Development of Ecological Performance Measures for California Timberlands under AB 1492

Timberland in Siskiyou County; CDFW photo by Robin Fallscheer.

Launch of a New Regionalized Monitoring and Assessment Effort

January 15, 2019

CalEPA California Environmental Protection Agency

California Natural Resources Agency

Approximate Agenda

First Half

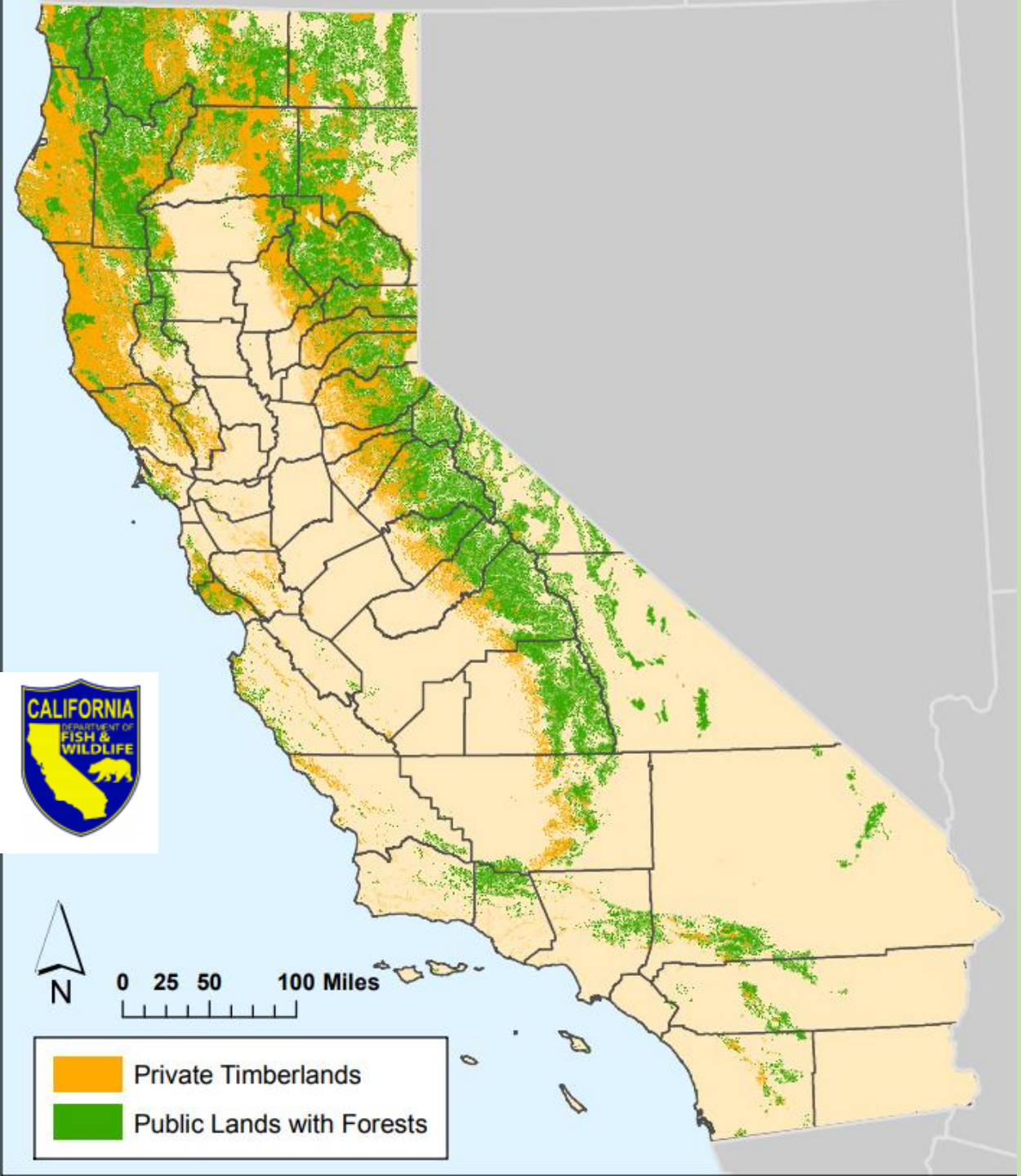
- Welcome/Objectives/Overview
- Background
- Definitions
- Presentation on Proposed Approach/Methods

~ 10:30 AM

- Break

Second Half

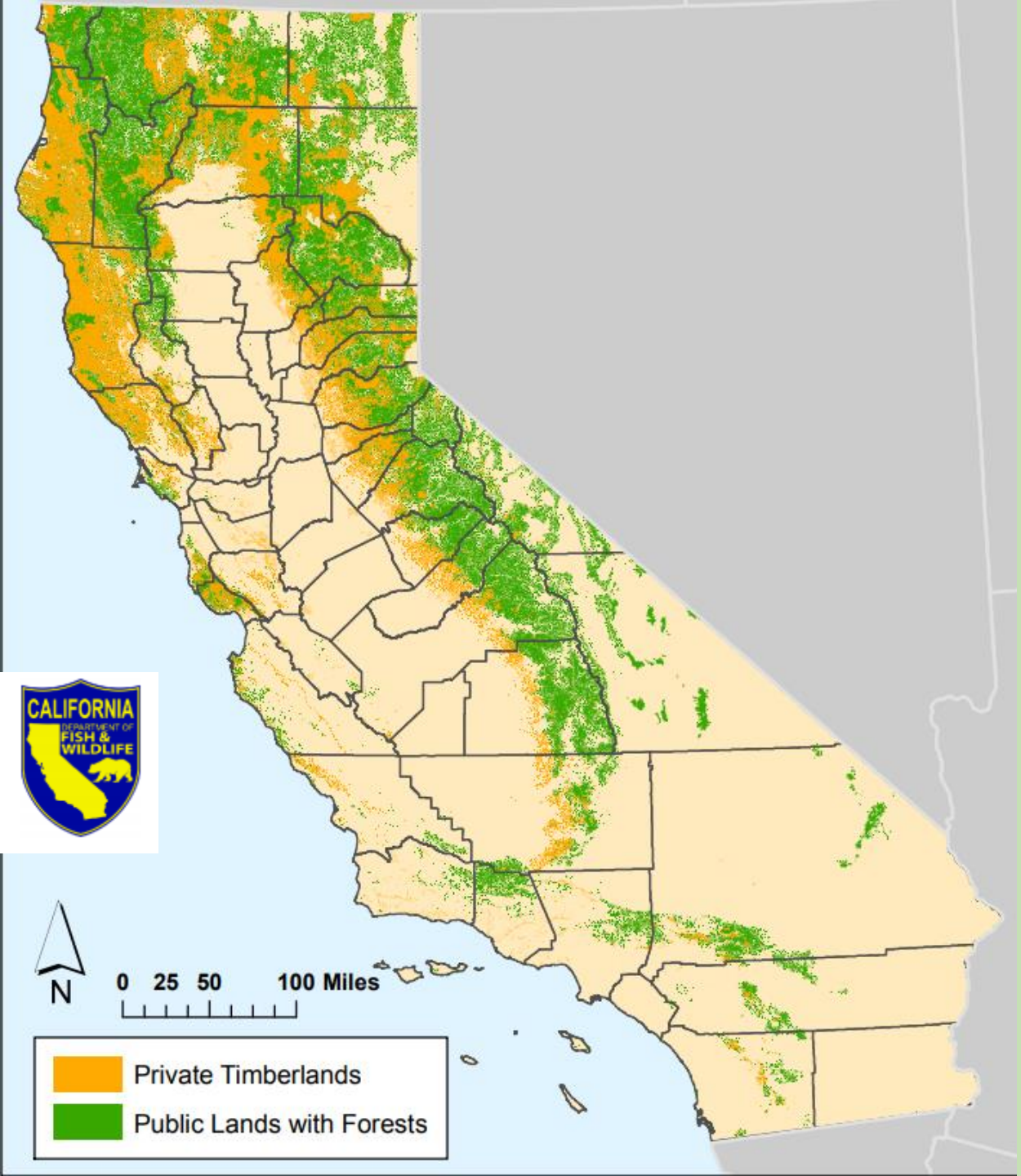
- Questions, Comments, Feedback with Working Group Panel
- Next Steps
- Opportunities to Engage



Focus on Timberlands

Forest is considered **timberland** if it is growing on ground capable of significant annual tree growth and considered available for timber management (FIA).

