California Water Sustainability Indicators Framework

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with
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Pacific Institute, Sacramento River Watershed Program, Sacramento Regional County Sanitation District, Napa County, and South Yuba River Citizens League

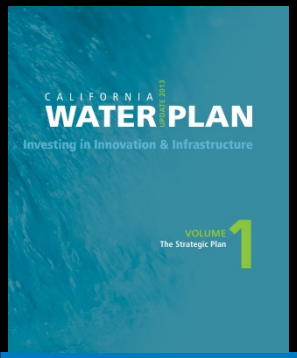
http://indicators.ucdavis.edu

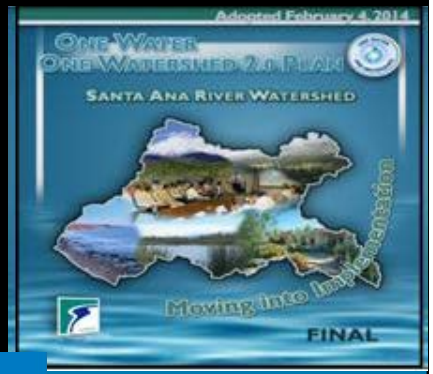
Definitions

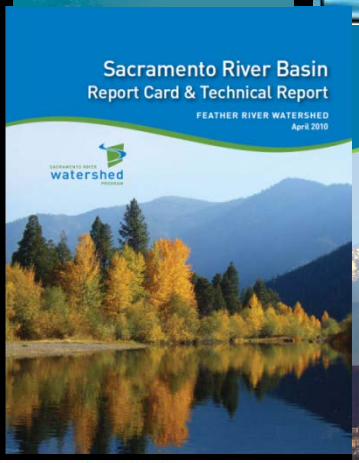
- Metrics– things we can measure in “the wild”
- Indicators – often composed of metrics, things we can evaluate around us that can tell us a story about components of a natural or human system
- Performance Measures – similar to indicators, except often confined to management actions and other intentional human actions
- Index – an aggregation of indicators that convey a more complete story about a system

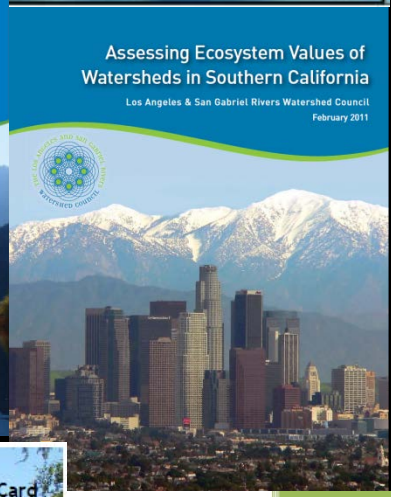
Water sustainability is the dynamic state of water use and supply that meets today’s needs without compromising the long-term capacity of the natural and human aspects of the water system to meet the needs of future generations. (CWP, 2013)

Report Cards







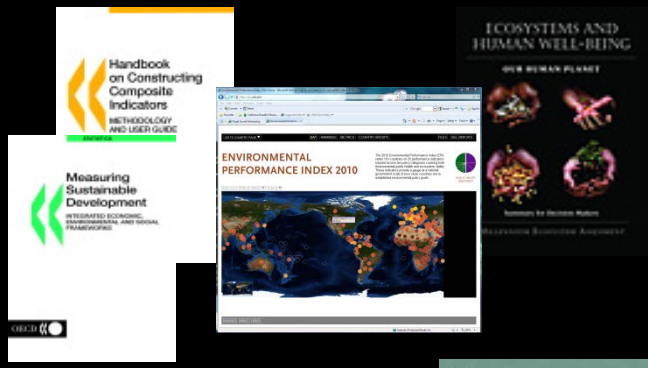


Goals	Icon	Objectives
A. Maintain and improve water quality and supply to sustainably meet the needs of natural and human communities		1) Protect receiving waters from pollution to comply with current and future water quality regulations
		2) Maintain water quality for healthy aquatic systems*
		3) Protect the quality of drinking water supplies
		4) Maintain and restore natural stream flows for aquatic and riparian communities*
		5) Maintain water supplies to meet human needs within the watershed
B. Protect and enhance native aquatic and terrestrial species, especially sensitive and at-risk species and natural communities		1) Protect and enhance native fish populations, including anadromous fish*
		2) Protect and enhance bird populations
		3) Protect and enhance amphibian populations
		4) Protect and enhance mammal populations*
		5) Protect and enhance native invertebrate communities*
		6) Discourage and reduce invasive, non-native species
C. Protect and enhance landscape and habitats structure and processes to benefit ecosystem and watershed functions		1) Protect and enhance riparian habitat quality
		2) Protect and enhance wetland habitat quality
		3) Protect and enhance aquatic habitat connectivity*
		4) Protect and enhance terrestrial habitat connectivity*
		5) Maintain and restore stream geomorphic processes
		6) Optimize primary production and nutrient cycling to support aquatic and terrestrial communities* (for N)
		7) Manage land-uses to reduce impacts on aquatic and terrestrial habitats
D. Maintain and restore natural disturbance processes that balance benefits for natural and human communities		1) Reduce high severity fire frequency; encourage natural fire regimes that support native communities*
		2) Reduce flood risk to human communities; encourage natural flood processes that support native communities*
		3) Reduce greenhouse gas emissions and encourage activities to adapt to climate change
E. Maintain and improve the social and economic conditions, including benefits from healthy watersheds		1) Protect and enhance wildlife friendly agricultural practices*
		2) Improve grazing management
		3) Encourage sustainable land use practices
		4) Improve community economic status in balance with watershed condition*
		5) Improve community relationship with watershed processes
		6) The watershed supports sustainable social practices
		7) Support and improve human uses associated with watershed condition*
		8) To have widespread community awareness and deep civic engagement in the protection and improvement of watersheds*

Global use of indicators

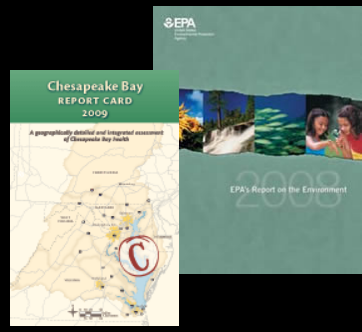
World

United Nations Environment Programme (2006)
Millenium Ecosystem Assessment (2005)
Environmental Performance Index (2010)
NOAA Arctic Report Card (2010)
New Zealand Ministry of Environment “State of NZ” (2007)
Kingdom of Bhutan Happiness Index
European Commission – OECD



