California Whole System Report Card

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Acknowledgments

Sacramento River Watershed Project:

UC Davis Crew, Carrie Monohan (Sierra Fund), Carol Murray, Darcy Pickard, Marc Porter, David Waetjen, & Katherine Wieckowski (ESSA Technologies Ltd.), Mary Lee Knecht (Sacramento River Watershed Project)

Napa River Watershed Project:

UC Davis Crew, Caitlin Cornwall & Deanne Dipietro (Sonoma Ecology Center), Frances Knapcyk & Bob Zlomke (Napa County RCD), Jeff Sharp (Napa County)

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Keir Keightley, Lisa Komoroske, David Waetjen

Definitions

- Indicators/Metrics – things we can measure around us that can tell us about components of a natural or human system
- Performance Measure – similar to indicators, except often confined to management actions and other intentional human actions
- Index – an aggregation of indicators that convey a story about a system

Assumptions

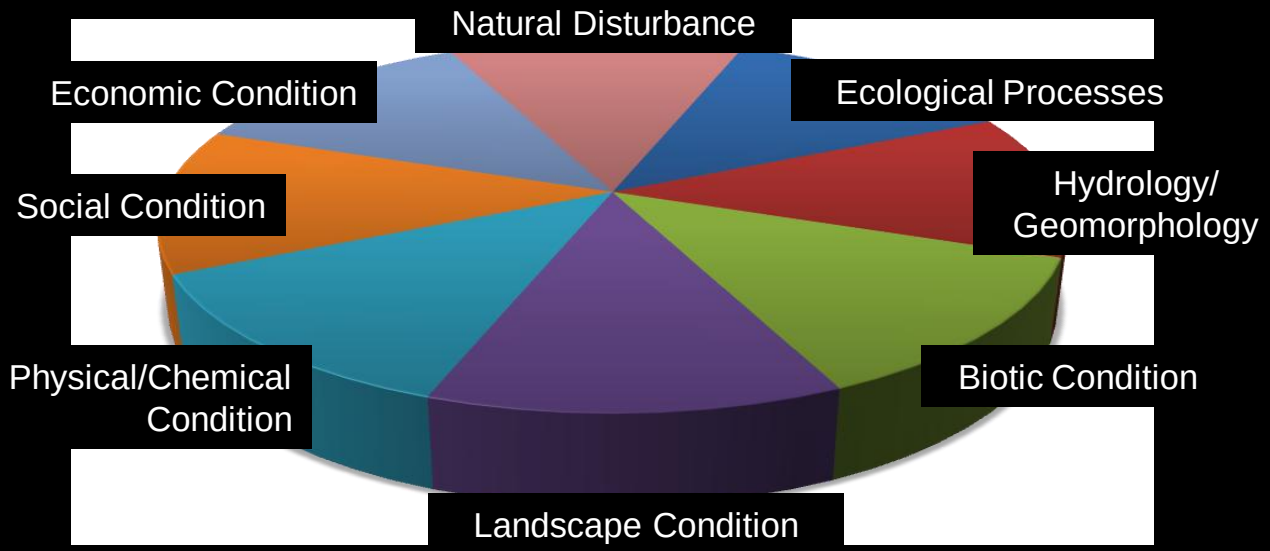
Reporting status and trends according to social goals

Science is the basis of report cards

Measuring system performance relative to targets

Indicator scores can be aggregated in multiple dimensions

Measuring aspects of the whole system



What is Needed

- Scaleable analysis and reporting system – from sub-watershed/municipality to nation
- Comprehensive way to organize information collected for multiple system attributes
- Reporting on conditions relative to standards and goals
- Step-wise process:
  - Goals for communities and ecosystems
  - Objectives/measurable outcomes
  - Corresponding indicators and measurable metrics
  - Evaluation of reporting area condition using indicators
  - Evaluation of goals using indicators
  - Reporting condition and success in reaching goals to public and decision-makers

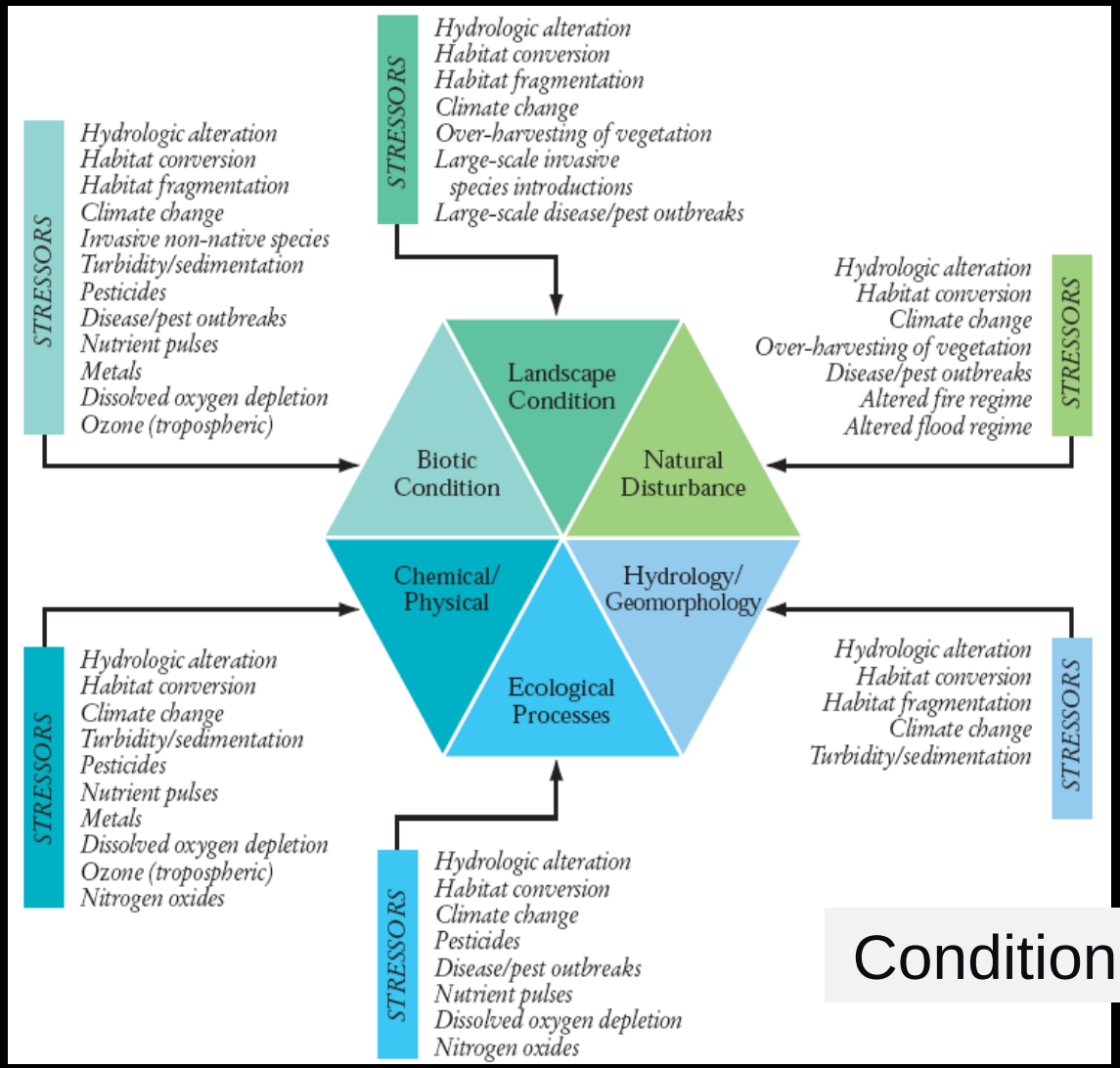
Developing the Report Card

California Whole System Report Card

One Option

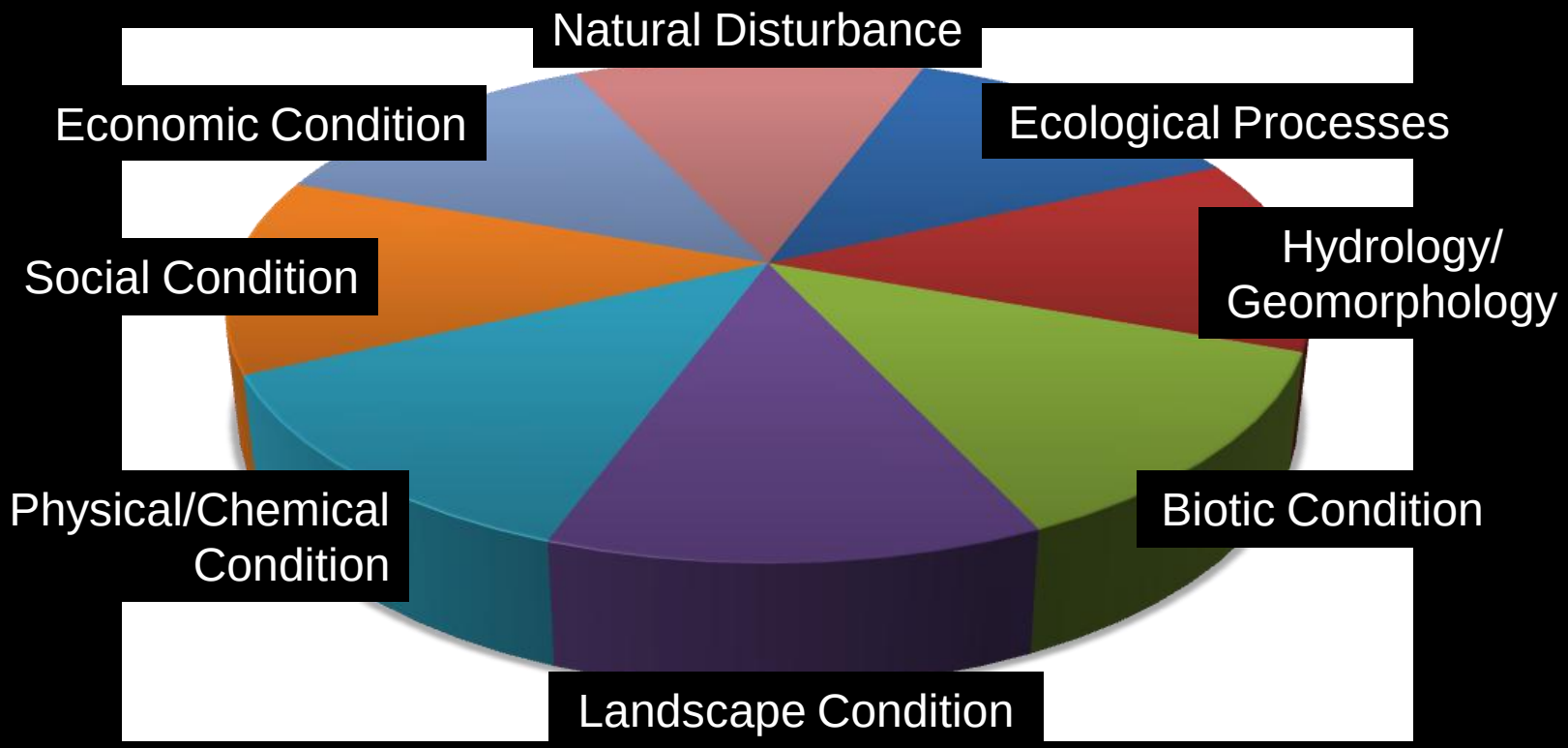
"SAB Framework"