- Coniferous and mixed-coniferous forest ecosystems



Focus on Timberlands

~ 33 M acres of forest land in CA

~ 17 M acres are considered timberlands

~ 8 M acres are under non-federal ownership

- **Non-Federal Focus**

AB 1492 Timber Regulation and Forest Restoration Program

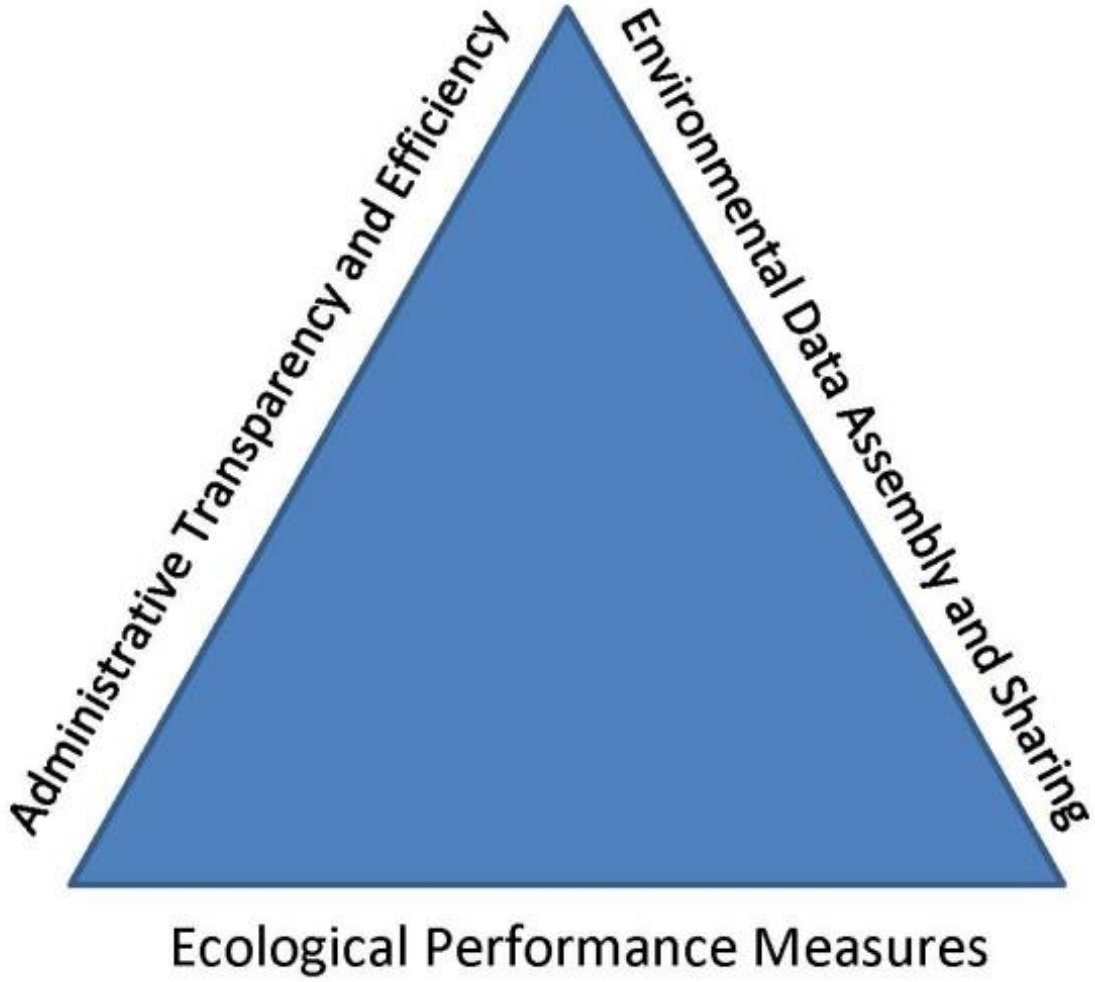
"The Legislature further finds that the state's forest practice regulatory program needs to develop **adequate performance measures to provide transparency** for both the regulated community and other stakeholders." Public Resources Code (PRC) § 4629.1

"…shall submit to the Joint Legislative Budget Committee a[n annual] report on the activities of all state departments, agencies, and boards relating to forest and timberland regulation. This report shall include, at a minimum, all of the following:…

(8) In order to assess efficiencies in the program and the effectiveness of spending, **a set of measures for, and a plan for collection of data on, the program**, including, but not limited to:...

(F) **Evaluating ecological performance**." PRC § 4629.9(a)

The AB 1492 Accountability Triangle



Timber Regulation and Forest Restoration Program

- Ecological Performance Measures

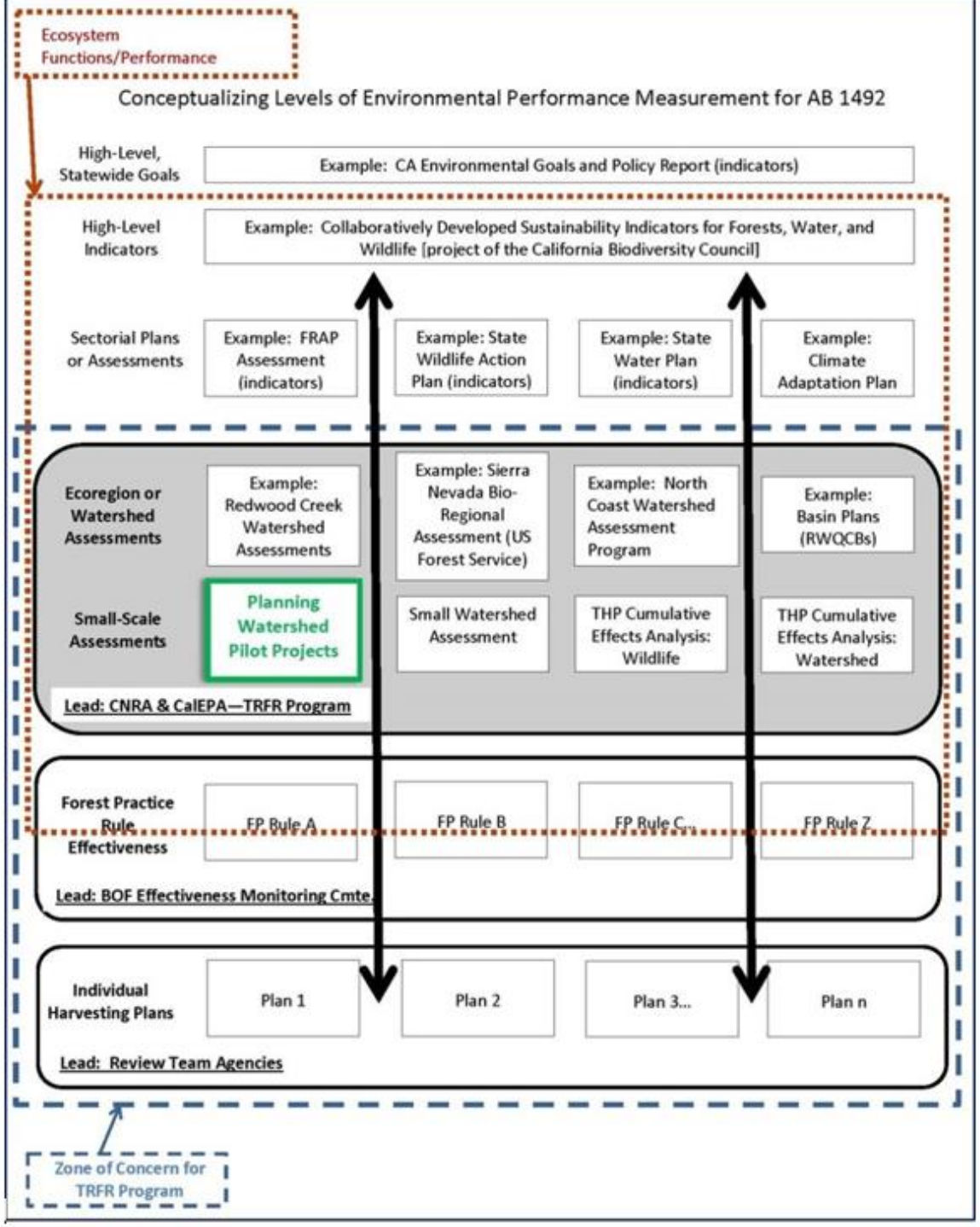
  Need to support consideration of not just standard commercial timber harvest, but also other forest management activities, such as restoration, biomass removal, fuels management, and carbon offset projects.

  In addition to supporting backward-looking program evaluation, the ecological performance measures also will be useful in a forward-looking mode for project planning.

Timber Regulation and Forest Restoration Program

Linkages with other governmental planning or assessment activities:

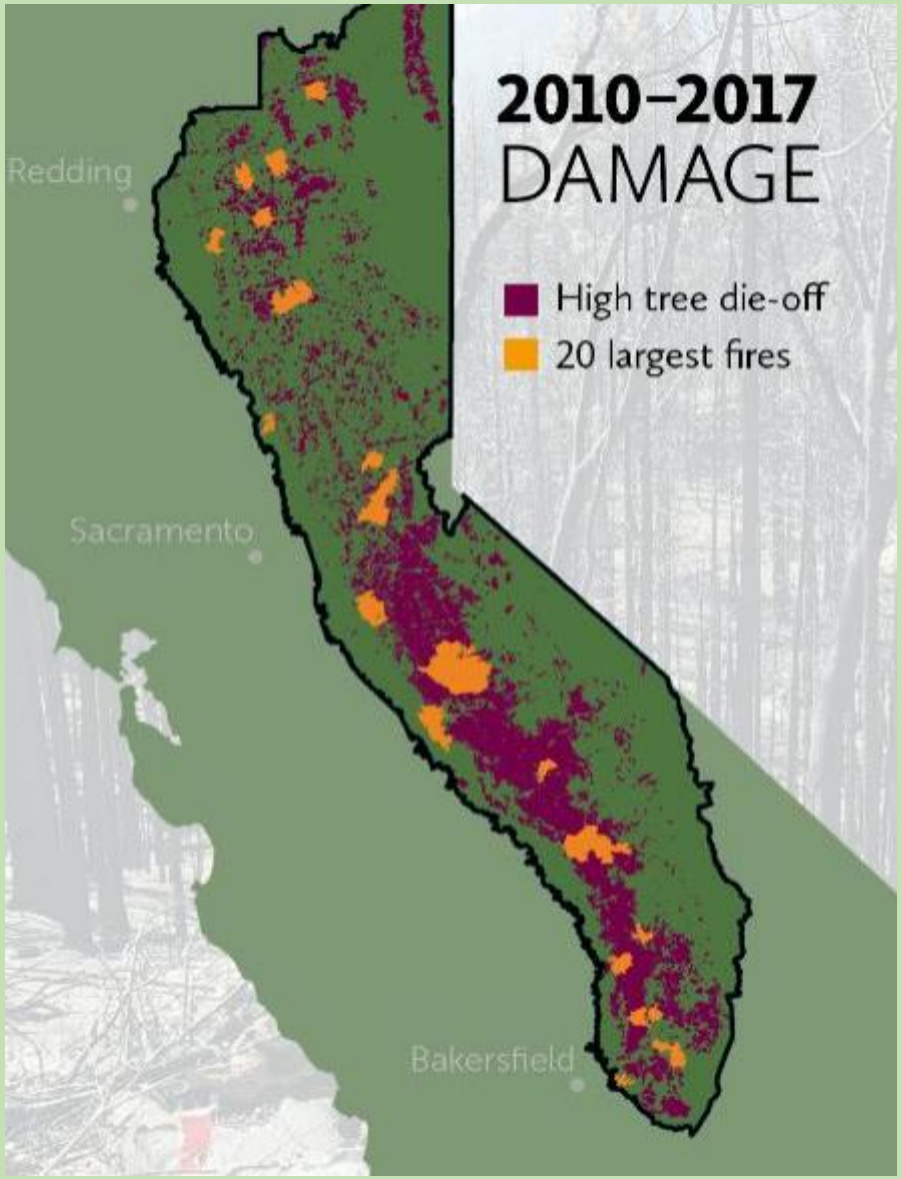
State Wildlife Action Plan
Forest and Rangeland Resource Assessment
California Biodiversity Council indicators project
State Water Plan
Healthy Watersheds Partnership
Nature Conservancy's Freshwater Conservation Blueprint
US Forest Service "Broader Scale Monitoring Strategy"
Effectiveness Monitoring Committee
Tahoe Central Sierra Initiative
Forest Management Task Force


