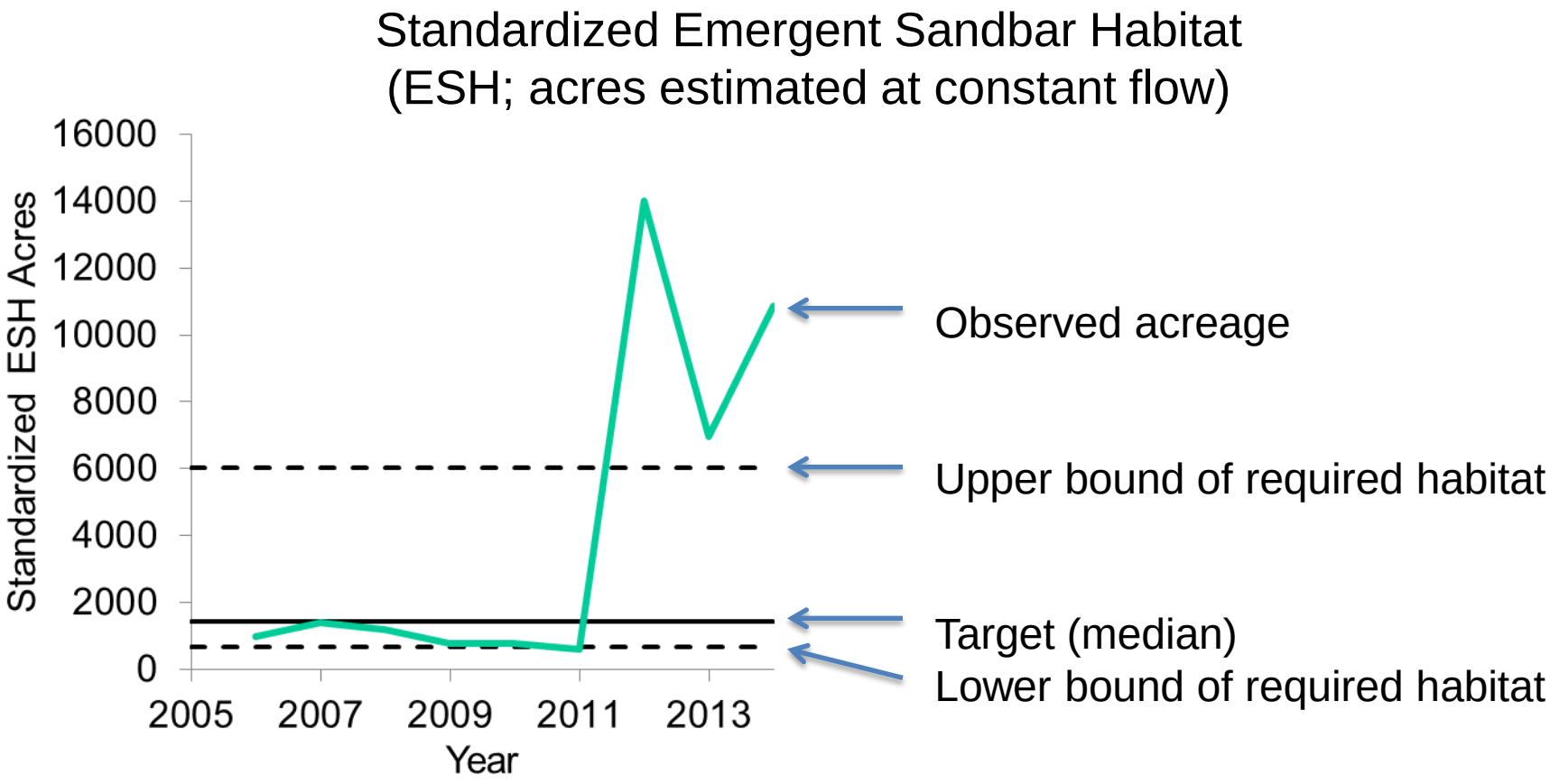
Human Considerations

1) Navigation
2) Irrigation
3) Flood Control
4) Fish and Wildlife
5) Recreation
6) Water Quality
7) Water Supply
8) Agriculture
9) Conservation Districts
10) Waterway Industries
11) Major Tributaries
12) Thermal Power
13) Hydro power
14) At large/other interests, e.g. cultural and historic preservation
15) Local Government
16) Environmental/conservation organizations