US

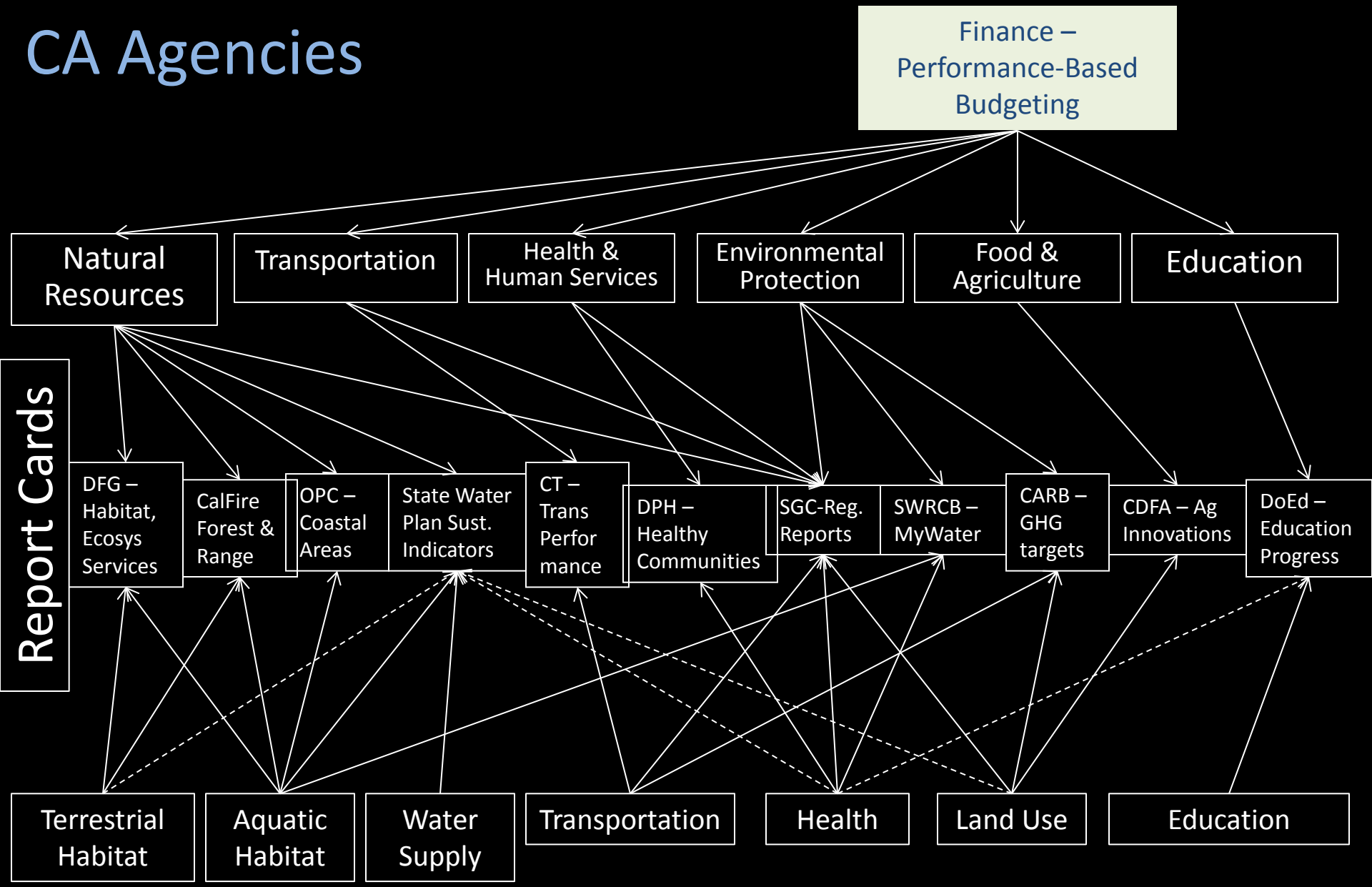
US EPA Environmental Indicators & Report on the Environment
Chesapeake Bay Eco-Check
State of the Sound (Puget Sound Partnership)



California

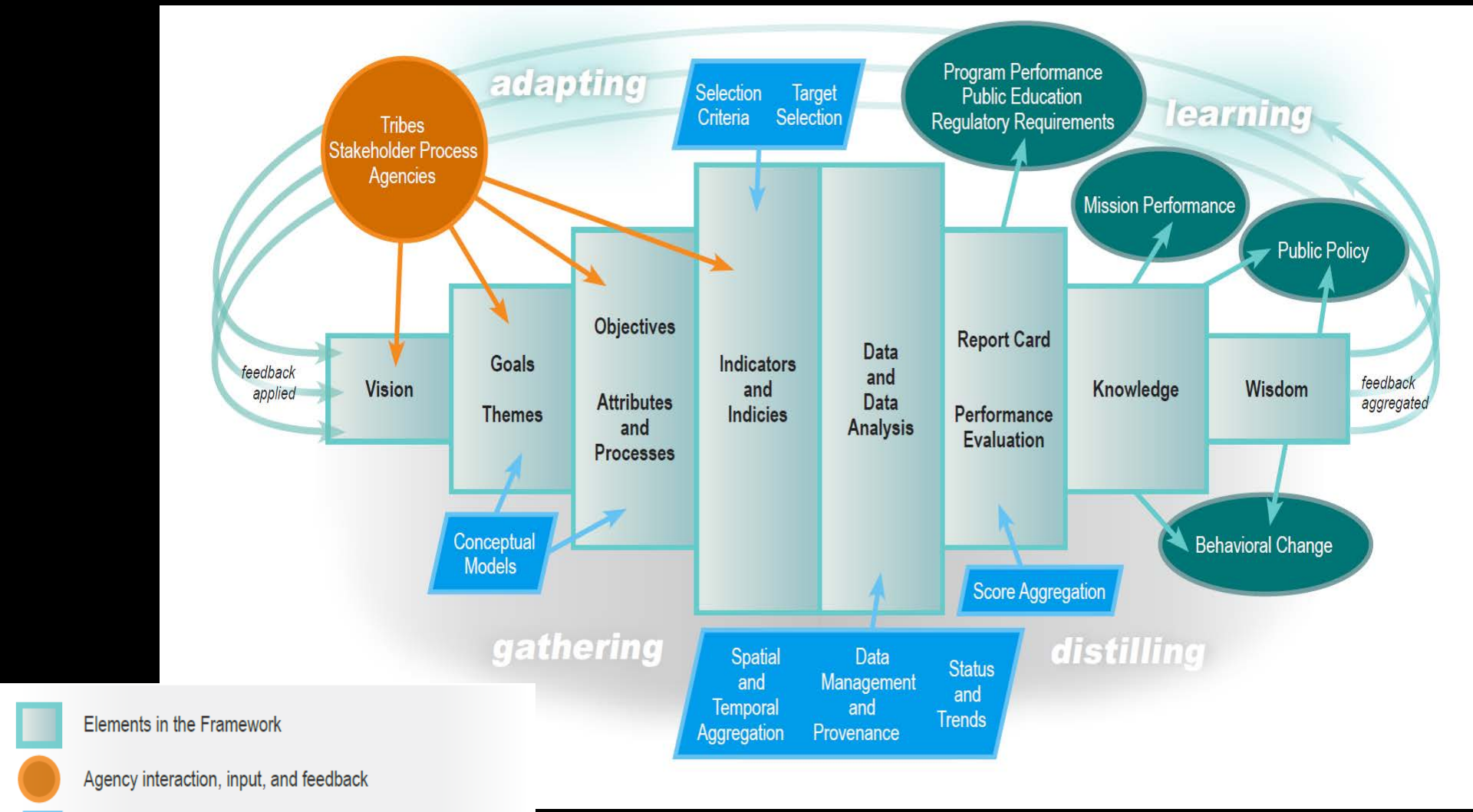
California’s Legislative Report Card (Sierra Club)
Southern California Issue-specific reports (Institute of the Environment, UCLA)
Beach Report Card (Heal the Bay, annual)
Ski Areas Report Card (Sierra Nevada Alliance and others)
Central Valley Economy and Environment (Great Valley Center)