Ecosystem Functions/Performance
Conceptualizing Levels of Environmental Performance Measurement for AB 1492
High-Level, Statewide Goals
Example: CA Environmental Goals and Policy Report (indicators)
High-Level Indicators
Example: Collaboratively Developed Sustainability Indicators for Forests, Water, and Wildlife [project of the California Biodiversity Council]
Sectorial Plans or Assessments
Example: FRAP Assessment (indicators)
Example: State Wildlife Action Plan (indicators)
Example: State Water Plan (indicators)
Example: Climate Adaptation Plan
Ecoregion or Watershed Assessments
Example: Redwood Creek Watershed Assessments
Example: Sierra Nevada Bio-Regional Assessment (US Forest Service)
Example: North Coast Watershed Assessment Program
Example: Basin Plans (RWQCBs)
Small-Scale Assessments
Planning Watershed Pilot Projects
Small Watershed Assessment
THP Cumulative Effects Analysis: Wildlife
THP Cumulative Effects Analysis: Watershed
Lead: CNRA & CalEPA—TRFR Program
Forest Practice Rule Effectiveness
FP Rule A
FP Rule B
FP Rule C...
FP Rule Z
Lead: BOF Effectiveness Monitoring Cmte.
Individual Harvesting Plans
Plan 1
Plan 2
Plan 3...
Plan n
Lead: Review Team Agencies
Zone of Concern for TRFR Program


1) Policy Formulation
2) Management Actions- Policy Implementation
3) Monitoring and Evaluation
4) Assessment and Feedback
5) Policy Evaluation/ Possible Modification

Context for EPM Program

- Rapid changes and stressful conditions facing forests statewide.
- Significant and growing investment and action in forest management across the State



Example showing Sierra Nevada tree mortality and forest fires (2010-2017). Figure from J. Branham, Sierra Nevada Conservancy.

EPM Working Group

Core Staff

Loretta Moreno, CNRA

Current Members

Russ Henly, CNRA
Sandra Jacks, CDFW
Caroline Petersen, CDFW
Pete Ode, CDFW
Bill Short, DOC
Pete Cafferata, CAL FIRE
Michael Baker, CAL FIRE
Drew Coe, CAL FIRE
Rich Walker, CAL FIRE
Jim Burke, SWRCB
Ali Dunn, SWRCB
Matt Dias, BOF
Forest Schafer, Tahoe Conservancy
Adam Moreno, CARB

EPM Working Group Role

- Provide technical expertise to support all stages of EPM Program including:

  - Methods development
  - Data acquisition
  - Data processing
  - Assessment
  - Reporting
  - Management recommendations

Setting Common Definitions

Ecological Monitoring

Repeated, systematic, consistent collection of measurements at one or more locations to determine the current state and trends of abiotic and/or biotic indicators in the environment.

Various types of monitoring occurs (baseline, implementation, trend, effectiveness, validation, and compliance).

Setting Common Definitions

Assessment

The use of monitoring data to evaluate or appraise a resource of concern and/or to determine the condition and provision of ecosystem services and support decision-making and planning processes.

Setting Common Definitions

Ecological Performance Measures

Used to evaluate ecosystem services against a suite of indicators and associated metrics to help determine an ecosystem's state and level of function and represent a method of ecological monitoring

Setting Common Definitions

Ecosystem Services

Also called “criteria”, or “values”, are the direct and indirect contributions of ecosystems to human well-being.

They include neutral identification of

1) processes, such as carbon sequestration, water quantity regulation, etc.;
2) physical entities such as timber, wildlife, etc.; and
3) forest condition such as biodiversity, soil bulk density, etc.

Socioeconomic factors may also be incorporated.

Setting Common Definitions

Indicators

A measurable variable relating directly to one or more ecosystem services and refers to a site-specific condition at a given moment. Using multiple indicators taken together can approximate a process, physical entity, or condition.

Indicators are used to measure the degree to which ecosystem services are being delivered.

Setting Common Definitions

Indicators

Measuring an indicator implies identifying an appropriate unit of measurement (a "**metric**" be it biological, physical or chemical), and then creating or utilizing a corresponding data set.

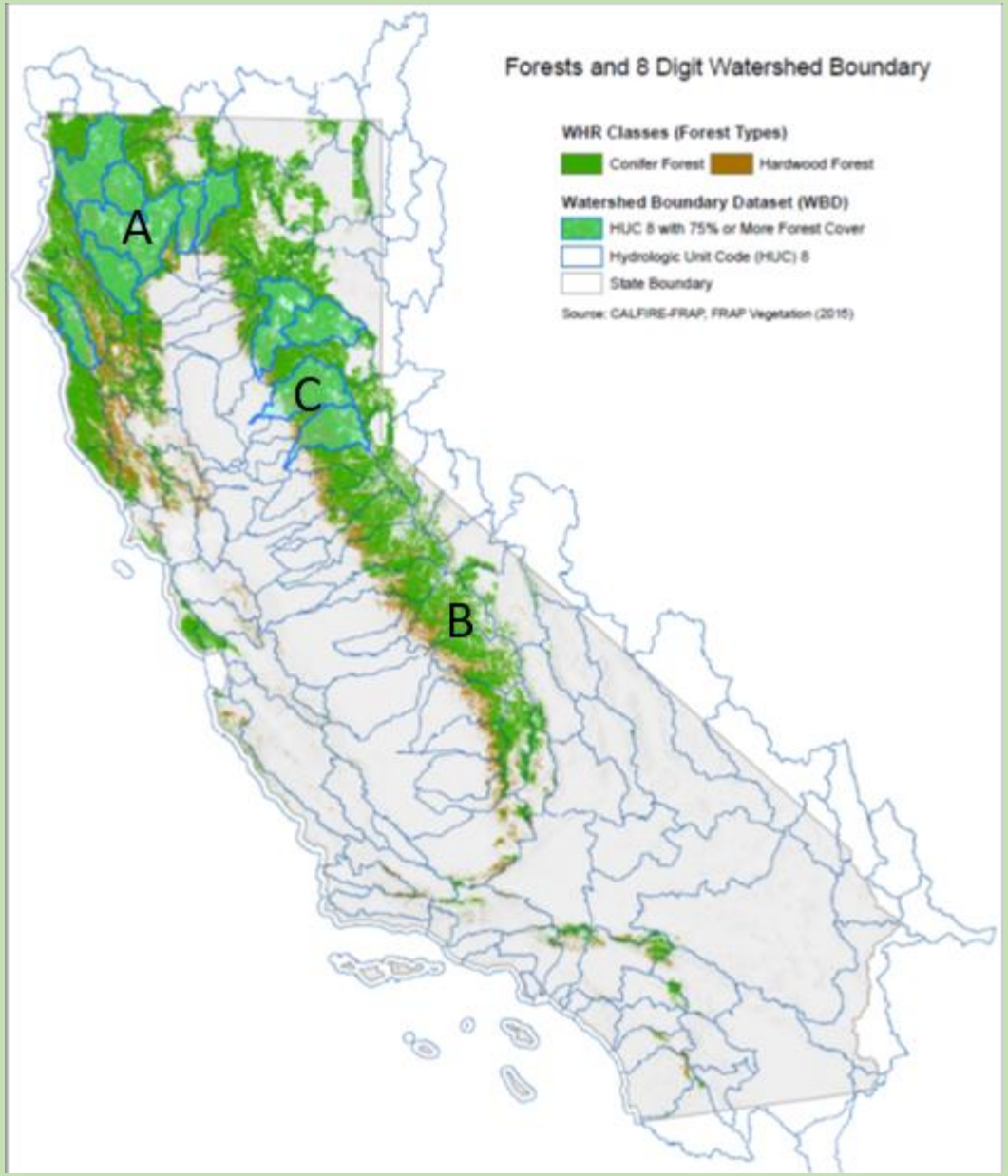
Vision for EPM Program

End product:

Statewide, spatially explicit, consistent monitoring and assessment of timberland ecosystems at regional scale to track efficacy of existing regulations and programs, and highlight where improvements may be needed.

Vision for EPM Program

- Aggregate ecological data to inform regulatory program evaluation.
- Produce interactive dashboard/ data story to display monitoring results, descriptions of indicators, geospatial maps, etc.
- Assessment results inform recommendations to support adaptive management



Potential Sample Product of EPM Program

EPM	Region A	Region B	Region C
i	50	89	X
ii	20	76	X
iii	90	56	X
iv	100	X	12
v	5	45	x

Management/ Policy Response

Flexible Assessment:

Process may change with user or with new science/ needs

Assessment

Ecoregion Maps

Modeling

Ecological Performance (Monitoring)

Indicator(s)