USEPA-Science Advisory Board



Condition and stressor indicators

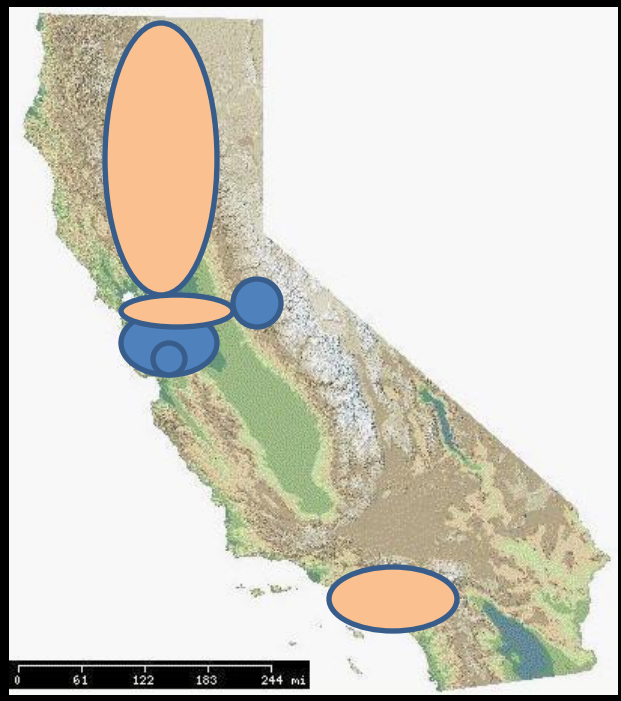
California Version: Watershed Assessment Framework (adopted by Governor)



SAB + Economic and Social Condition

Statewide WAF Program

- DWR-funded, $2.5 million
- 2007 – 2010/11
- 20 funded entities, each of the 6 projects with a regional technical advisory committee of ~10-20 organizations



Strength of WAF Approach

- Blessed by USEPA Science Advisory Board process
- Sound scientific underpinnings
- Scalable – local – regional – state – national
- Uses available information and aggregates information
- Uses ecological and social/economic attributes as the basis for reporting
- Simple Reporting - Consistent presentation and treatment of information

California Whole System Report Card

Outcome: Sub-region report card

Sacramento River Watershed – Feather

Goals	Measurable Objective	Condition	Trend	Confidence
Water quality and supply for natural and human communities	Water quality for aquatic health	50	↔	Medium-high
	Maintain natural stream flows	55	n/a	Medium
Protect and restore native animals and plants	Native birds	100	↔	Medium
	Native invertebrates	46	↔	High
	Native fish	49	↔	High
	Agricultural/urban development	90	n/a	Medium
Protect and enhance habitats, ecosystems, and watersheds	Protect aquatic connections	77	n/a	Medium-high
	Protect landscape connections	33	n/a	High
	Maintain natural production and nutrient cycles	82	↓	Medium
Maintain and restore natural disturbance	Restore natural fire regimes	9	↔	Medium
	Encourage natural flooding, while protecting people	50	n/a	Low
Improve social and economic conditions & benefits from healthy watersheds	Enhance wildlife-friendly agriculture	83	↑	Medium-high
	Improve community economic status	51	↓	High

California Whole System Report Card

Outcome: Sub-region report card

North Bay Region – Napa

Napa River Watershed Health Report Card

Each watershed subregion was evaluated for its condition relative to targets for each indicator. Scores close to 100 reflect excellent watershed health. The subregions are: WM - Western Mountains, LW - Lower Watershed, EM - Eastern Mountains, SVF - South Valley Floor, NVF - North Valley Floor. Trend was evaluated from a combination of trend assessments from each subregion. Confidence refers to quantitative and professional assessment of confidence in the result. ND indicates that the score or trend was not determined because data were not available or sufficient. Go to http://sfcommons.org/scorecards/waf/napa for more detailed information.

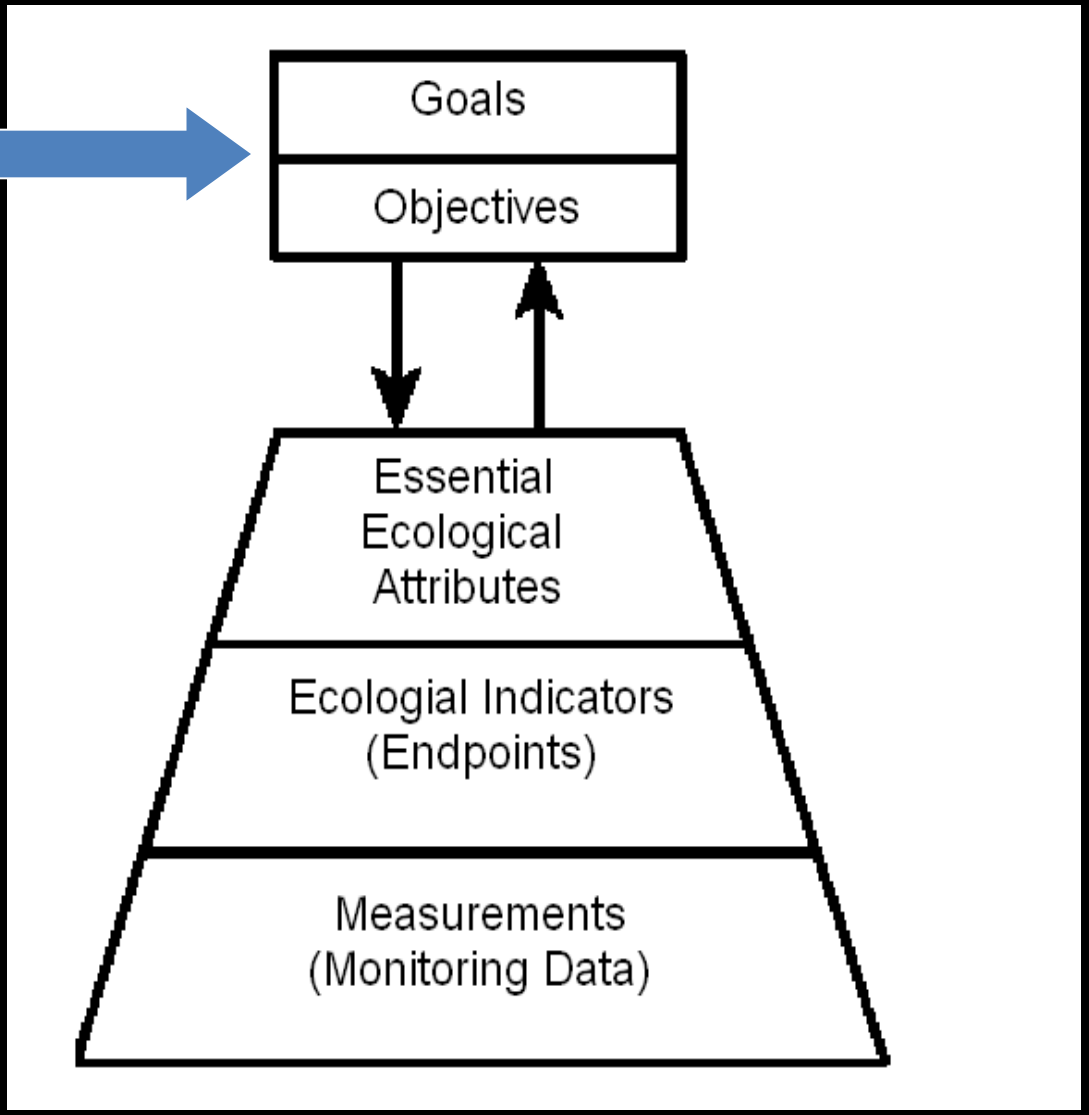
Goals	Indicators	Watershed Subregion Condition Score					Watershed Condition Score	Trend	Confidence for Subregion Scores
		WM	LW	EM	SVF	NVF			
Improve and protect geomorphic and hydrologic processes	Impervious area	ND	ND	ND	ND	ND	75	Declining	Moderate
Promote watershed awareness and stewardship through improved education, recreational access, and community involvement in decision-making	Local media coverage of watershed topics	ND	ND	ND	ND	ND	46	No trend	High
	Access to public open space	2	22	1	74	58	38	ND	Low - High
Conserve, protect and improve native plant, wildlife and fish habitats and their communities	Fish community	ND	37	ND	78	ND	ND[1]	ND	Moderate
	Habitat fragmentation and connectivity	77	34	100	29	51	67	ND	High
	Sensitive bird species	64	77	82	88	60	74	No trend	Low
	Aquatic insects	59	33	53	39	41	45	ND	Moderate - High
	Fire recurrence	84	80	42	99	48	65	ND	Moderate
Improve and sustain watershed conditions and functions that advance human and environmental economies, in particular water quality and quantity	Groundwater	Spring: Main Basin = 100, MST Basin = 29; Fall: Main Basin = 67, MST Basin = 7					ND[1]	ND	Moderate
	Water conservation	ND	ND	ND	39	ND	ND[1]	ND	High
	Stream temperature	100	81	ND	87	54	82	No trend	Moderate
Reduce greenhouse gas emissions and adaptively manage watershed resources to address climate change	Carbon storage and net primary productivity	98	100	97	93	94	97	No trend	Moderate
Support community planning and management actions that further the goal of a healthy, happy, and economically just community	School lunch program enrollment	ND	45	55	70	61	58	Declining	Low - High
	Housing affordability	66	60	66	57	40	58	Declining	Moderate - High

[1] No watershed score was calculated for Fish Community, Groundwater and Water Conservation as data for these indicators was available for only for a few select subregions of the watershed.