CA Agencies



Domains of Concern

Sustainability Indicator Framework



Elements in the Framework

Agency interaction, input, and feedback

Analytical inputs to the Framework (modeling, data, analysis)

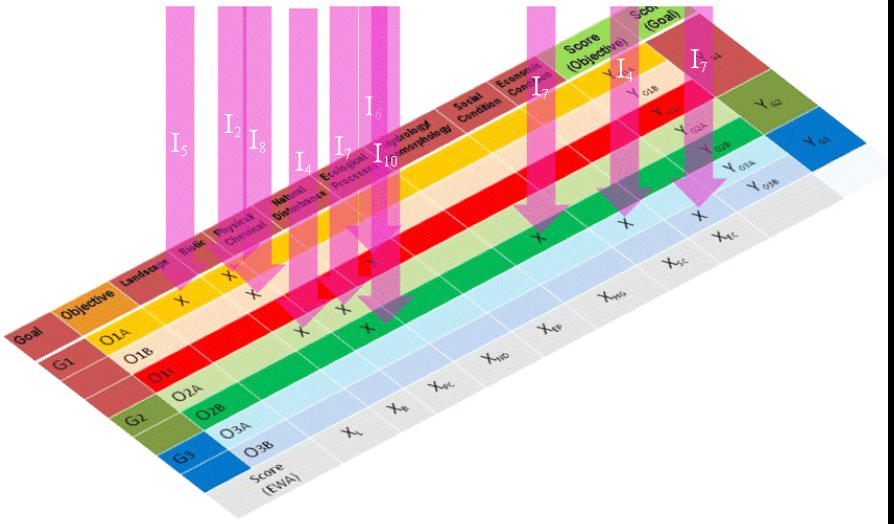
End use of assessments from the Framework

1. Goals and Objectives

Condition

Goal	Objective	Landscape	Biotic	Physical/ Chemical	Natural Disturbance	Ecological Processes	Hydrology/ geomorphology	Social Condition	Economic Condition	Score (Objective)	Score (Goal)
G1	O1A	X	X							Y_{O1A}	Y_{G1}
	O1B		X							Y_{O1B}	
	O1C				X					Y_{O1C}	
G2	O2A		X	X						Y_{O2A}	Y_{G2}
	O2B			X			X			Y_{O2B}	
G3	O3A							X		Y_{O3A}	Y_{G3}
	O3B								X	Y_{O3B}	
Score (EWA)		X_L	X_B	X_{PC}	X_{ND}	X_{EP}	X_{HG}	X_{SC}	X_{EC}		

Influences on Condition



Domains:
Water Supply Reliability, Water Quality, Ecosystem Health, Adaptive and Sustainable Management, Social Benefits and Equity

Water Sustainability Goals

Water Plan Update 2013
Goal 1. Manage and make decisions about water in a way that integrates water availability, environmental conditions, and community well-being for future generations.
Goal 2. Improve water supply reliability to meet human needs, reduce energy demand, and restore and maintain aquatic ecosystems and processes.
Goal 3. Improve beneficial uses and reduce impacts associated with water management.
Goal 4. Improve quality of drinking water, irrigation water, and in-stream flows to protect human and environmental health.
Goal 5. Protect and enhance environmental conditions by improving watershed, floodplain, and aquatic condition and processes.
Goal 6. Integrate flood risk management with other water and land management and restoration activities.
Goal 7. Employ adaptive decision-making, especially in light of uncertainties, that support integrated regional water management and flood management systems.

SAWPA One Water One Watershed 2.0
Goal 1: Maintain reliable and resilient water supplies and reduce dependency on imported water
Goal 2: Manage at the watershed scale for preservation and enhancement of the natural hydrology to benefit human and natural communities
Goal 3: Preserve and enhance the ecosystem services provided by open space and habitat within the watershed
Goal 4: Protect beneficial uses to ensure high quality water for human and natural communities
Goal 5: Accomplish effective, equitable and collaborative integrated watershed management in a cost-effective manner