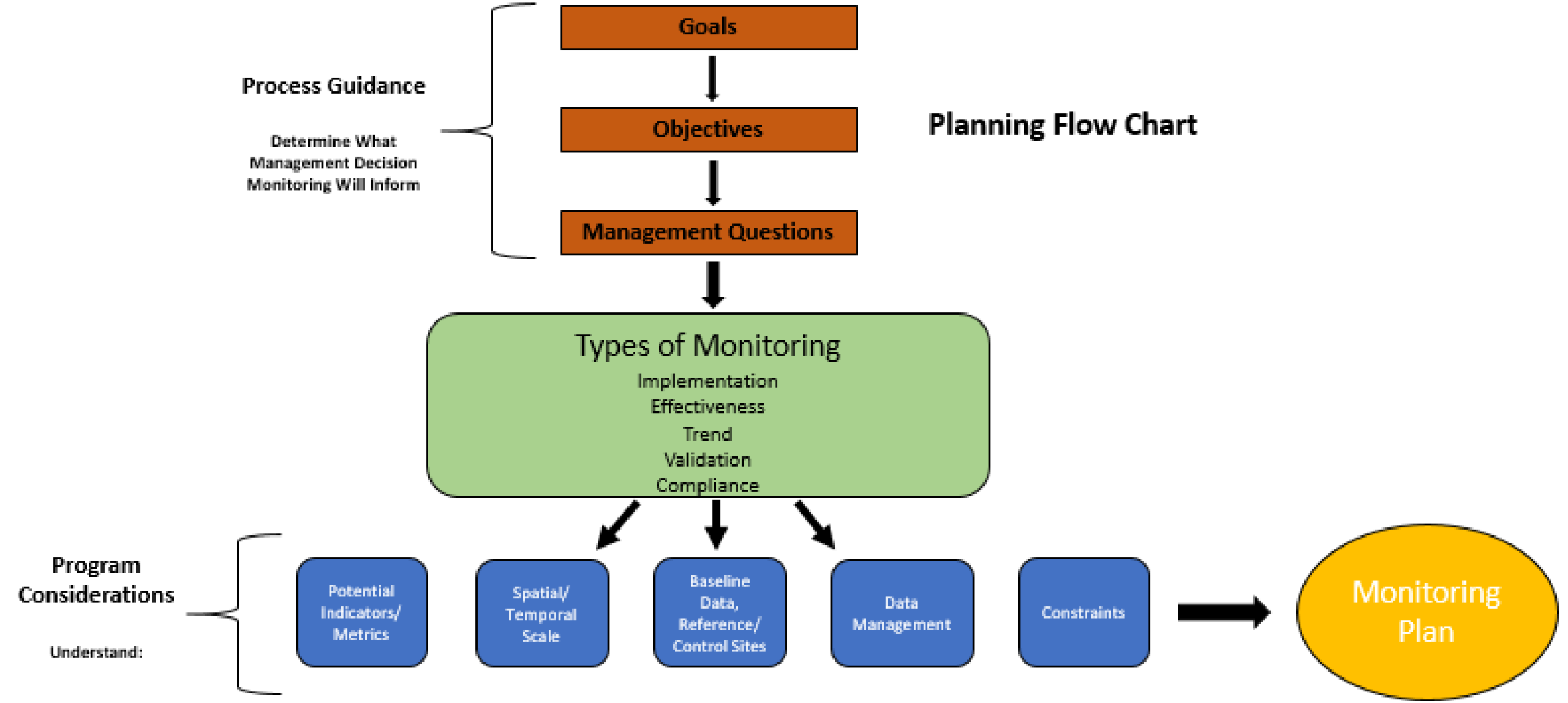
Ecosystem Service(s)

Static Monitoring:

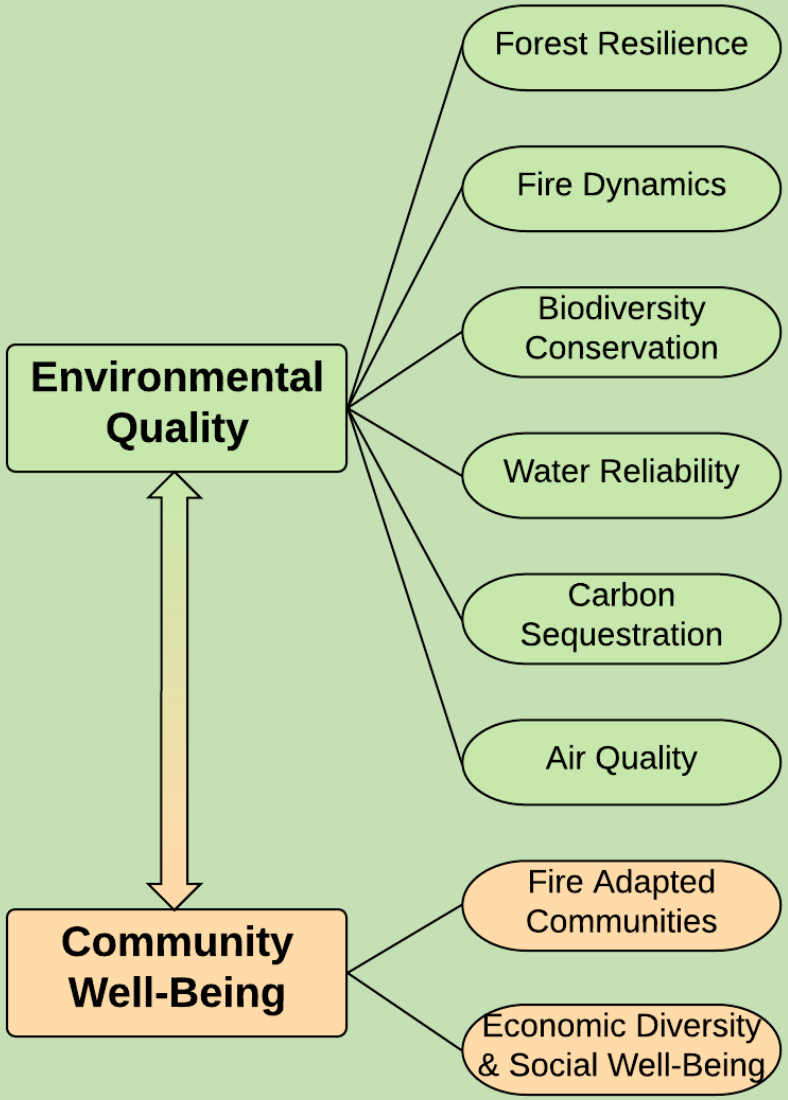
Data collection is standardized and temporally and spatially consistent

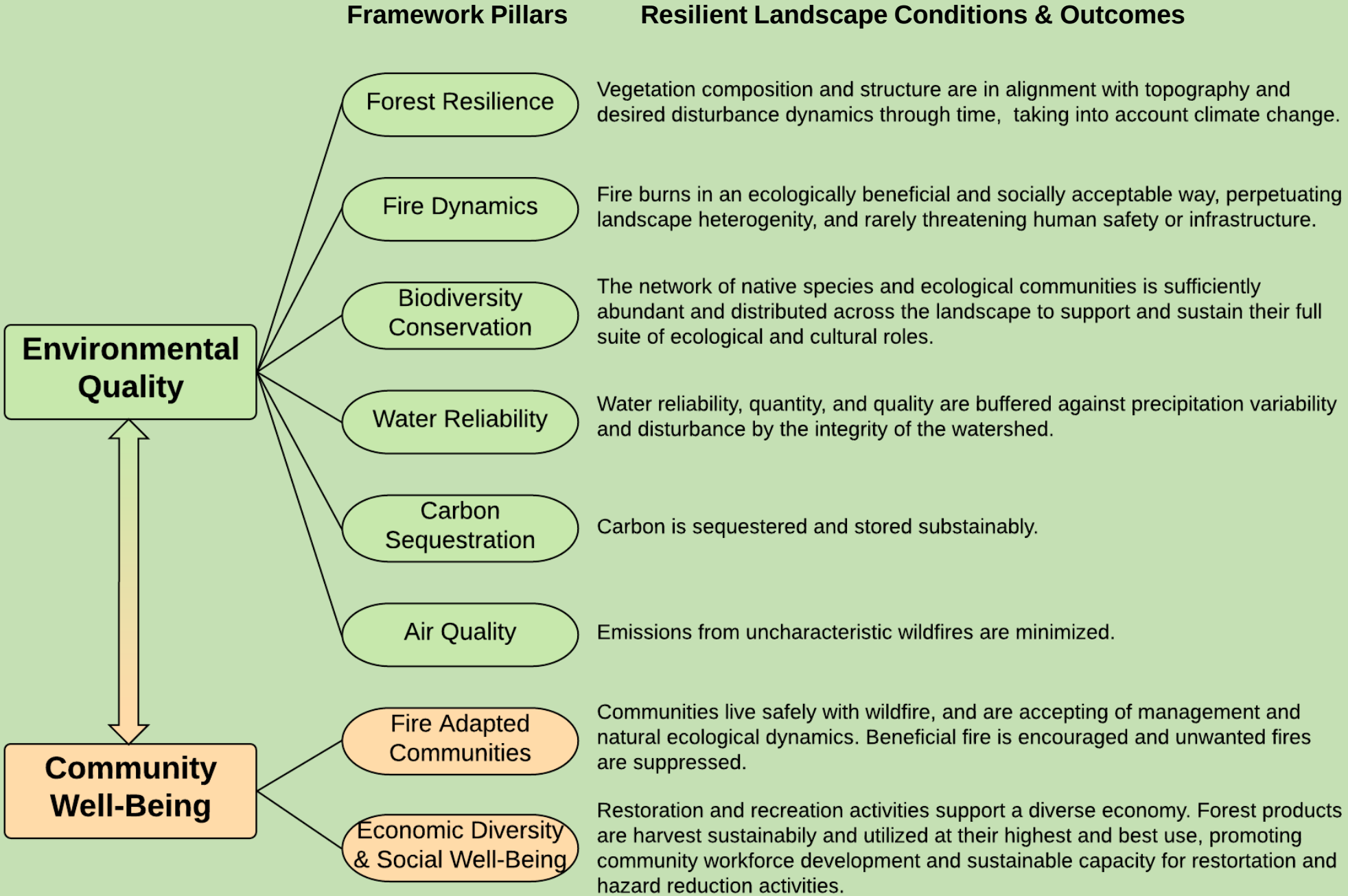
Management needs/questions

Planning Flow Chart



Framework Pillars




Framework Pillars
Resilient Landscape Conditions & Outcomes
Environmental Quality
Community Well-Being
Forest Resilience
Vegetation composition and structure are in alignment with topography and desired disturbance dynamics through time, taking into account climate change.
Fire Dynamics
Fire burns in an ecologically beneficial and socially acceptable way, perpetuating landscape heterogenity, and rarely threatening human safety or infrastructure.
Biodiversity Conservation
The network of native species and ecological communities is sufficiently abundant and distributed across the landscape to support and sustain their full suite of ecological and cultural roles.
Water Reliability
Water reliability, quantity, and quality are buffered against precipitation variability and disturbance by the integrity of the watershed.
Carbon Sequestration
Carbon is sequestered and stored substainably.
Air Quality
Emissions from uncharacteristic wildfires are minimized.
Fire Adapted Communities
Communities live safely with wildfire, and are accepting of management and natural ecological dynamics. Beneficial fire is encouraged and unwanted fires are suppressed.
Economic Diversity & Social Well-Being
Restoration and recreation activities support a diverse economy. Forest products are harvest sustainabily and utilized at their highest and best use, promoting community workforce development and sustainable capacity for restortation and hazard reduction activities.