Process Overview

California Whole System Report Card

Step 1: describe goals & objectives

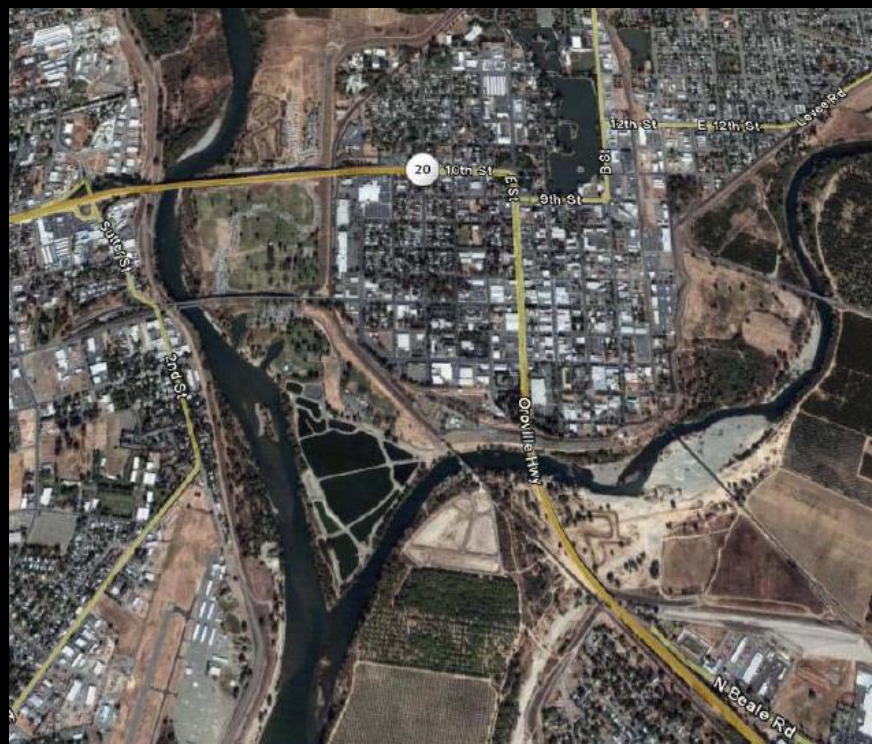


Sample

Goal & Objectives

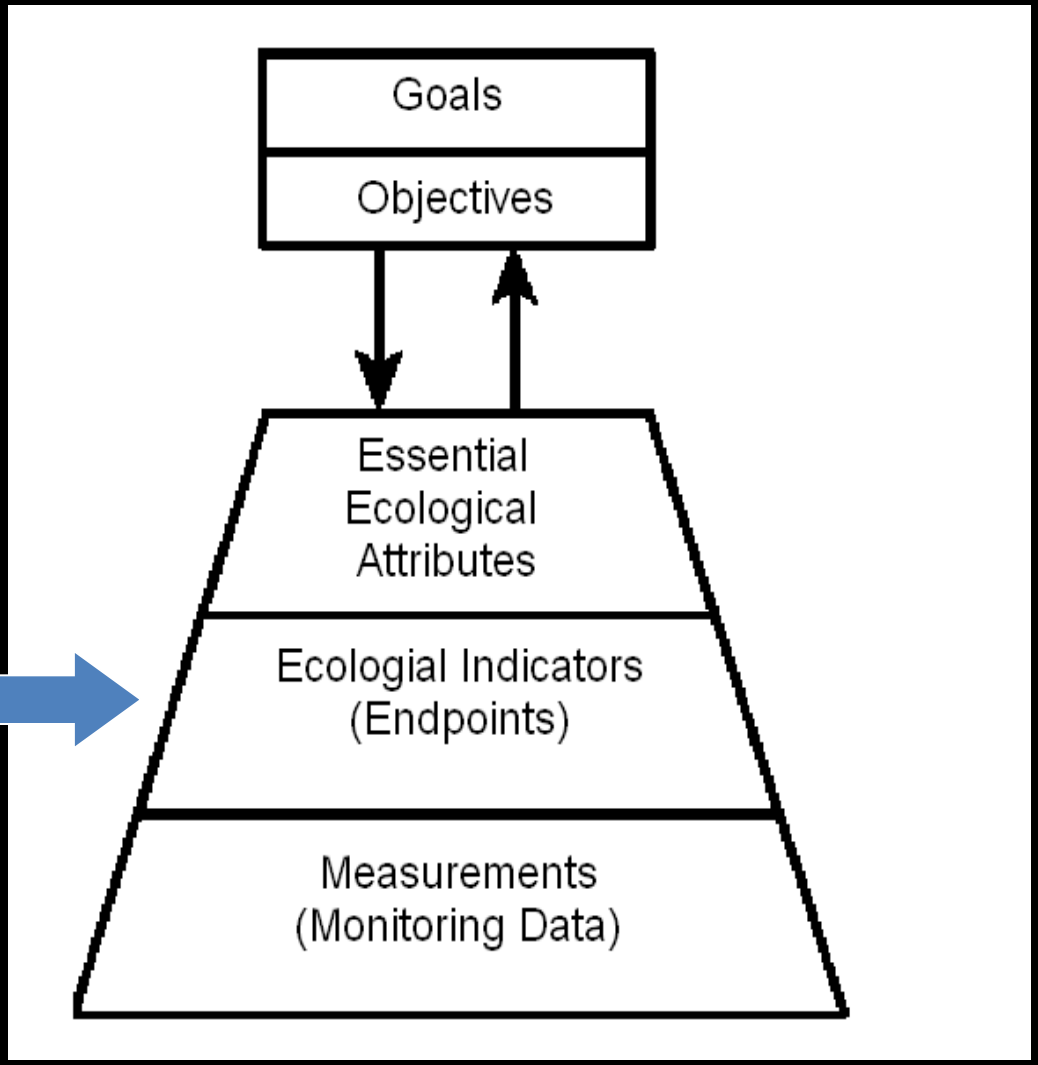
Improve aquatic habitat for salmonids & other native spp.

- maintain or reduce stream temperature
- improve stream cover & complexity
- maintain areas of clean gravel



Candidate Indicators

Step 2: list candidate indicators (track corresponding stressors)



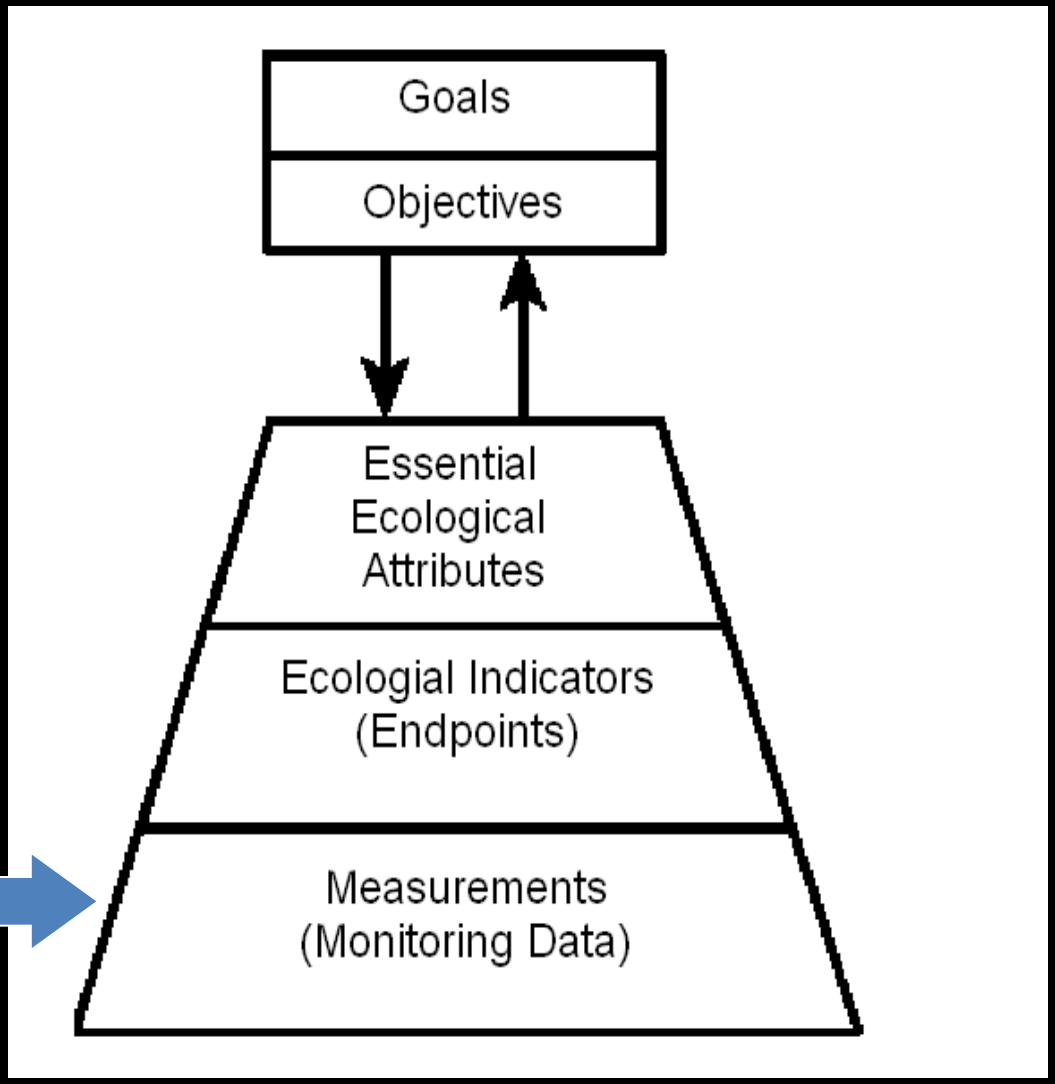
Sample Objectives & Indicators/Metrics

1) maintain or reduce stream temperature → Mean weekly average or max in-stream temp.