Sustainability Indicators: California

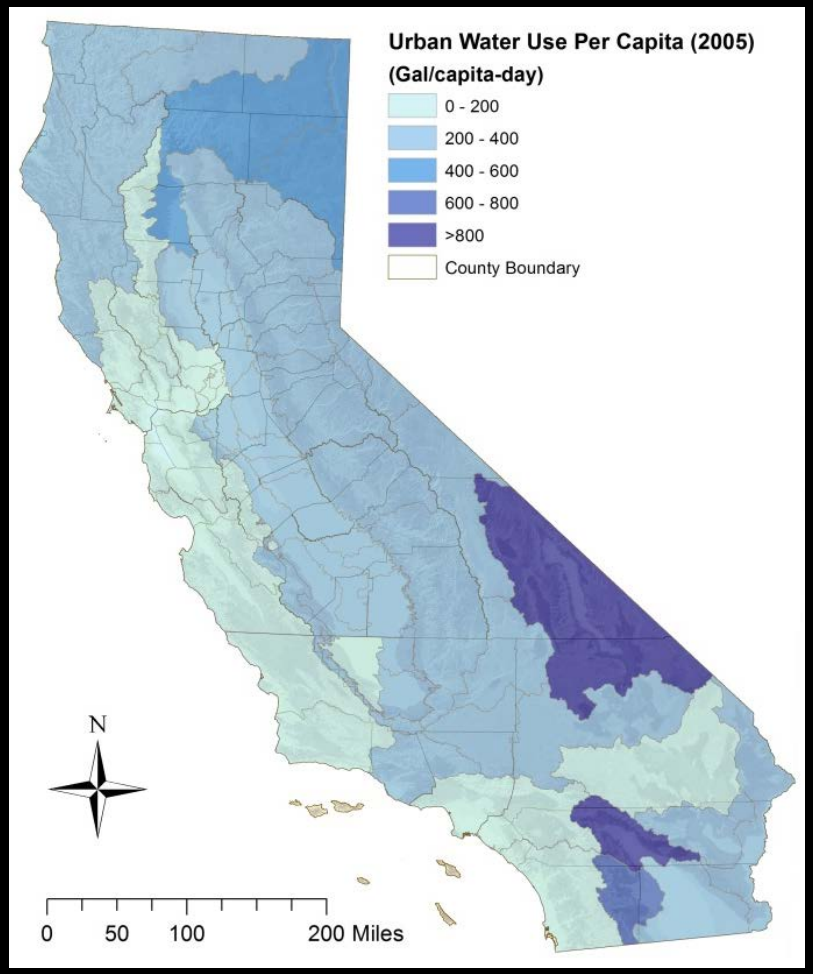
Indicator Name	Sustainability Goals
Aquatic Fragmentation	5
Baseline Water Stress	1,2
California Stream Condition Index	5
CalEnviroScreen-Groundwater Threats	4
Geomorphic Condition	5,6
Groundwater Quality-Nitrate	4
Groundwater Stress	2
Historical Drought Severity	2,5
Historical Flooding	6
Interannual variability	2,5,7
Native Fish Species	5
Public Perceptions of Water	7
Return Flows	2,3
Threats to Amphibians	5
Upstream Protected Lands	2,4
Upstream Storage	2,3
Water Footprint	1,2,7
Water Quality Index	4
Water Use and Availability	2

State pilot indicators and indices and corresponding Sustainability Goals. 19 of 120 indicators in the Water Plan Sustainability Indicators Framework

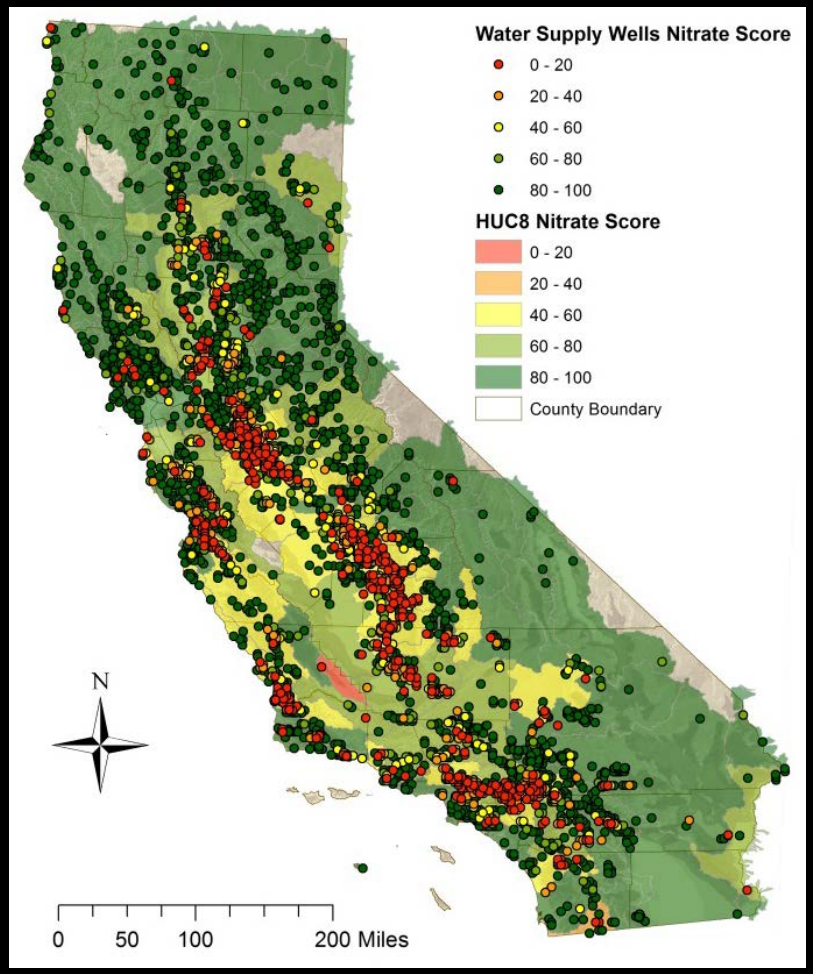
Sustainability Indicators: SAWPA

Indicator Name	SAWPA OWOW 2.0 Sustainability Goal
Proportion of Water Use from Imported and Recycled Sources	1
Water Use (per capita)	1
Local Water Supply Reserves	1
Adoption of Sustainable Water Rates	1
Water Availability and Stress (WRI Aqueduct 2.0)	1
Annual Water Resource Energy Use Relative to Rolling Average	1
Stream Network with Natural Substrate Benthos	2
Impervious Surface: Water Quality Index and Geomorphic Condition	2,4
Coastal Impacts from Sea Level Rise	3,5
Aquatic Habitat Fragmentation	2
Open Space for Recreation	3
Invasive Species and Native Landscapes	3
Area with Restoration Projects and Conservation Agreements	3
Exceedance of Water Quality Objectives in Watershed	4
Exceedance of Groundwater Salinity Standards	4
Exceedance of Water Quality Objectives at Discharge	4
Exceedance of Water Quality Objectives at Recreation Sites	4
Biological Condition Index	3,5
OWOW (Stakeholder-Community) Participation	5