ECOLOGICAL PERFORMANCE MEASURES

Carbon Sequestration

Kg/ha/year net carbon flux

Water Quality

pH, temperature, flow, suspended sediment

Fire Resilience

Fire severity, fire frequency, vertical and horizontal continuity, loading vegetation fuels, insect and/or disease patterns

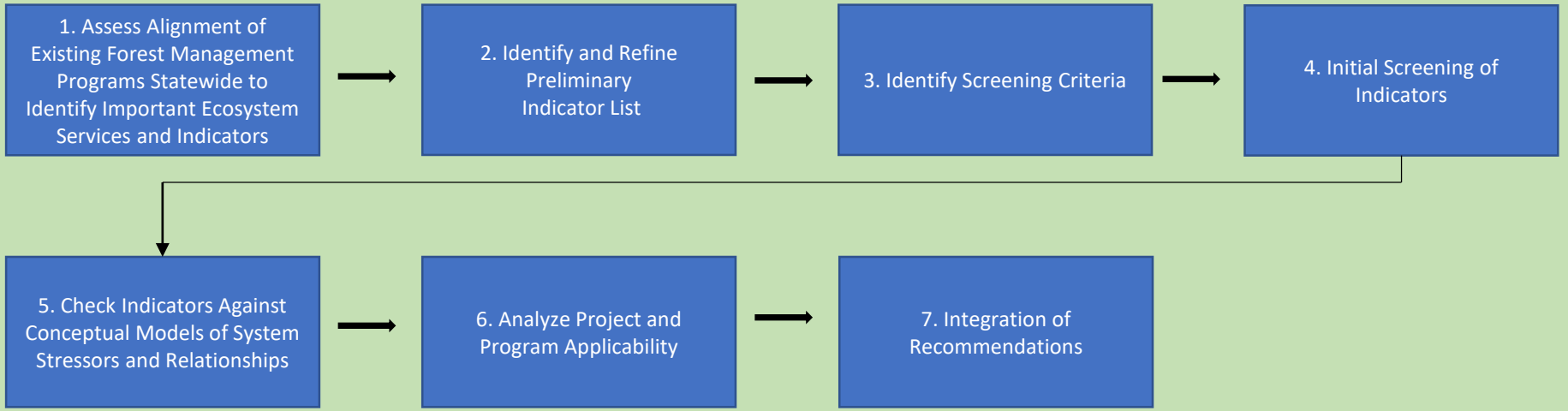
Biodiversity

Species abundance, species' habitat fragmentation

Ecosystem Services

Indicators

Summary of Suggested 7-step approach to Selecting Ecological Performance Measures



3. Identify Screening Criteria

Criterion- Indicator Selection	Definition
Sensitive	Indicator must be sensitive and responsive to change so that management actions can readily influence its behavior (responsive to human disturbance gradients)
Predictable	Future indicator levels must be predictable (metric range is clear)
Practical/Feasible to implement	Monitoring techniques readily available and are not cost-restrictive to encourage its continued use and improve the rigor of the indicator as longer time series are collected
Relevant	Relevant to stated goals, objectives, priorities of program, ecosystem of interest
Scientifically valid	An accepted relationship exists between the indicator and its purpose, with scientific consensus that change in the indicator signifies a response to a management action (directly or indirectly) and that the data used are reliable and verifiable
Measurable	It is possible to measure the indicator (i.e., technology exists to measure the indicator) and objective empirical measurements are possible to capture over time. Changes in indicator are readily detectable.

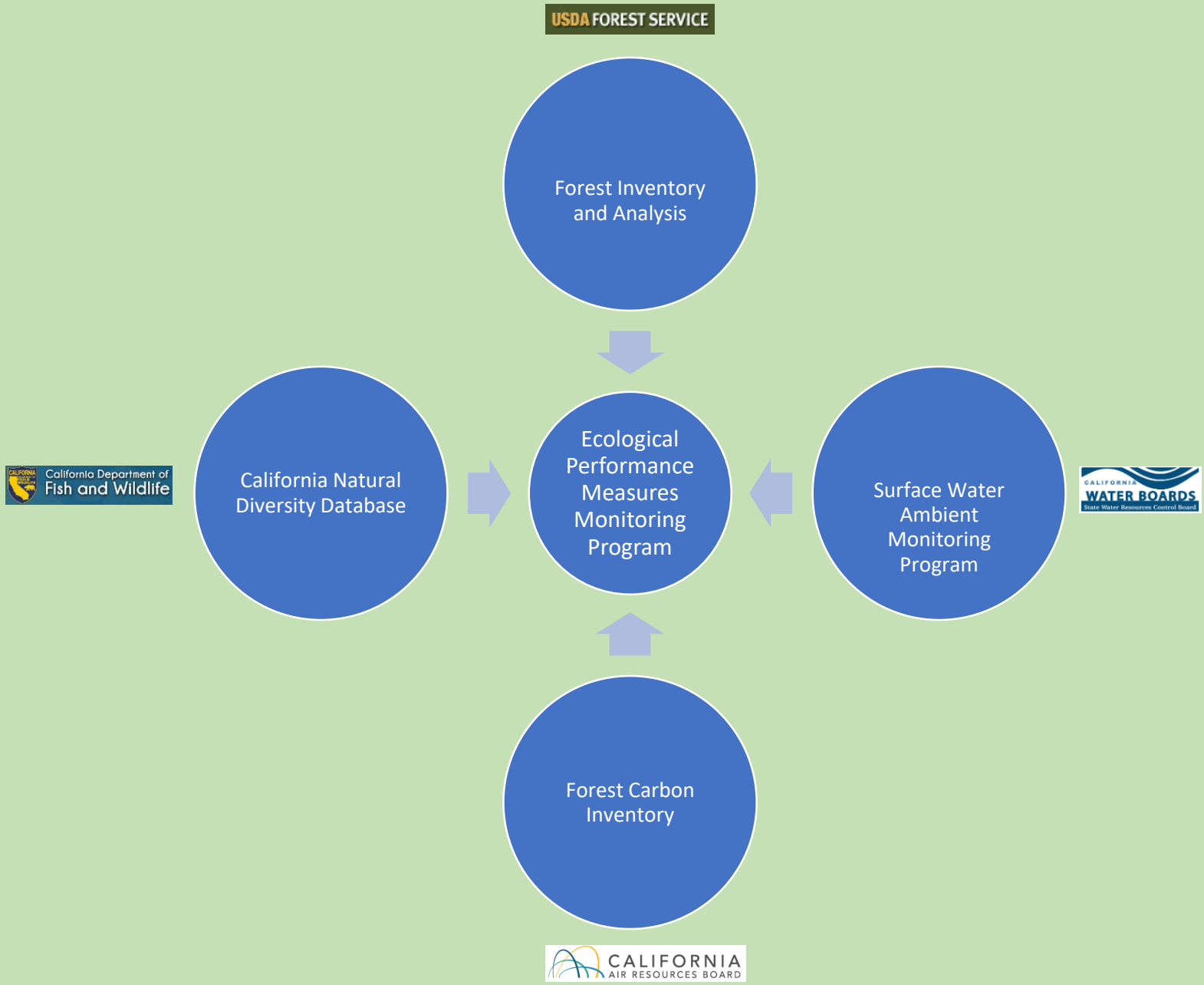
Scientifically valid	**An accepted relationship exists between the indicator and its purpose, with scientific consensus that change in the indicator signifies a response to a management action (directly or indirectly) and that the data used are reliable and verifiable**

Practical/Feasible to implement	**Monitoring techniques readily available and are not cost-restrictive to encourage its continued use and improve the rigor of the indicator as longer time series are collected**

Applicable (across state)	**The indicator is important for documenting changes for two or more management categories (e.g. meadows, wetlands)**

Data

- Access existing datasets/leverage existing monitoring efforts
- While EPM program will use existing data/monitoring, program initiative may spawn expanded or new monitoring



Filling in the Gaps

- Predicting /modelling in cases where we don't have sufficient data coverage from monitoring

  - LEMMA: Landscape Ecology, Modeling, Mapping and Analysis
  - Remote Sensing products- e.g., LANDSAT
  - Statistical Extrapolation

Monitoring California at multiple spatial scales

Dr. Adam Moreno

California Air Resources Board

Note: Dr. Moreno’s presentation is based on his previous work and experience before employment with the California Air Resources Board (CARB). It does not necessarily represent the views and policies of CARB and has not been approved or disapproved by CARB

The basis for understanding

Field based measurements

Forest Inventories

https://www.state.sc.us/forest/scfia.htm

Stream Gauges

http://www.engr.colostate.edu/~mgooseff/hydroscapes.html

Camera Traps

https://jrbp.stanford.edu/research/wildlife-photo-gallery

Flux Towers

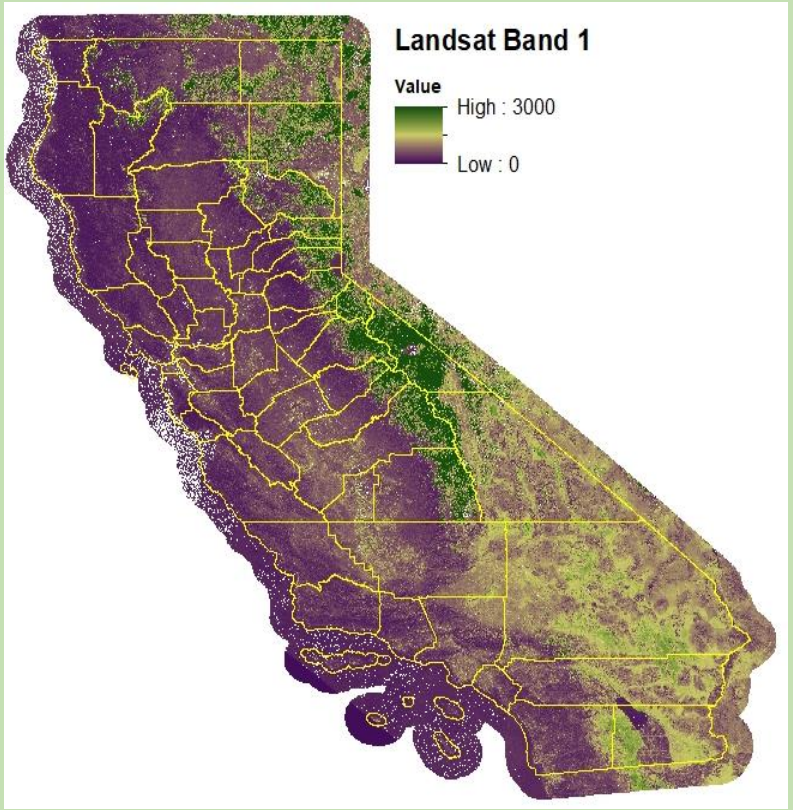
http://ameriflux.lbl.gov/wp-content/uploads/2018/06/US-NGC-Flux-at-CouncilAK-1.jpg

The bigger picture

Remote sensing (also empirical)

Computer rendition of Terra by NASA

An artist's depiction of Landsat 8, which launched in 2013 (NASA)



Combining data at multiple scales

Using field and remotely sensed data, how can we best monitor California?