2) improve stream cover & complexity → % Riparian cover and diversity

3) maintain areas of clean gravel → Sediment grain-size

Metrics and Data



Step 3: list metrics and data sources

Step 4: Reporting on Condition/Performance

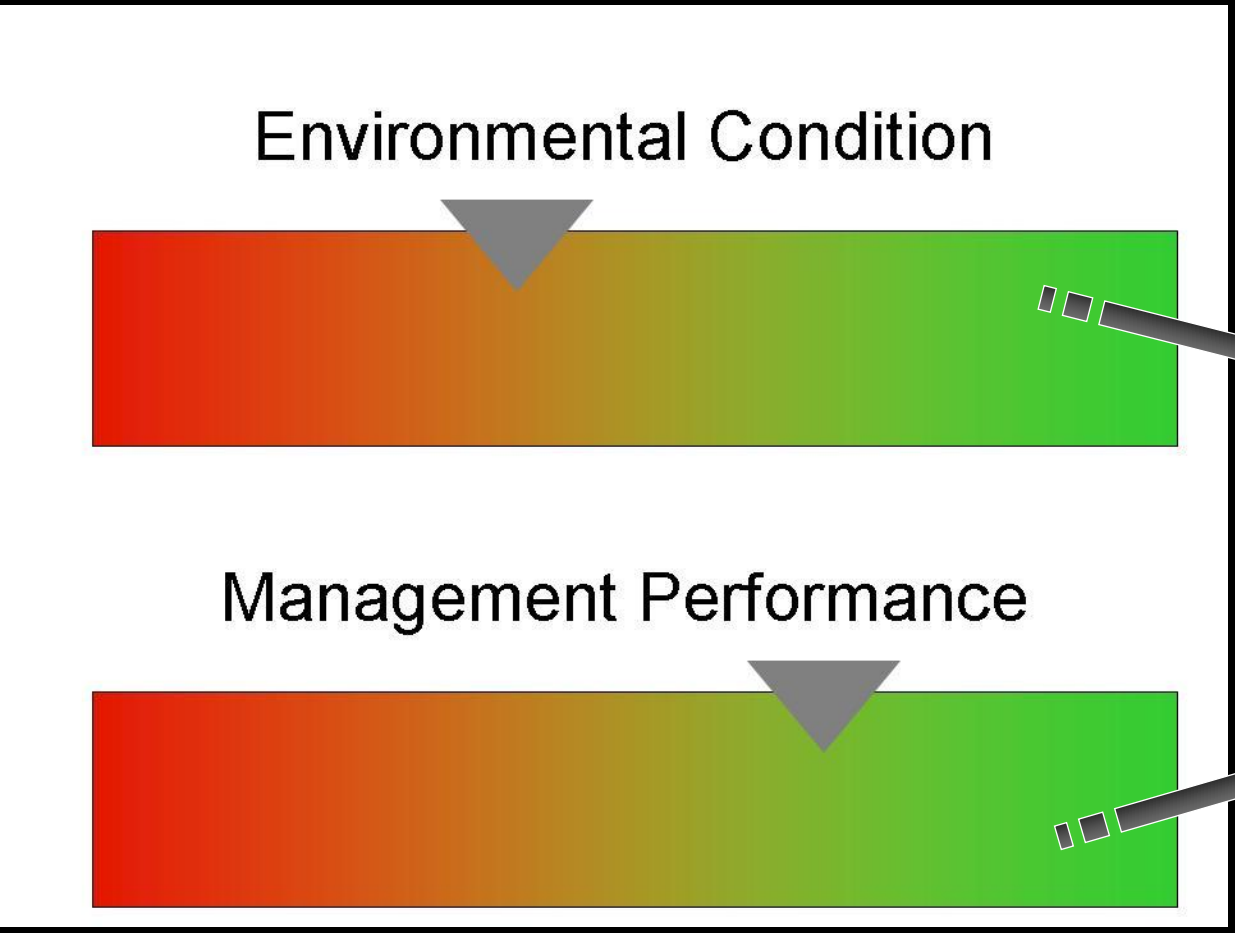
- This a critical component of indicator programs – reporting back to the public and decision-makers

- Reporting methods must be rigorously reflective of the underlying science, easy to understand, and straight-forward to act upon

Reporting

- What are effective ways to report condition?
- What scale to report (sub-watershed, watershed, county, region, state)
- What level of detail is needed?
- Who should report?

Sample Reporting Method 1: Graphic Symbols



Sample Reporting Method 2: Report Card

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(SRWP WAF project, 2010)

Sample Reporting Method 3: Narrative Reporting by Experts

The specter of severe and sustained drought beyond the magnitude of any drought experienced in the last 100 years could create a massive water and power crisis.

much less to be shared with the other states and Mexico. Should such a severe and sustained drought occur we could see one of the biggest water and power crises ever to confront the Southwest.

POLICY RECOMMENDATIONS

In light of the possibility of resource battles because of the low average flow of the Colorado, the potential for long term drought, and increasing regional populations, we make the following recommendations:

GRADES

For water conservation and other measures taken following recent California droughts and the 4.4 Plan in response to current demands for Colorado River water. **Grade B+**

For long-term planning for the double threats of rapidly increasing population and water demand and the potential for severe and sustained drought of greater magnitude than any experienced in the past 100 years. **Grade D**

Glen MacDonald is a Professor of Geography and of Ecology and Evolutionary Biology at UCLA. He is also the current Chair of the UCLA Geography Department. Following an undergraduate degree in Geography at UC Berkeley he pursued a M.Sc. in Geography at the University of Calgary and a Ph.D. in Botany at the University of Toronto. Before returning to California he taught for a number of years in Canada. His research focuses upon climatic variability over the past 10,000 years, the impacts of such

(UCLA Southern California Environment Score Card 2005)

Sample Reporting Method 4: Web/map-based scoring by sub-watershed

Southeast Queensland

Nexus with Management and Decision-Making

Category	Indicator	Metric	Score
Landscape Condition	Development	Impervious surface Fragmentation	65±13
Biotic Condition	Native fish	Out-migrants Habitat	43±22

Management Response: Improve/restore in-stream spawning and rearing habitat

Nexus with Management and Decision-Making

Category	Indicator	Metric	Score
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Management Response: Land-use decision-making under General Plan reduces land subdivision and overall paved surface

What does a regional report card implementation look like?

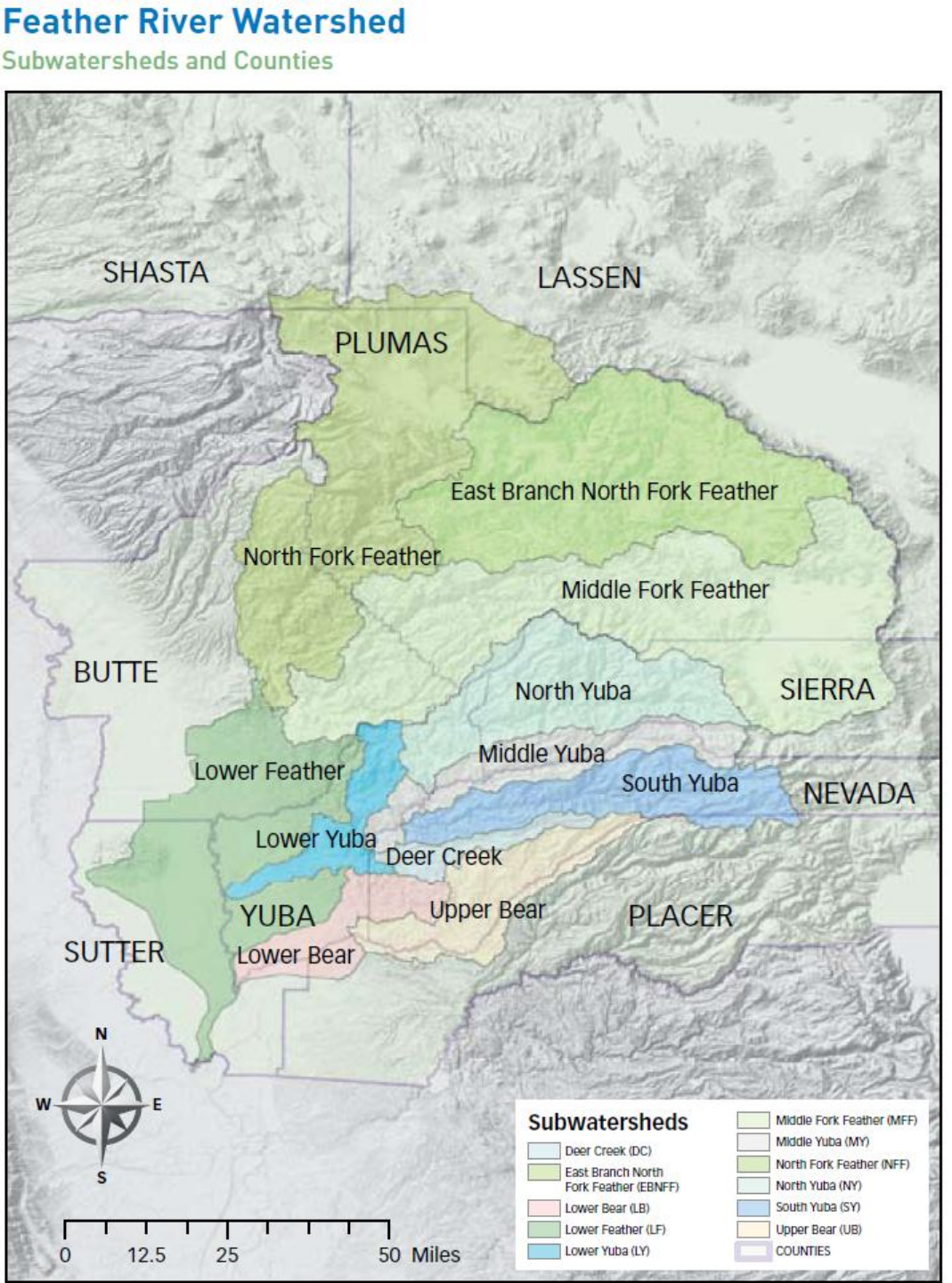
Representative Watershed -- Feather River Basin