Sample Findings: California

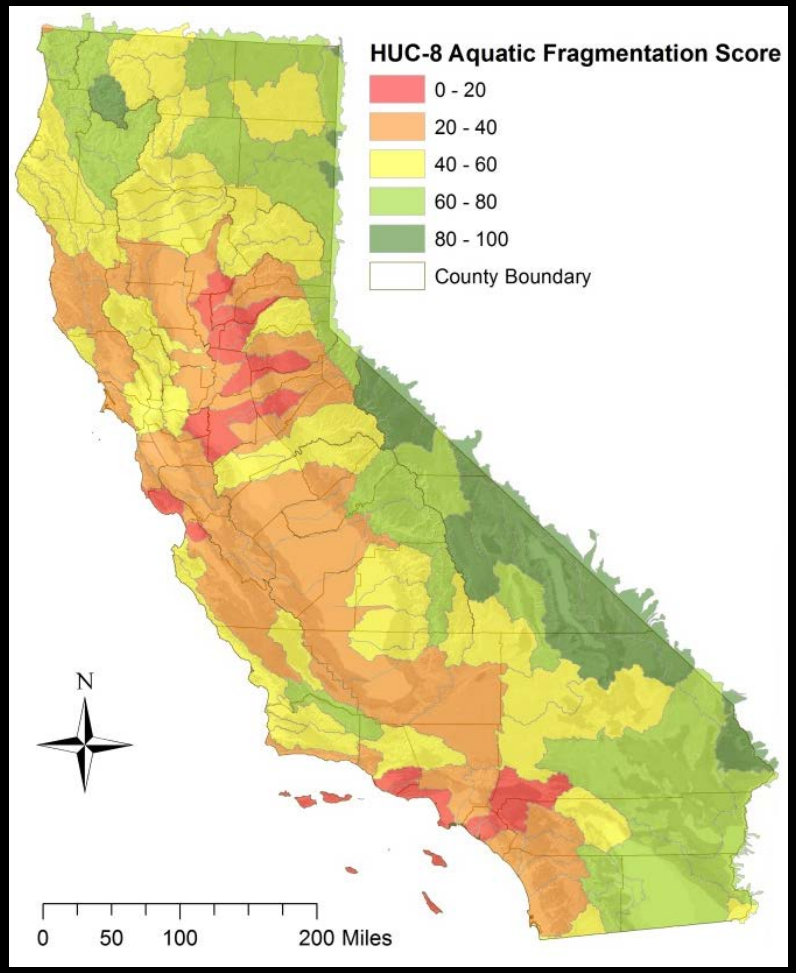


Water use by DWR planning area

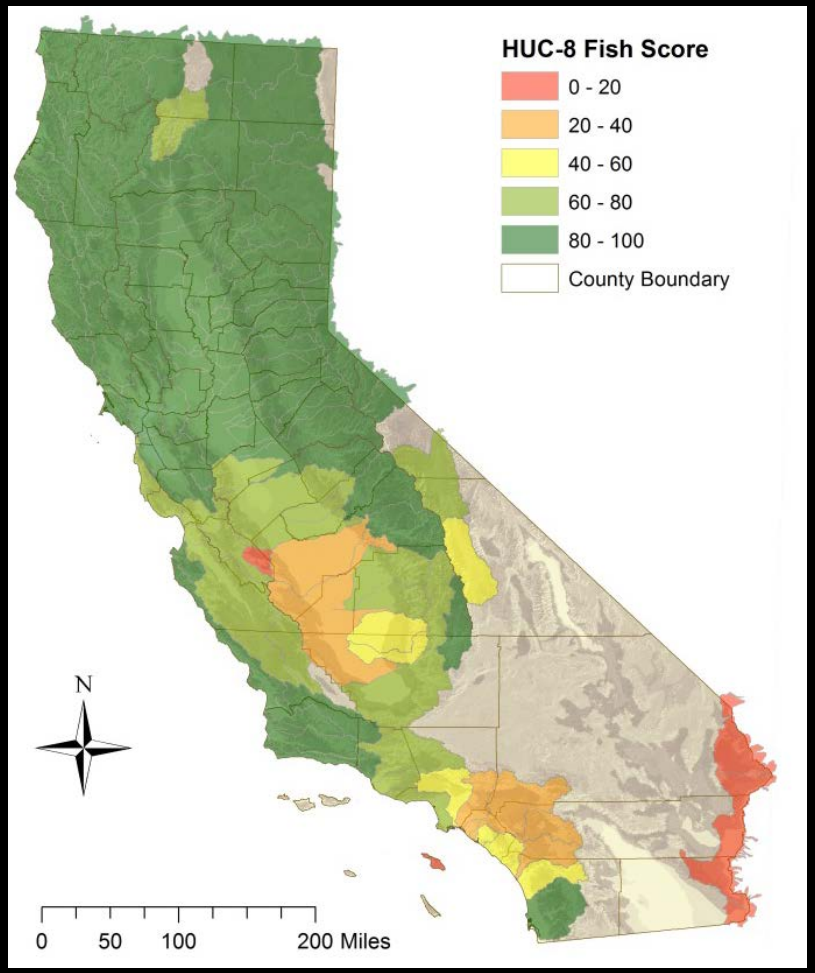


Water supply wells affected by nitrate contamination

Sample Findings: California

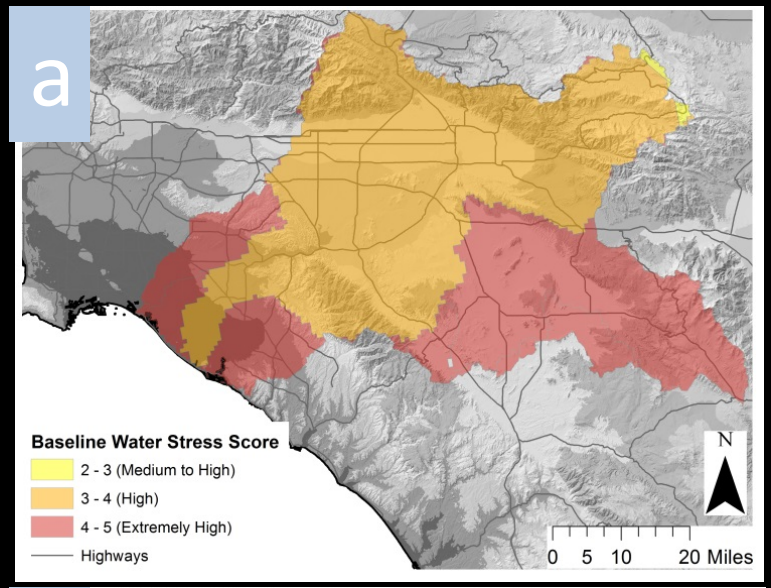


Aquatic fragmentation from road-stream crossings

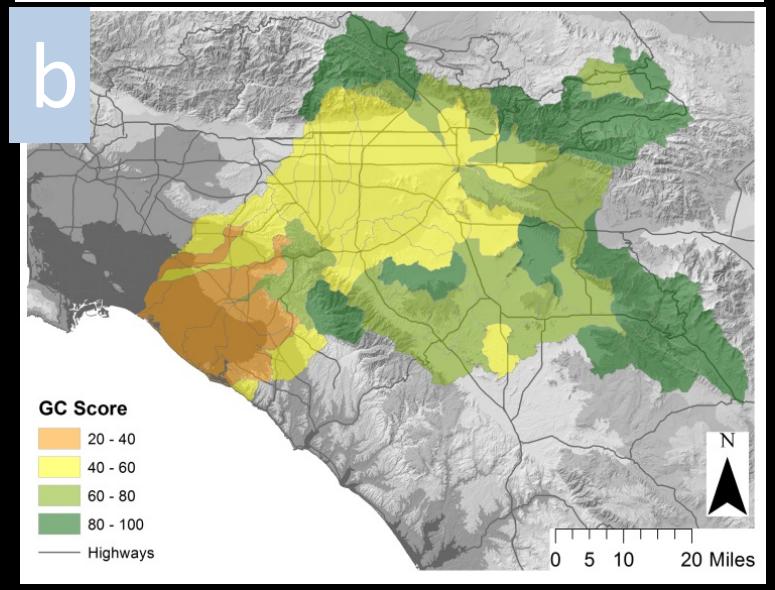


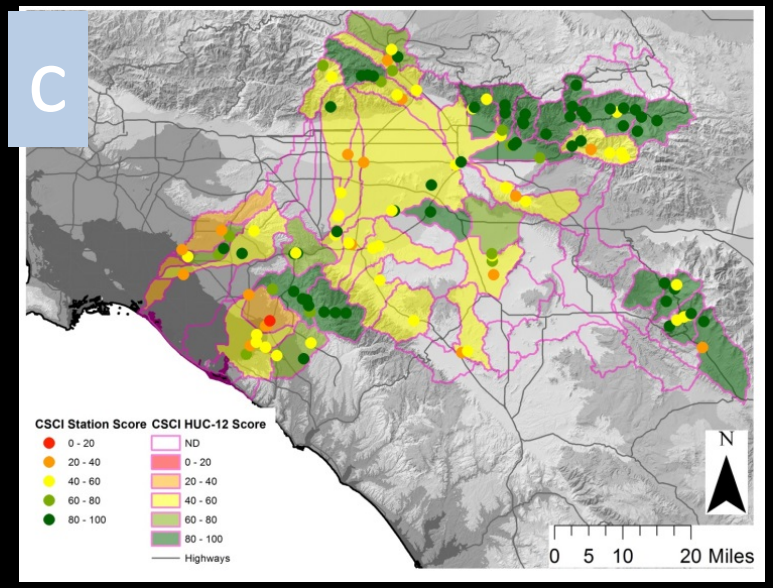
Current presence of native fish species relative to historic presence.

Sample Findings: SAWPA