One number for the entire state

Where's the sweet spot?

One number for every 30 m^2

Statistics leads the way

Contents lists available at ScienceDirect

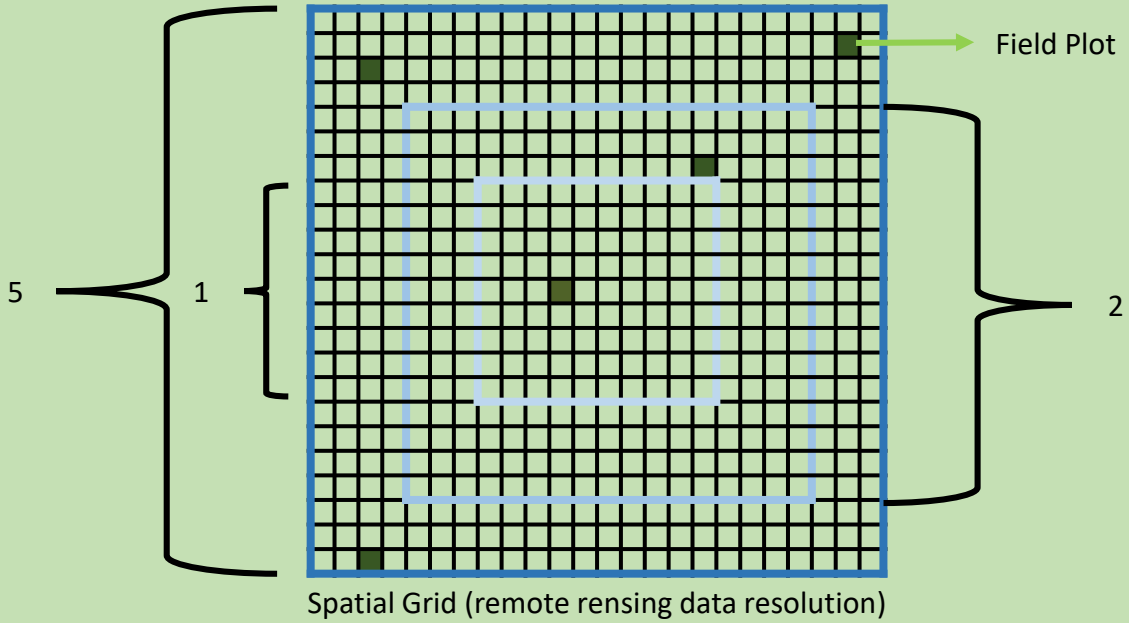
Remote Sensing of Environment

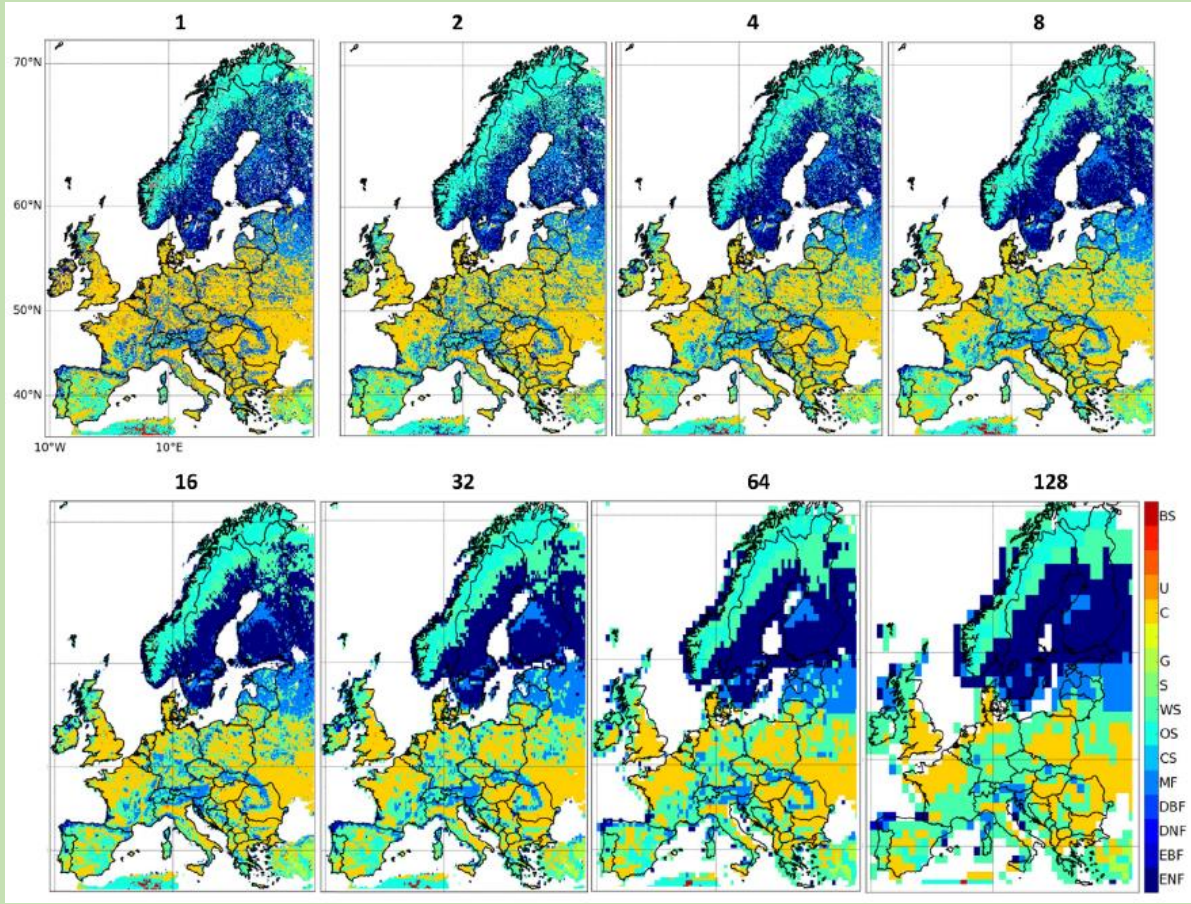
journal homepage: www.elsevier.com/locate/rse

Optimal resolution for linking remotely sensed and forest inventory data in Europe

Adam Moreno *, Mathias Neumann, Hubert Hasenauer

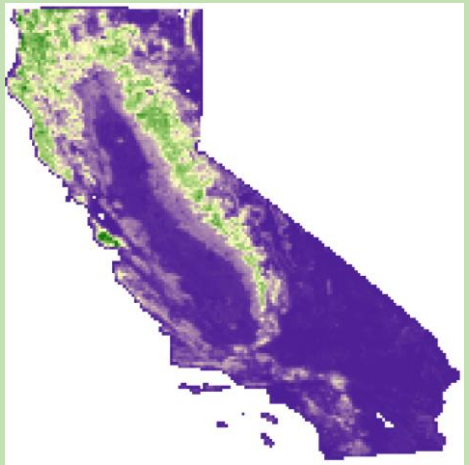
Institute of Silviculture, Department of Forest and Soil Sciences, University of Natural Resources and Life Sciences, Vienna, Peter-Jordan-Str. 82, A-1190 Wien, Austria