- Mixture of land-uses: agriculture, urban, rural residential, logging, grazing, mining, wild areas
- Water management: combination of undammed and dammed reaches, water supply and hydro-power, use of ground-water
- Presence of wild and hatchery salmon
- Presence of active watershed groups and history of monitoring
- Mixture of private and public lands

Feather River Basin

6,543 sq. miles
20% of SRW
3% of California

11 sub-watersheds in the Upper and Lower Feather, Yuba & Bear watersheds



Goals and Objectives

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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 native bird populations
3) Protect and enhance native amphibian populations
4) Protect and enhance native mammal populations
5) Protect and enhance native invertebrate communities
6) Discourage and reduce invasive, non-native species, including impacts of feral species

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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 (native upland) habitat connectivity both within the watershed and into adjacent watersheds
5) Maintain and restore stream geomorphic processes
6) Protect and maintain natural variability and rates of primary production and nutrient cycling to support aquatic and terrestrial communities
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 to more natural levels; encourage natural fire regimes that support native communities
2) Reduce flood risk to human communities and encourage “wise” development (outside of floodplains); encourage natural flood processes that support native communities
3) Reduce greenhouse gas emissions and encourage activities to adapt to climate change

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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) Encourage efforts through wcich the watershed supports sustainable social practices
7) Support and improve human uses associated with watershed condition
8) Encourage and actively promote widespread community awareness and deep civic engagement in the protection and improvement of watersheds

Corresponding Indicators

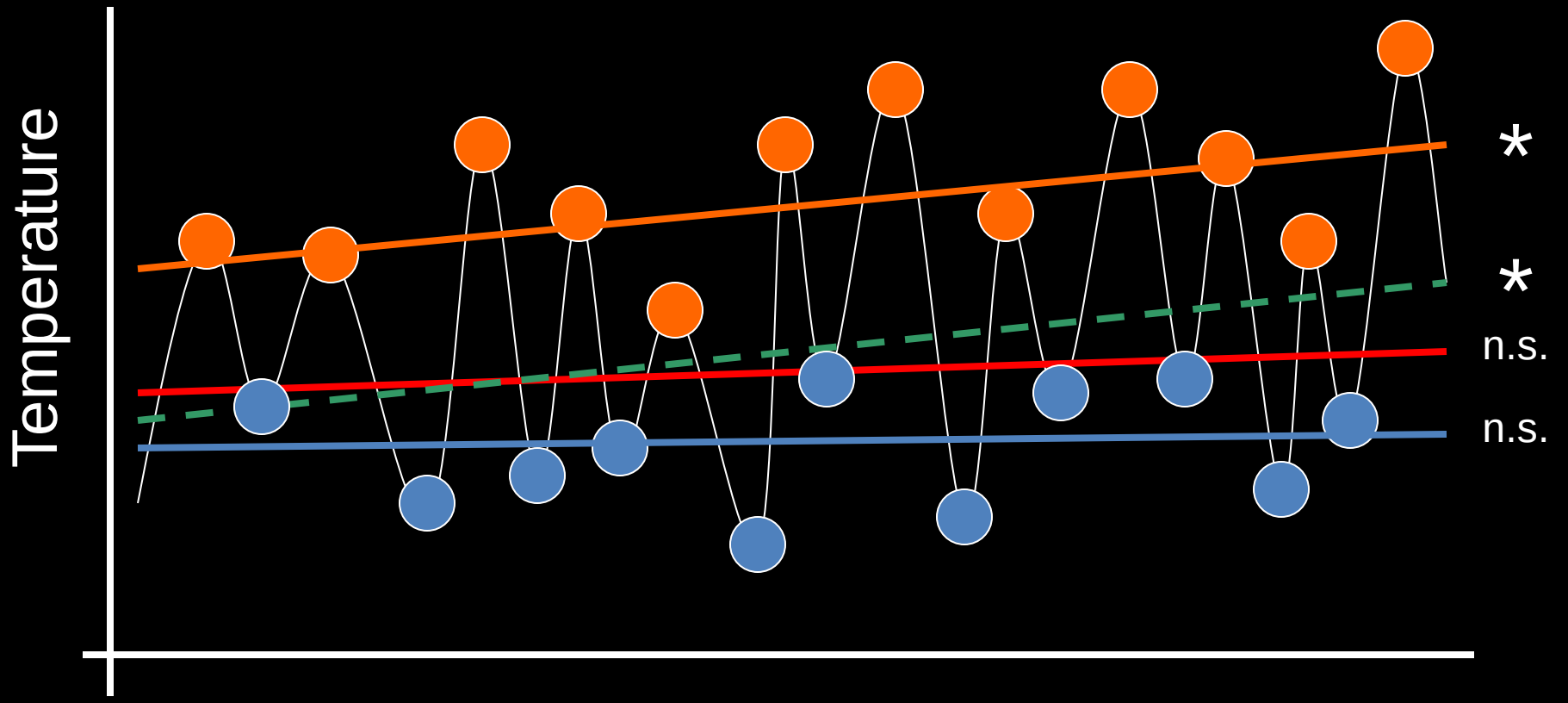
Goal	Objectives	Indicators
A. Maintain and improve water quality and supply to sustainably meet the needs of natural and human communities	1) Maintain water quality for healthy aquatic systems	i. Periphyton Cover and Biomass
		ii. Surface Water Temperature
		iii. Mercury in Fish Tissue
	2) Maintain and restore natural stream flows for aquatic and riparian communities	i. Flow Patterns and Alteration
B. Protect and enhance native aquatic and terrestrial species, especially sensitive and at-risk species and natural communities	1) Protect and enhance native bird populations	i. Bird Species Diversity
	2) Protect and enhance native aquatic invertebrate communities	i. Proportion of Watershed in Agricultural/urban Development
	3) Protect and enhance native fish populations	ii. Benthic Macroinvertebrates Community Structure
		iii. Fish Community Diversity
C. Protect and enhance landscape and habitats structure and processes to benefit ecosystem and watershed functions	1) Protect and enhance aquatic habitat connectivity	i. Aquatic Habitat Barriers
	2) Protect and enhance terrestrial (native upland) habitat connectivity	ii. Terrestrial Habitat Fragmentation
	3) Protect and maintain natural variability and rates of primary production and nutrient cycling	i. Carbon Stock and Sequestration
		ii. Nitrogen Load/Cycling
D. Maintain and restore natural disturbance processes that balance benefits for natural and human communities	1) Reduce high severity fire frequency to more natural levels; encourage natural fire regimes that support native communities	i. Fire Frequency
	2) Reduce flood risk to human communities and encourage natural flood processes that support native communities	i. Flooding and Floodplain Access
E. Maintain and improve the social and economic conditions, including benefits from healthy watersheds	1) Protect and enhance wildlife friendly agricultural practices	i. Pesticide Application and Organic Agriculture
	2) Improve community economic status in balance with watershed condition	i. School Lunch Program Enrollment

Analytical Challenges

Amount and availability of data (e.g., ~500,000 temperature values at 162 sites)
Trends analysis
Distance to target
Non-linear response curves

Typical Challenges

Statistical Analysis Over Time

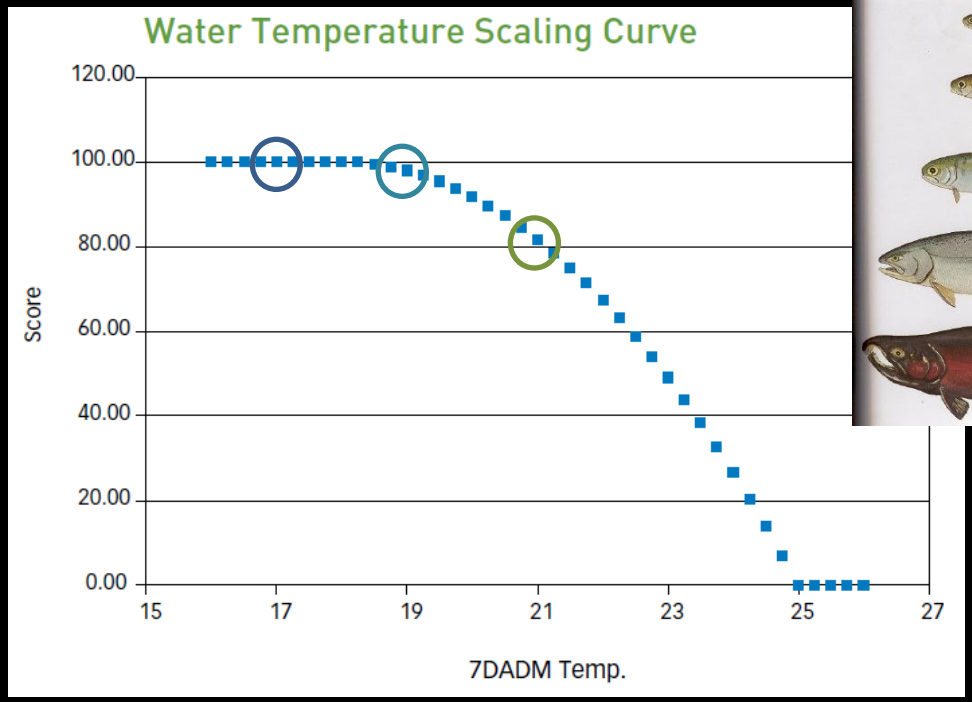


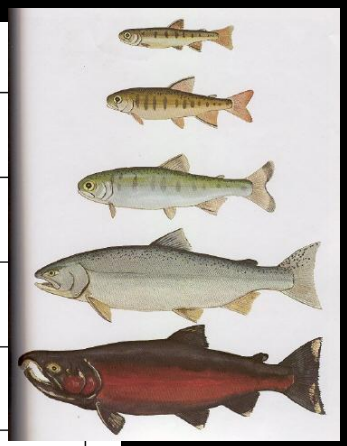
Mann-Kendall, Seasonal Kendall, Regional Kendal. Sen slope estimation– custom applications in “R”