Evaluation of (a) “baseline water stress”, (b) geomorphic condition (GC), and (c) California Stream Condition Index indicators at the SAWPA extent.



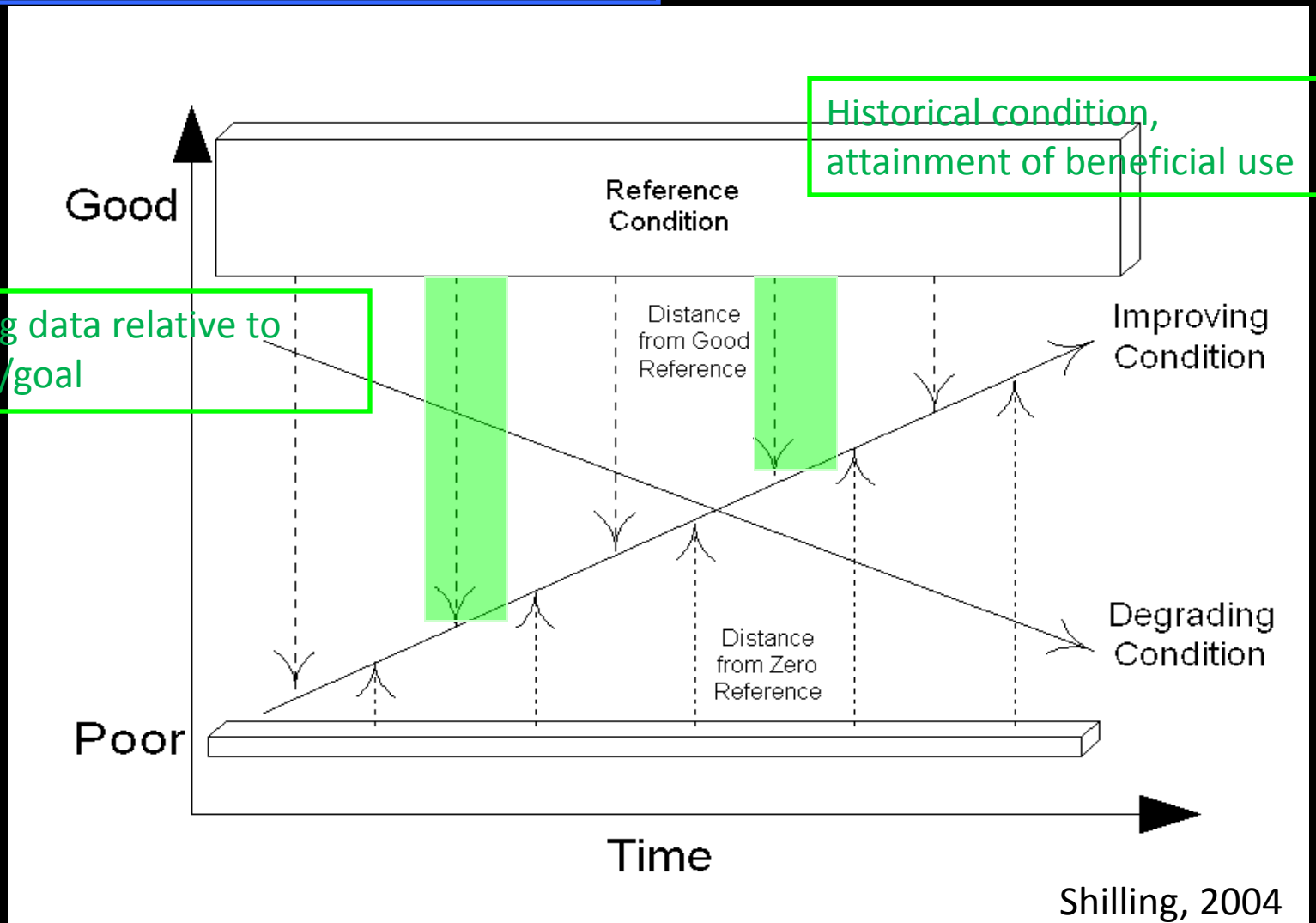


2. Measuring Performance

We are almost always measuring condition against some standard. It is unlikely that indicators would be as useful without this comparison. What approach allows inter-indicator and inter-regional comparison?

Some Issues & Examples

What is the condition and trend in condition?