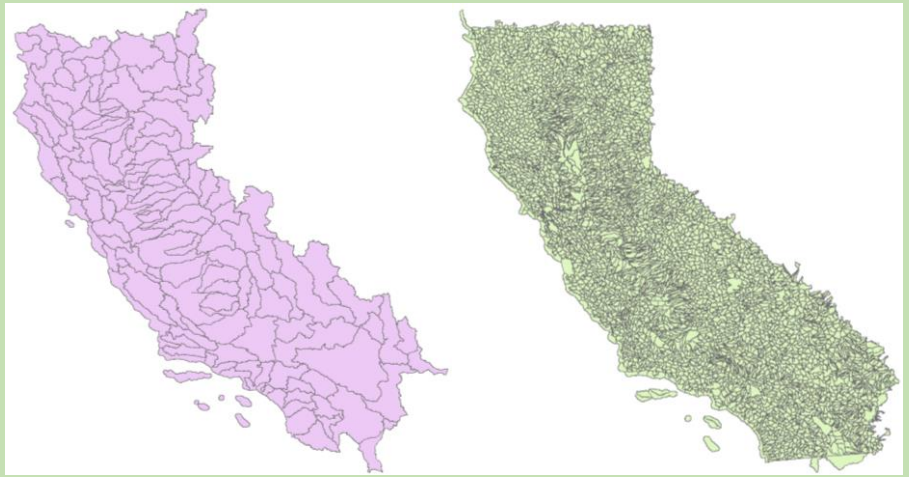


Lots of options

Depends on the question and the data

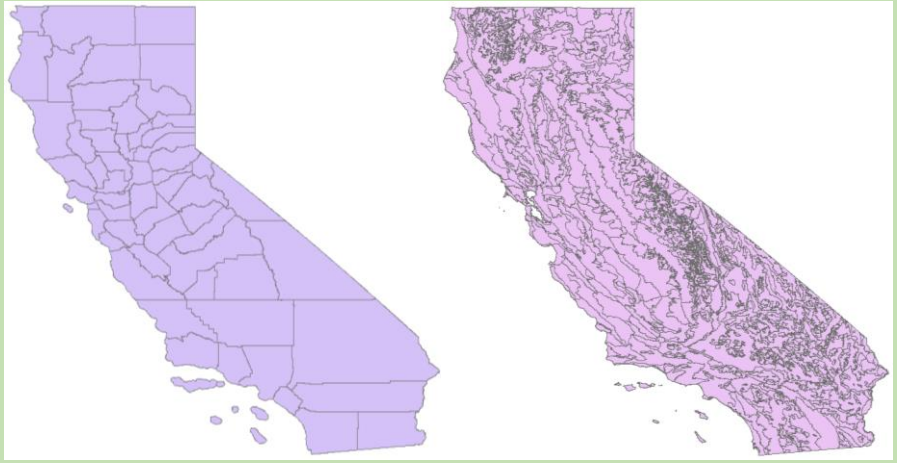


6km regular grid



Hydraulic Unit Code (HUC) 8

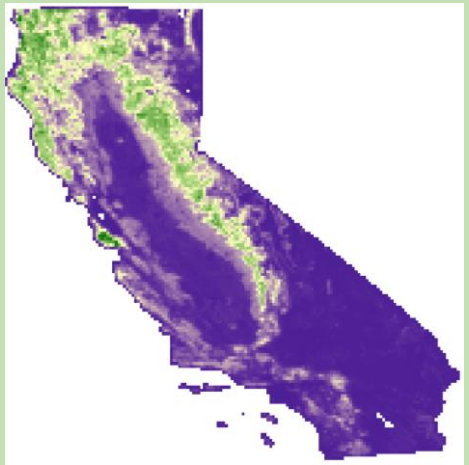
Hydraulic Unit Code (HUC) 12



Counties

Ecoregions

Questions or Comments?



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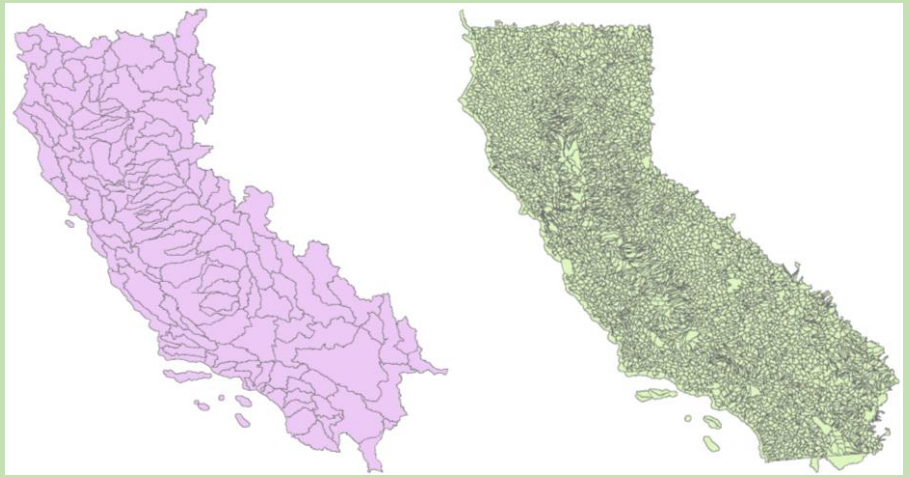

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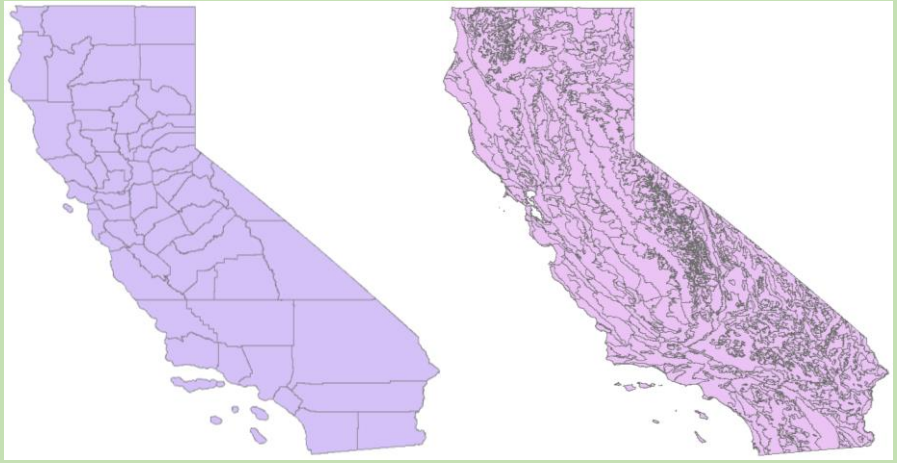


Counties

Ecoregions

Building the California Stream Condition Index:
a tool for measuring the ecological condition of California's streams

Peter Ode and Andy Rehn
Aquatic Bioassessment Laboratory
CA Department of Fish and Wildlife

Raphael Mazor
Southern Coastal California Water Research Project

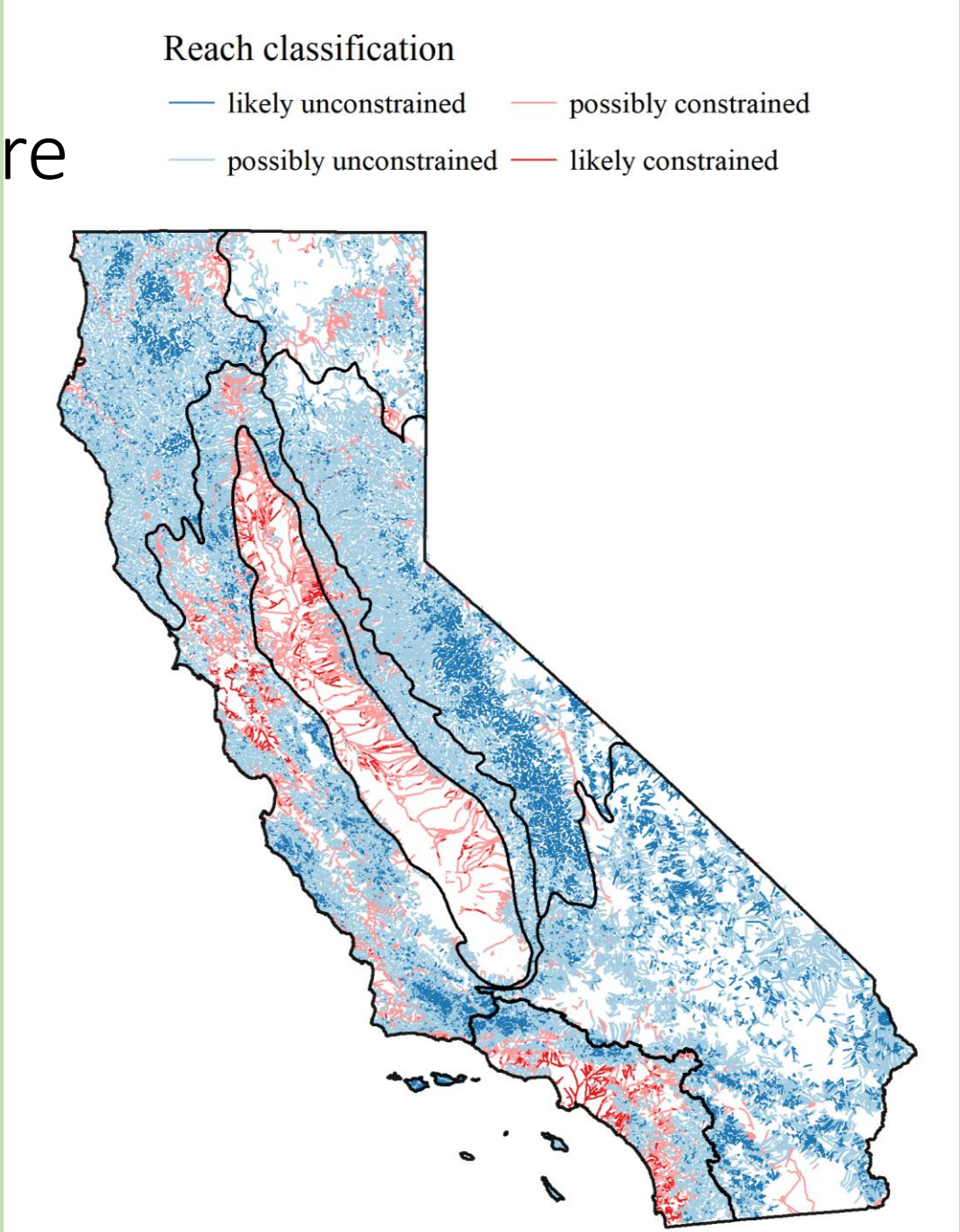
Primary ecological indicator for CA streams – benthic macroinvertebrates

- *Ubiquitous, abundant and diverse*
- *Responsive to stress*
- *Information rich*

- *CA has standard procedures for collection, identification, data management and QA (State Water Board's SWAMP Program)*

Goal: develop an index that can score health of California's streams

- Index should provide consistent interpretation of biological condition across CA
- Index should have optimal performance characteristics and performance consistency
  - Accuracy
  - Precision
  - Responsiveness
  - Sensitivity



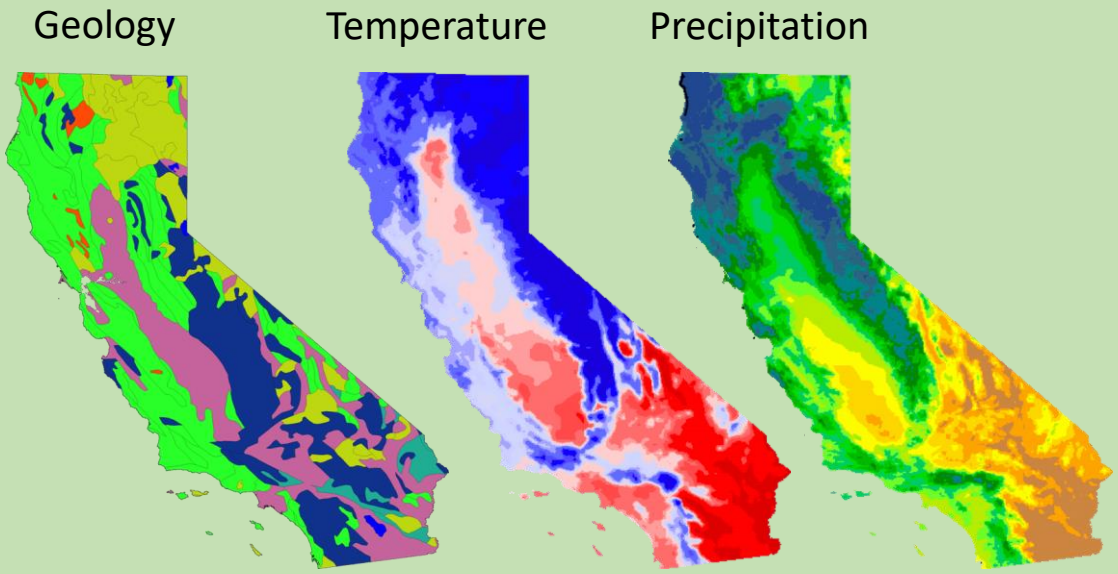
The California Stream Condition Index (CSCI)