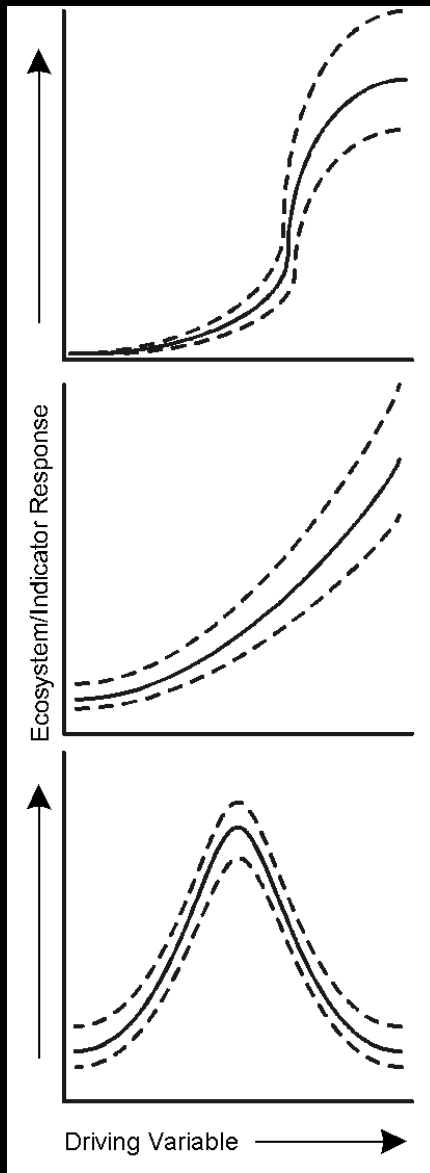
Challenges

Comparison Analysis and Aggregation

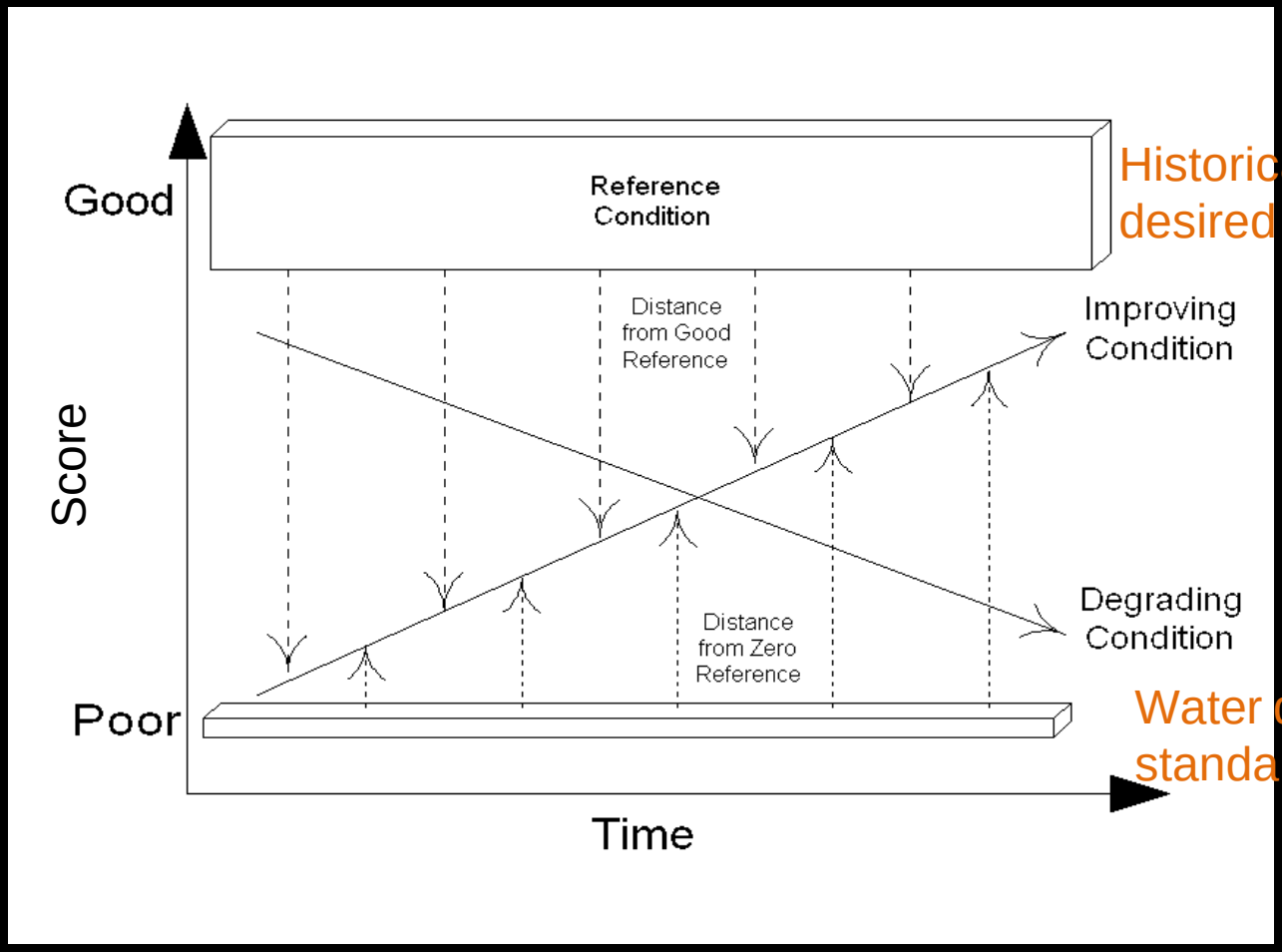
- Different indicators have different response patterns, resulting in different scaling curves for scoring







Distance to target (allows aggregation)



Historical or desired condition

Water quality standard

Integrating the Parts?

Aggregation into Index

- Goal or purpose?
- Conceptual Model-Based
- Scale of analysis (geographic, temporal, topical)
- Standard/reference for comparison of each indicator
- Re-scaled values (distance to target)
- Test and Confirm

Aggregation into Index

No single method, several to choose from. Three WAF projects used mean of re-scaled values, where scale is comparison to standard.

Table 2 – Methods for calculating composite indicators (CIs) (OECD, 2002a,b)

Method	Equation
1. Sum of country rankings	$CI_c^t = \sum_{i=1}^{N} Rank_{ic}^t$
2. Number of indicators above the mean minus the number below the mean	$CI_c^t = \sum_{i=1}^{N} \mathrm{sgn}\left[\frac{x_{ic}^t}{x_{EUi}^t} - (1+p)\right]$
3. Ratio or percentage differences from the mean	$CI_c^t = \frac{\sum_{i=1}^{N} w_i y_{ic}^t}{\sum_{i=1}^{N} w_i}$, $\mathrm{wherey}_{ic}^t = \frac{x_{ic}^t}{x_{EUi}^t}$
4. Percentage of annual differences over consecutive years	$CI_c^t = \frac{\sum_{i=1}^{N} w_i y_{ic}^t}{\sum_{i=1}^{N} w_i}$, $\mathrm{wherey}_{ic}^t = \frac{x_{ic}^t - x_{EUt}^t}{x_{ic}^t}$
5. Standardized values	$CI_c^t = \frac{\sum_{i=1}^{N} w_i y_{ic}^t}{\sum_{i=1}^{N} w_i}$, $\mathrm{wherey}_{ic}^t = \frac{x_{ic}^t - x_{EUt}^t}{\sigma_{EUi}^t}$
6. Re-scaled values	$CI_c^t = \frac{\sum_{i=1}^{N} w_i y_{ic}^t}{\sum_{i=1}^{N} w_i}$, $\mathrm{wherey}_{ic}^t = \frac{x_{ic}^t - \min(x_i^t)}{\mathrm{range}(x_i^t)}$

Note: x_{ic}^t is the value of indicator i for country c at time t. w_i is the weight given to indicator i in the composite index. In Method 2, p = an arbitrarily chosen threshold above and below the mean.

Singh et al., 2008

Whole system reporting – determine conditions within each sub-region

Table E.1 — How well are we meeting goals and objectives for the Feather River watershed?