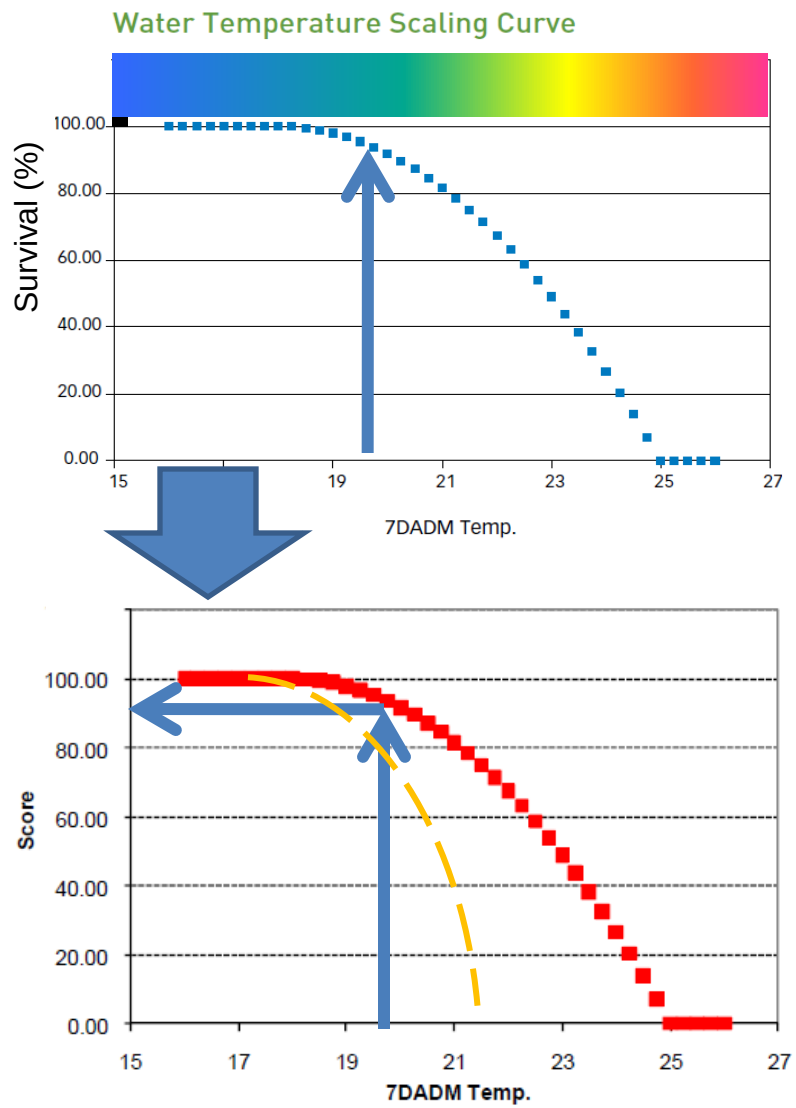
Shilling, 2004

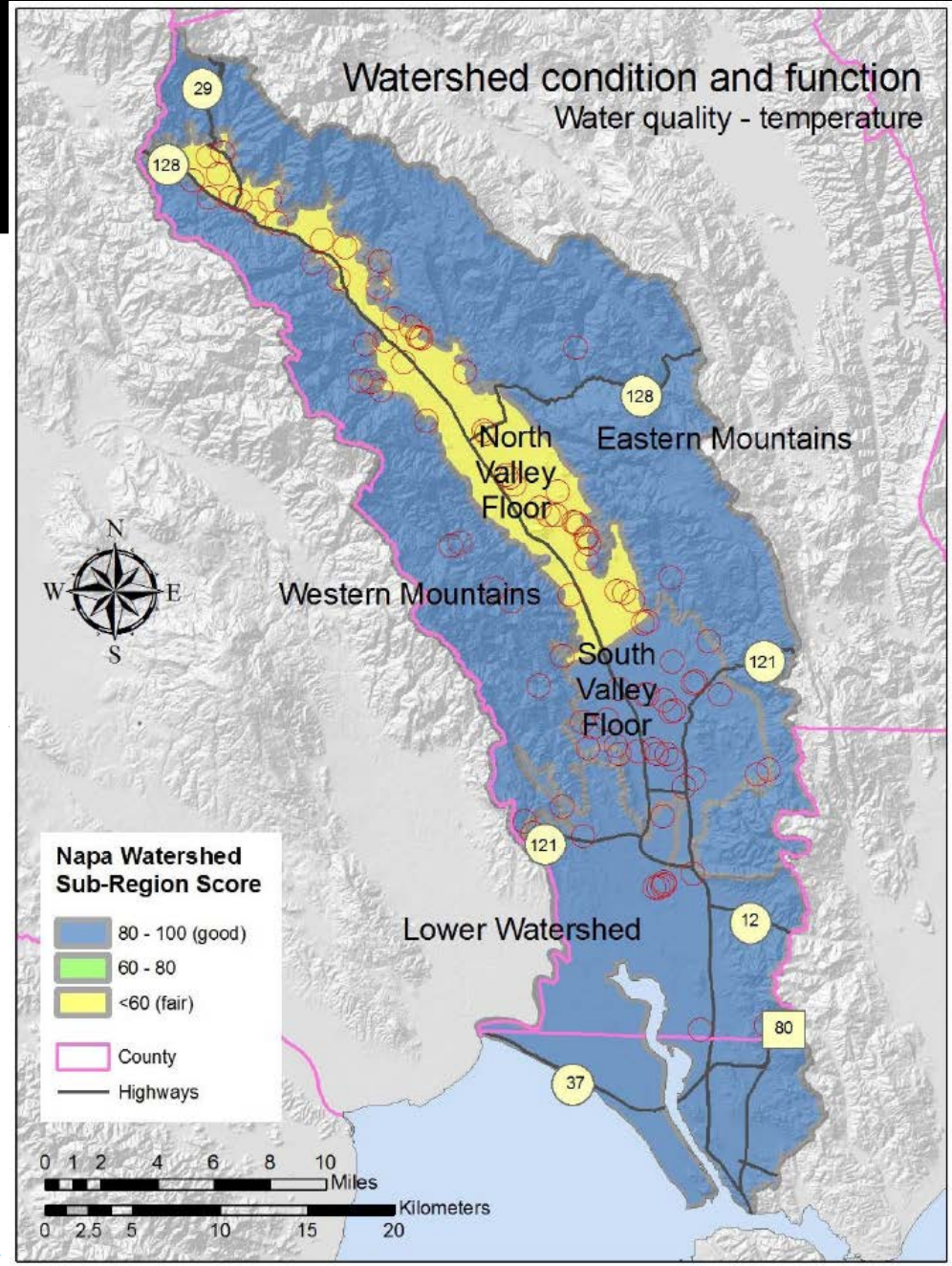
Transformation/re-scaling of indicators

- Ranking, empirical, axiological, mathematical, statistical

- Axiological normalization = relative distance between “good” and “bad” conditions (defined by user). This approach was termed the “distance to target” method in the California Water Plan, Update 2013

Re-scaling


Water Temperature Scaling Curve
Survival (%)
100.00
80.00
60.00
40.00
20.00
0.00
15
19
21
23
25
27
7DADM Temp.
Score
100.00
80.00
60.00
40.00
20.00
0.00
15
17
19
21
23
25
27
7DADM Temp.