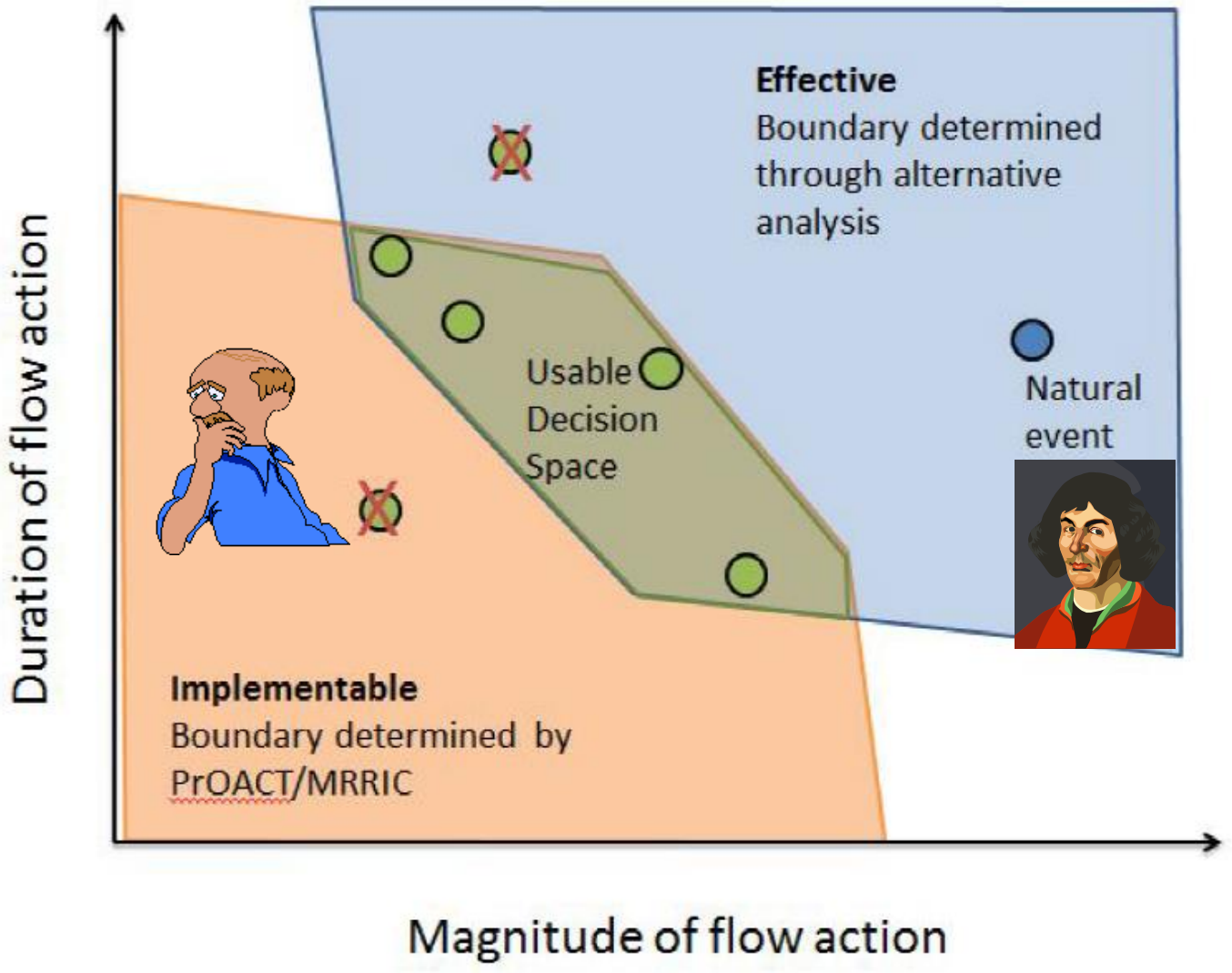
2011 Flood on Missouri River

MRRIC: 75 stakeholders

But the 2011 flood created **lots** of Emergent Sandbar Habitat for bird nesting

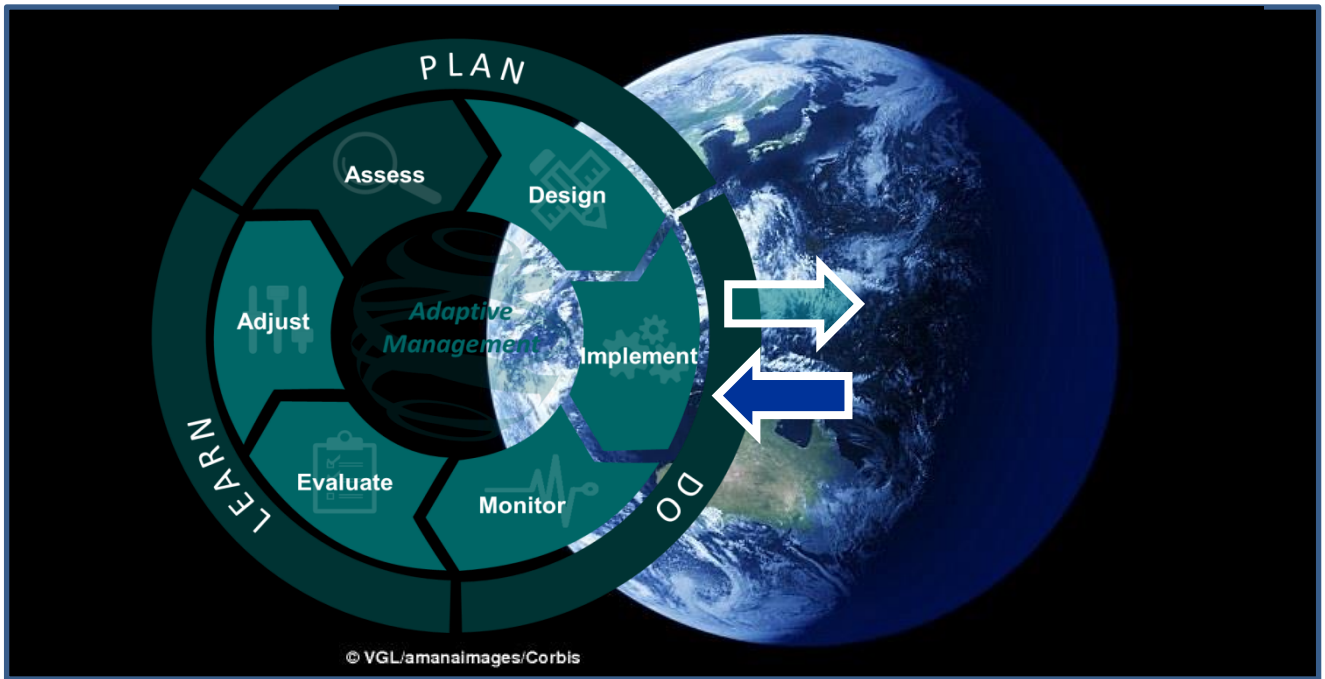


Is there a usable decision space for creation of sandbar habitat in the Missouri River???



3 key points

1. Climate change demands an AM Mindset
2. Both AM and adapting to climate change gets harder as the spatial scale increases
3. Climate change brings challenges, but also opportunities for both AM and human adaptation



More information

http://essa.com/services/adaptive-management/

http://essa.com/climate-change-adaptation-risk-reduction/

Marmorek, D.R. and C.N. Peters. 2001. Finding a PATH towards scientific collaboration: insights from the Columbia River Basin. Conservation Ecology 5(2): 8.

Greig et al. 2013. Insight into Enabling Adaptive Management. Ecology and Society 18(3): 24

Nelitz et al. 2013. Tools For Climate Change Vulnerability Assessments For Watersheds. http://www.ccme.ca/files/Resources/water/climate_change/pn_1494_vat.pdf

Murray et al. 2015**.** Adaptive Management Today: A Practitioner's Perspective. Ch. 10 in *Adaptive Management of Natural Resources in Theory and Practice (Allen, Garmestani and Smith (eds), Springer).*

Fischenich et al. 2016. Draft Science and Adaptive Management Plan for the Missouri River Recovery Program.