Goals	Measurable Objective	Condition	Trend	Confidence
Water quality and supply for natural and human communities	Water quality for aquatic health	51	↔	Medium-high
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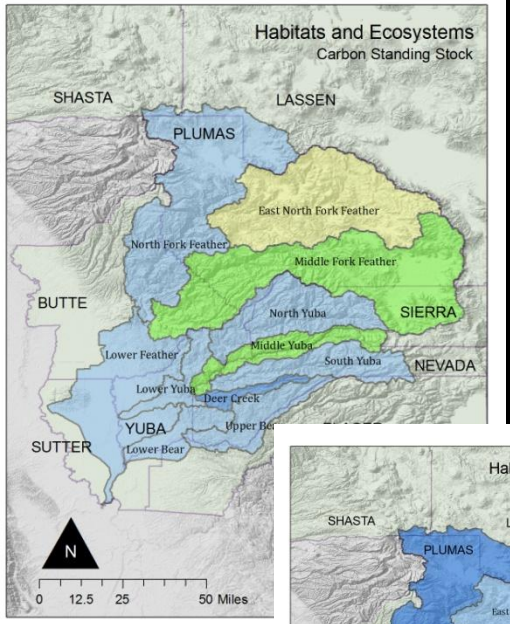

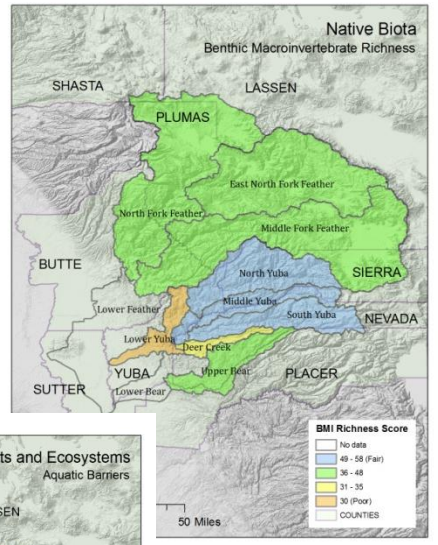

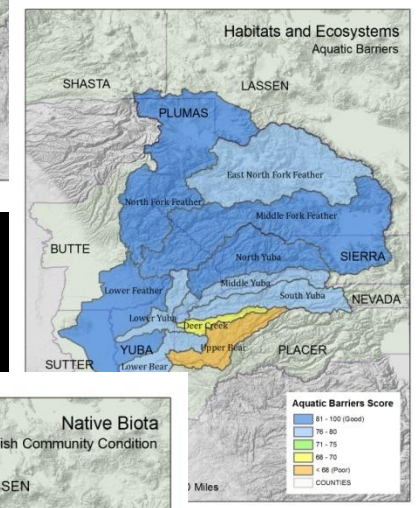

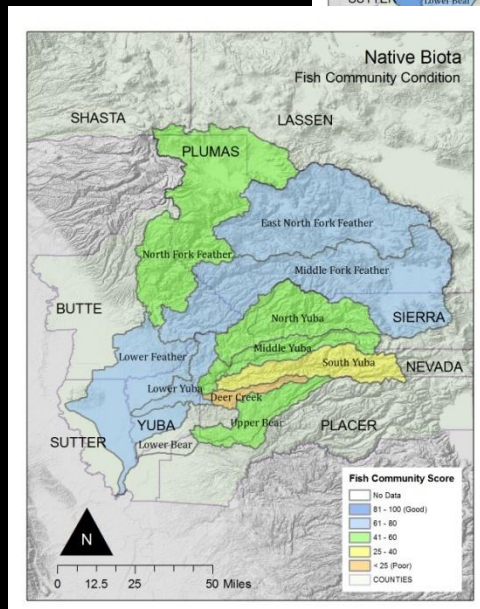

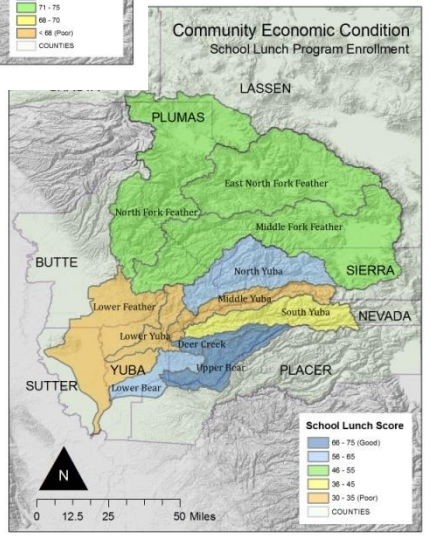

Whole system reporting – determine conditions for each goal & objective

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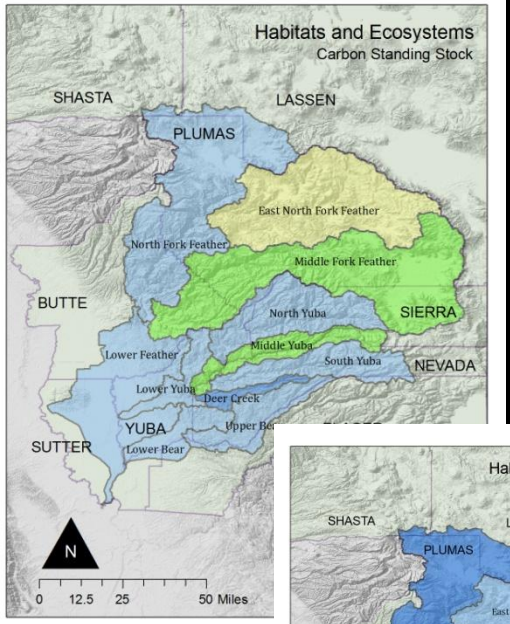
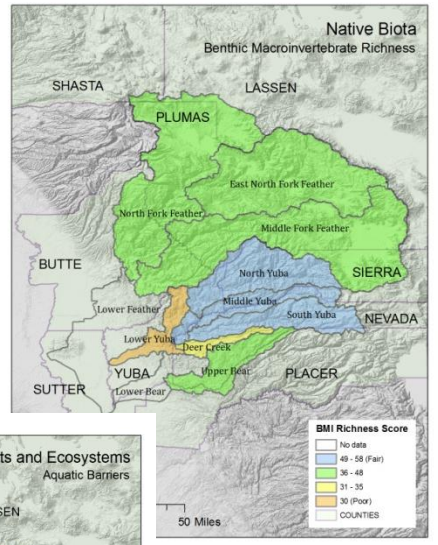
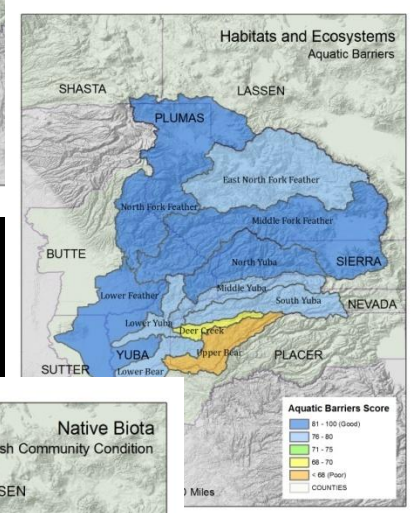
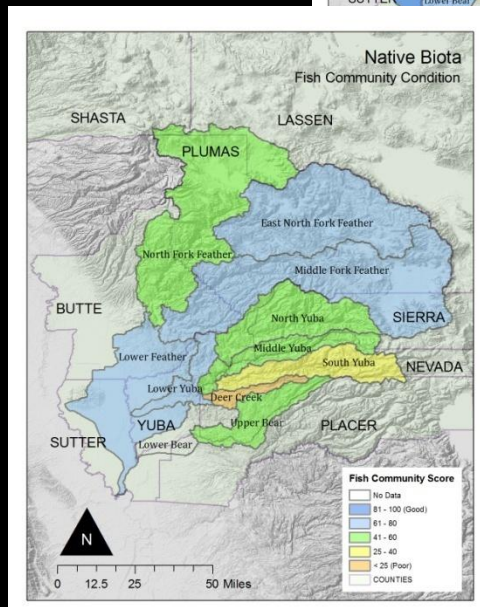
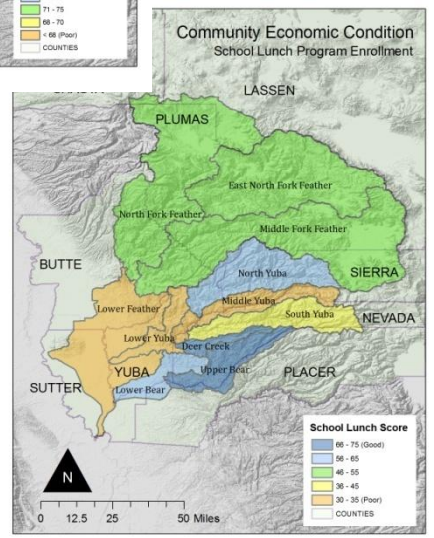
	Improve community economic status	51	↓	High







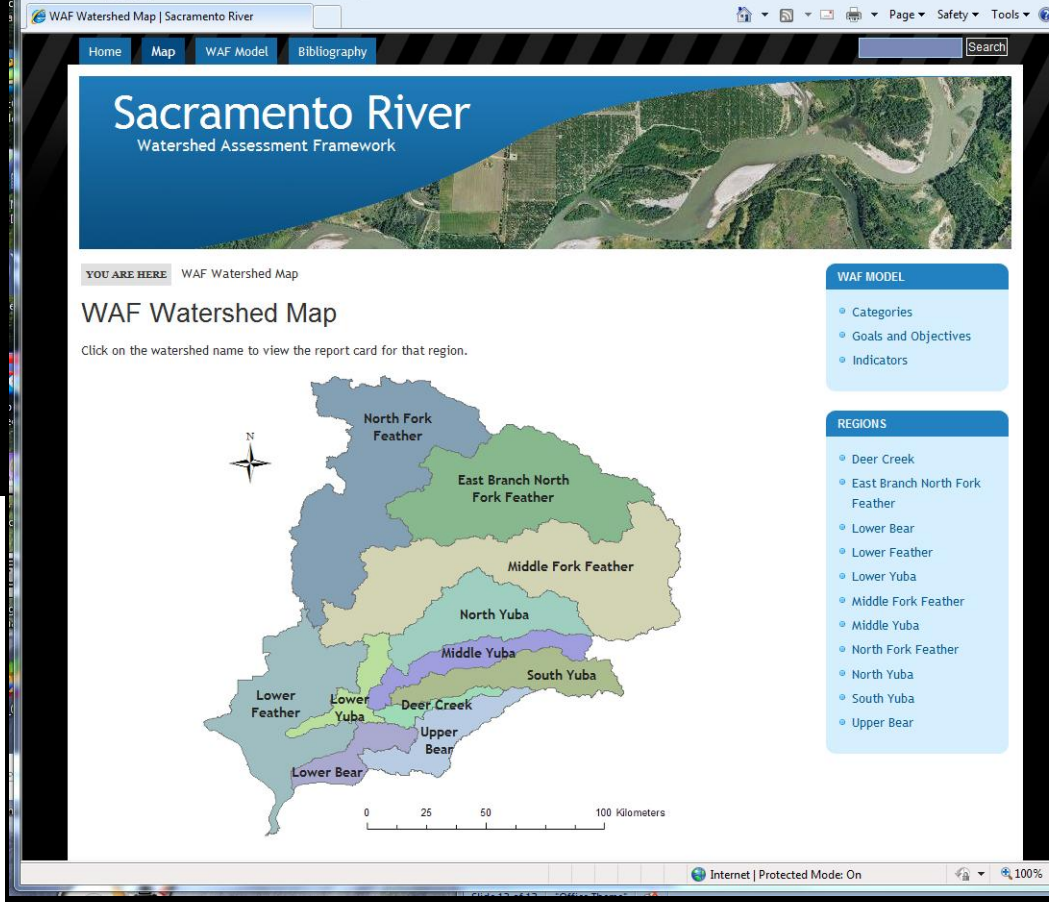




Report Card

Table E.1 — How well are we meeting goals and objectives for the Feather River watershed?