Watershed condition and function
Water quality - temperature
29
128
128
North Valley Floor
Eastern Mountains
Western Mountains
South Valley Floor
121
121
12
80
37
Lower Watershed
N
W
E
S
Napa Watershed Sub-Region Score
80 - 100 (good)
60 - 80
<60 (fair)
County
Highways
0 1 2 4 6 8 10
Miles
0 2.5 5 10 15 20
Kilometers

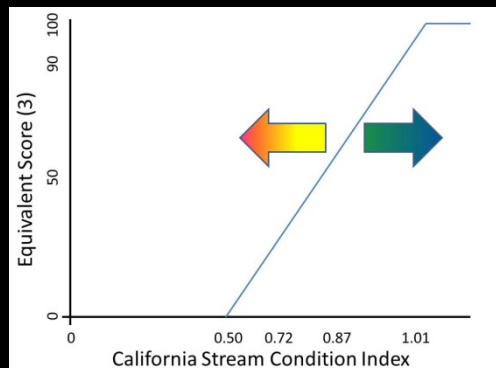
Re-scaling (CSCI)

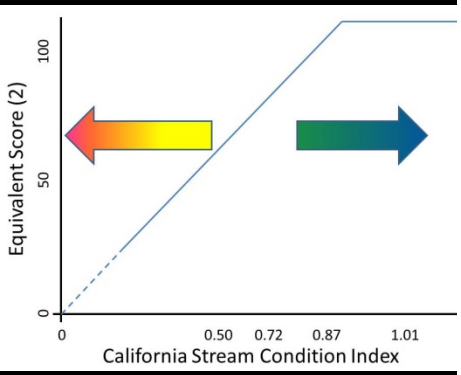
1.01 – mean reference

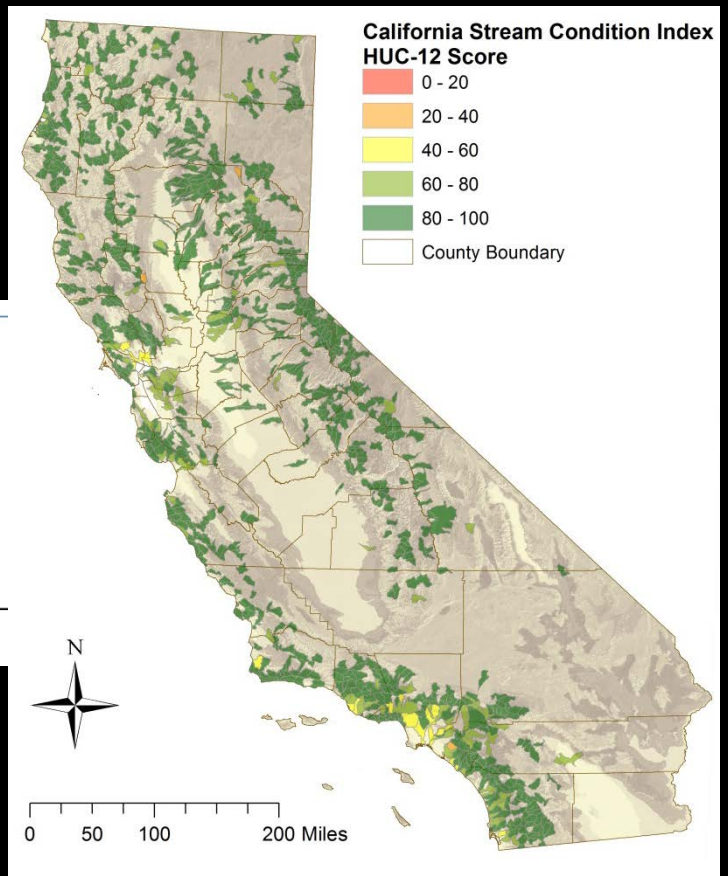
0.87 – low end reference

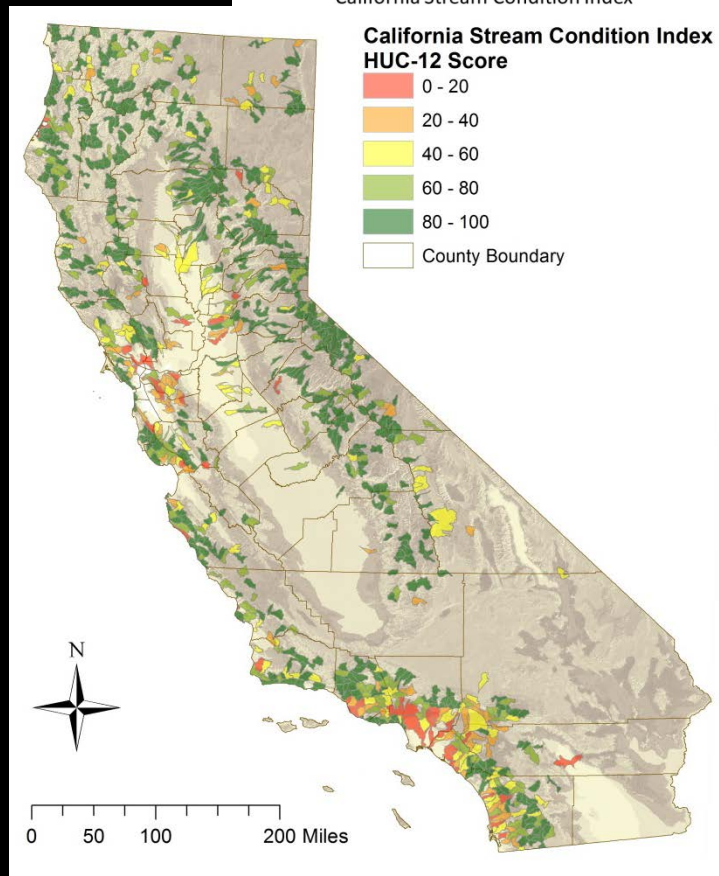
0.50 – stressed site mean minus variance

0 – theoretically worst condition









3. Averaging Indicator Scores: Score/HUC-12

$$I_{Avg} = (I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 + I_8 + I_9 + I_{10})/n$$

Alternatives include summing, choosing the lowest score/value, or non-equivalent weighted-averaging

Problem: Missing values affect final index score
Solution: Use average when most values present are the same across conditions/places; determine influence of individual indicators

Complications

Causation and co-varying indicator relationships

- (-) co-varying: temperature and dissolved oxygen
- (+) co-varying: low fish, low algae, low BMI (IBI)
- Causing or inhibiting: One system component may directly stop or cause change in another

Individual metrics or indicators may be more influential thatn others, or influence varies in time or space

Temporal resolutions and steps may be inconsistent among indicators

Spatial resolution and meaning varies among indicators

Indicators are usually imperfect reflections of process, patterns, and values

Contact

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