Goals	Measurable Objective	Condition	Trend	Confidence
Water quality and supply for natural and human communities	Water quality for aquatic health	51	↔	Medium-high
	Maintain natural stream flows	55	n/a	Medium
Protect and restore native animals and plants	Native birds	100	↔	Medium
	Native invertebrates	46	↔	High
	Native fish	49	↔	High
	Agricultural/urban development	90	n/a	Medium
Protect and enhance habitats, ecosystems, and watersheds	Protect aquatic connections	77	n/a	Medium-high
	Protect landscape connections	33	n/a	High
	Maintain natural production and nutrient cycles	82	↓	Medium
Maintain and restore natural disturbance	Restore natural fire regimes	9	↔	Medium
	Encourage natural flooding, while protecting people	50	n/a	Low
Improve social and economic conditions & benefits from healthy watersheds	Enhance wildlife-friendly agriculture	83	↑	Medium-high
	Improve community economic status	51	↓	High



http://ice.ucdavis.edu/waf/

Trend Analysis

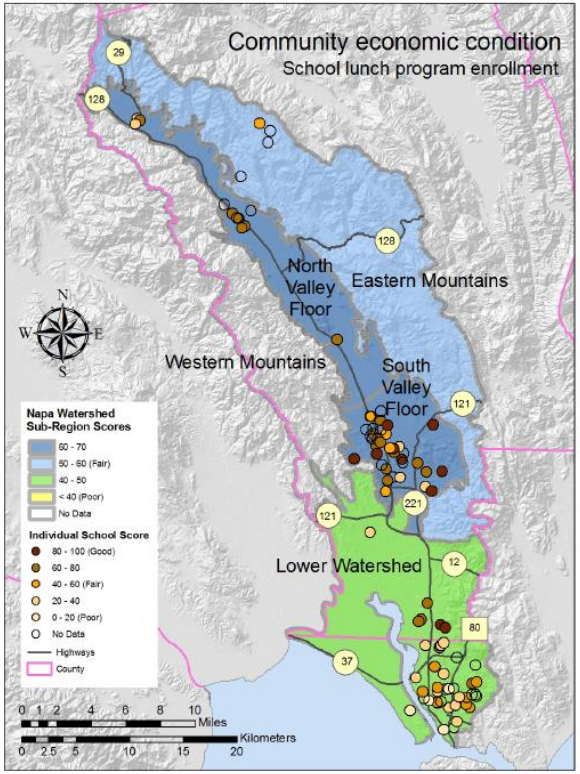
There was a statistically significant upward trend in school lunch program enrollment over the 22-year period ($p < 0.001$), with a 1.0% increase per year. This significant increase in enrollment was true of both Napa County and Solano County schools. In Napa, the increase in enrollment was 0.6% per year and in Solano, 1.6% per year. **Forty-two of the watershed's 87 schools individually increased in enrollment ($p < 0.05$), with 41 showing no statistically-significant change, and 4 Napa County schools showing a decrease in enrollment.**

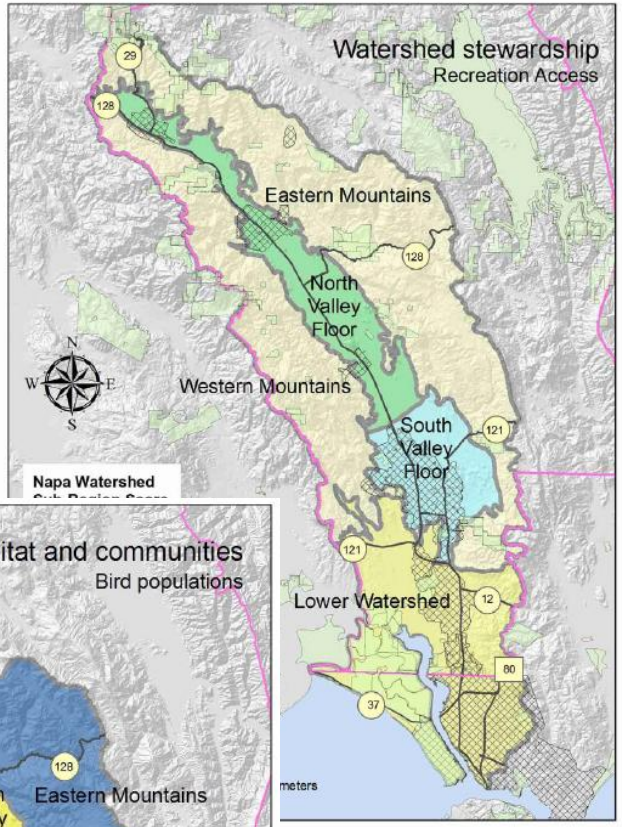
Can we Construct a Whole System Report Card Right Now?

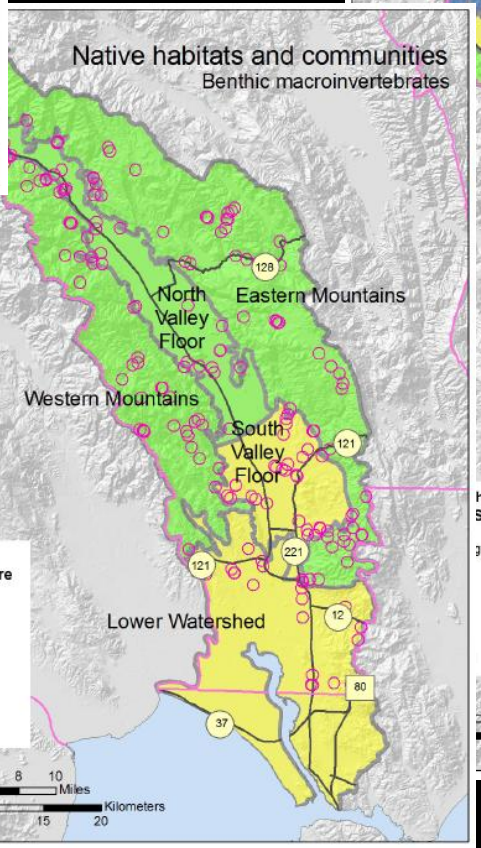
- For certain regions, yes!
- Should make goal/objective AND system attribute based
- Process and analytical steps are present
- Nested hierarchy for rolling up values geographically (sub-watershed to basin) and continuity across state

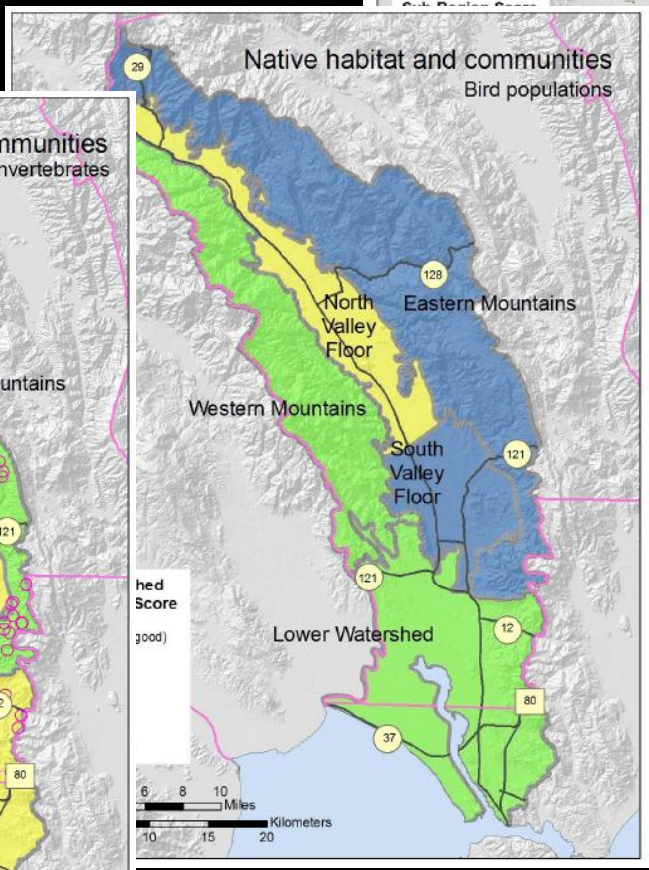
Contact

Fraser Shilling (fmshilling@ucdavis.edu)


Community economic condition
School lunch program enrollment
North Valley Floor
Eastern Mountains
Western Mountains
South Valley Floor
Lower Watershed
Napa Watershed Sub-Region Scores
60 - 70
50 - 60 (Fair)
40 - 50
< 40 (Poor)
No Data
Individual School Score
80 - 100 (Good)
60 - 80
40 - 60 (Fair)
20 - 40
0 - 20 (Poor)
No Data
Highways
County
Miles
Kilometers


Watershed stewardship
Recreation Access
Eastern Mountains
North Valley Floor
Western Mountains
South Valley Floor
Lower Watershed
Napa Watershed


Native habitats and communities
Benthic macroinvertebrates
North Valley Floor
Eastern Mountains
Western Mountains
South Valley Floor
Lower Watershed
Napa Watershed Sub-Region Score
60 - 80
40 - 60 (fair)
< 40
BMI Sites
County
Highways
Miles
Kilometers


Native habitat and communities
Bird populations
North Valley Floor
Eastern Mountains
Western Mountains
South Valley Floor
Lower Watershed
Miles
Kilometers