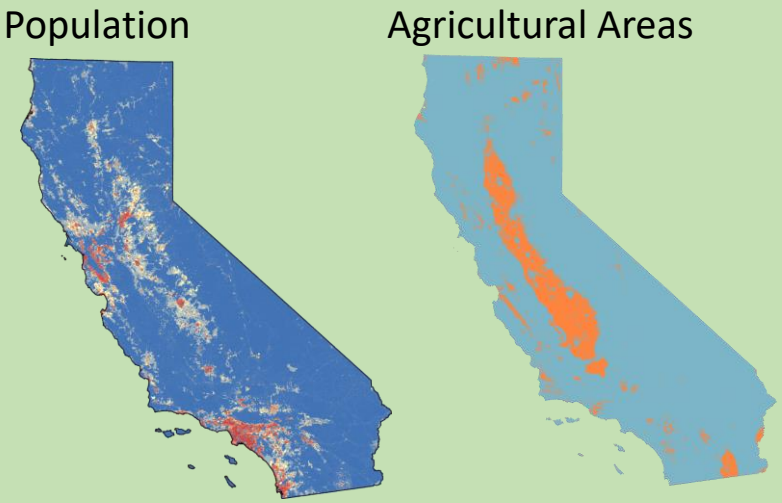
Grounded in the reference condition approach

- Compare species at test sites to similar sites with low levels of human influence (=reference sites)

CA's diversity is challenging

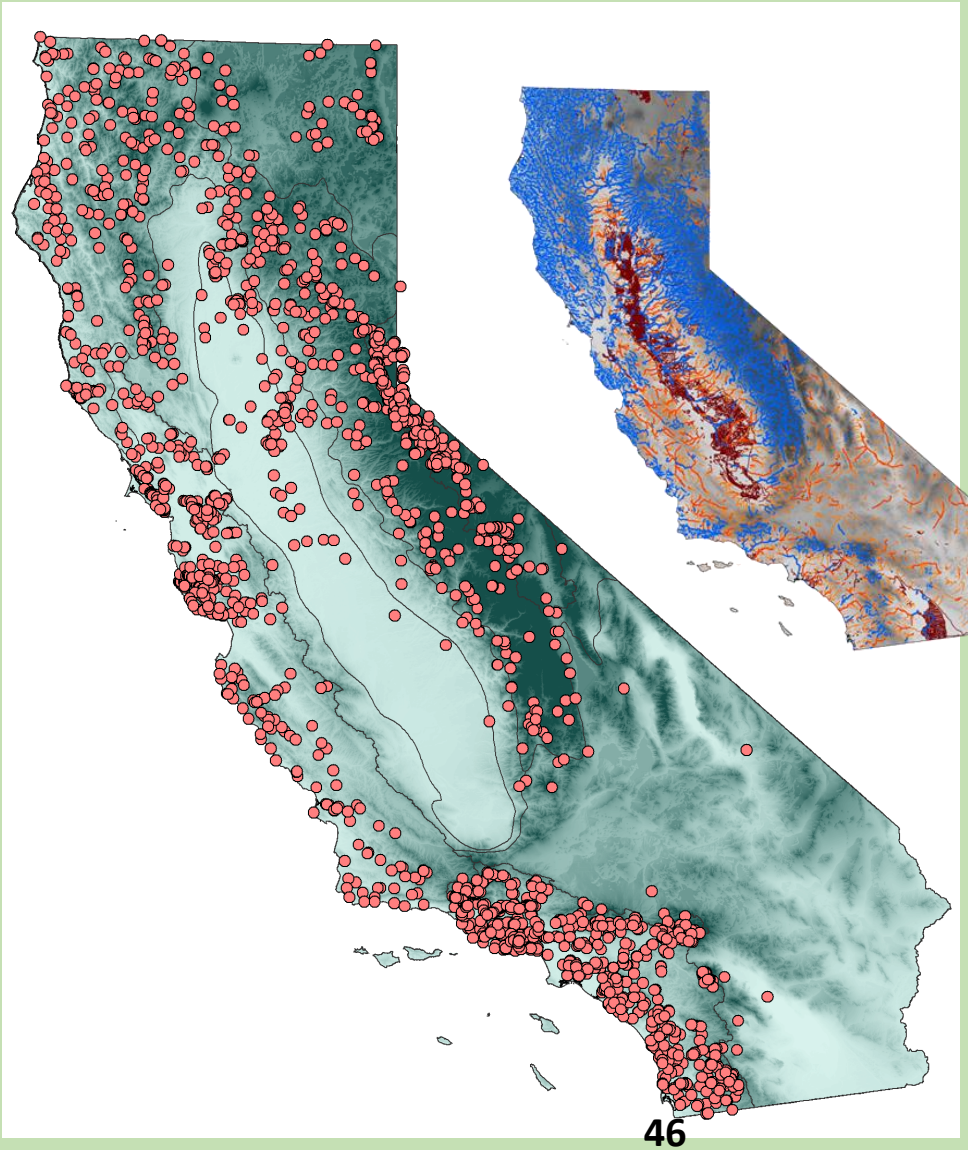
- Complex climate, geology, geography, landuse, etc.
- Expect different species in different settings even in absence of humans





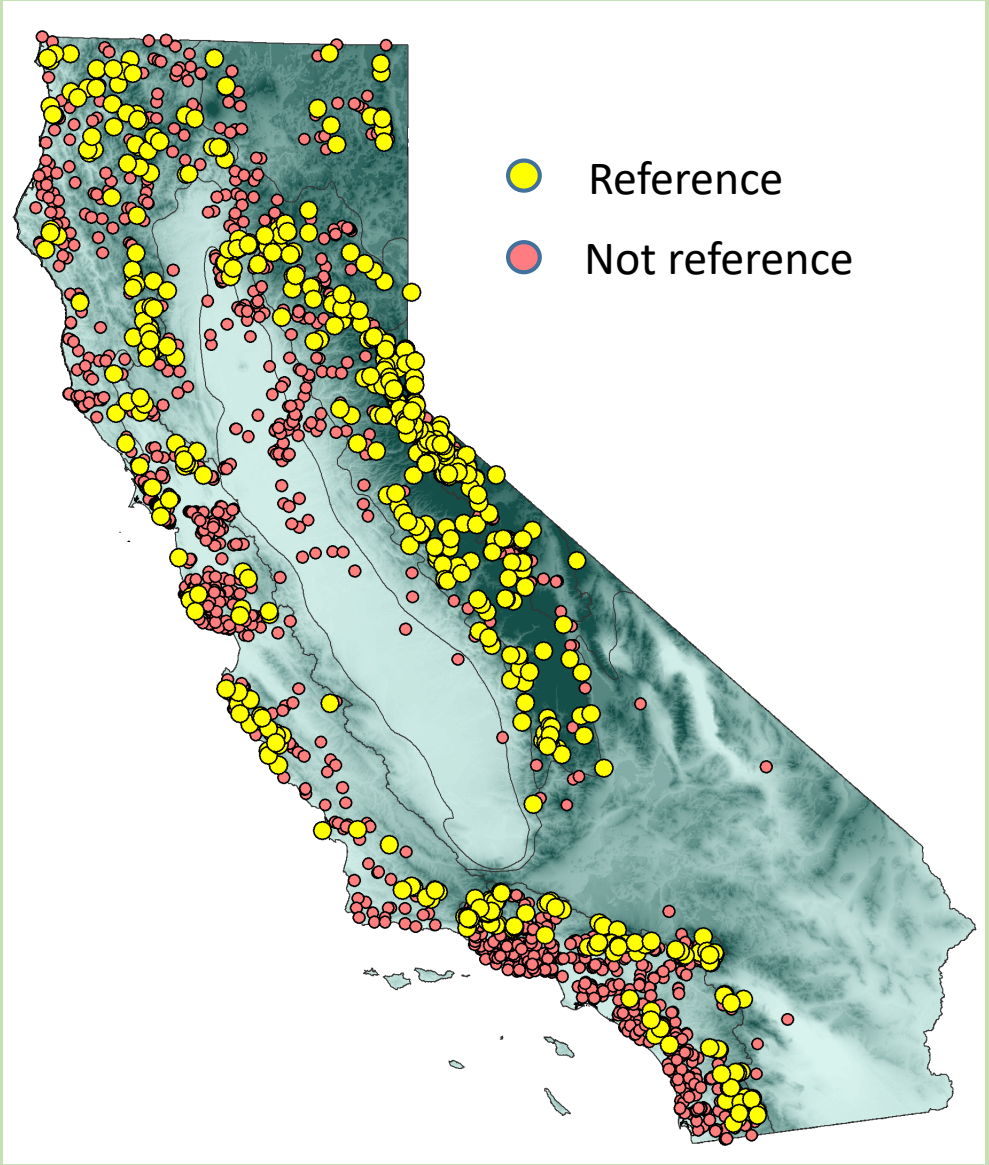
Screened ~ 2000 **candidate** reference sites based on potential stressors at site and in upstream watershed

- **Infrastructure**: roads, railroads
- **Population**
- **Hydromodification**
- **Landuse**: ag, urban, timber, grazing
- Fire history, dams, mines
- Water chemistry, 303d list, known discharges
- Invasive invertebrates, plants
- Instream and riparian habitat

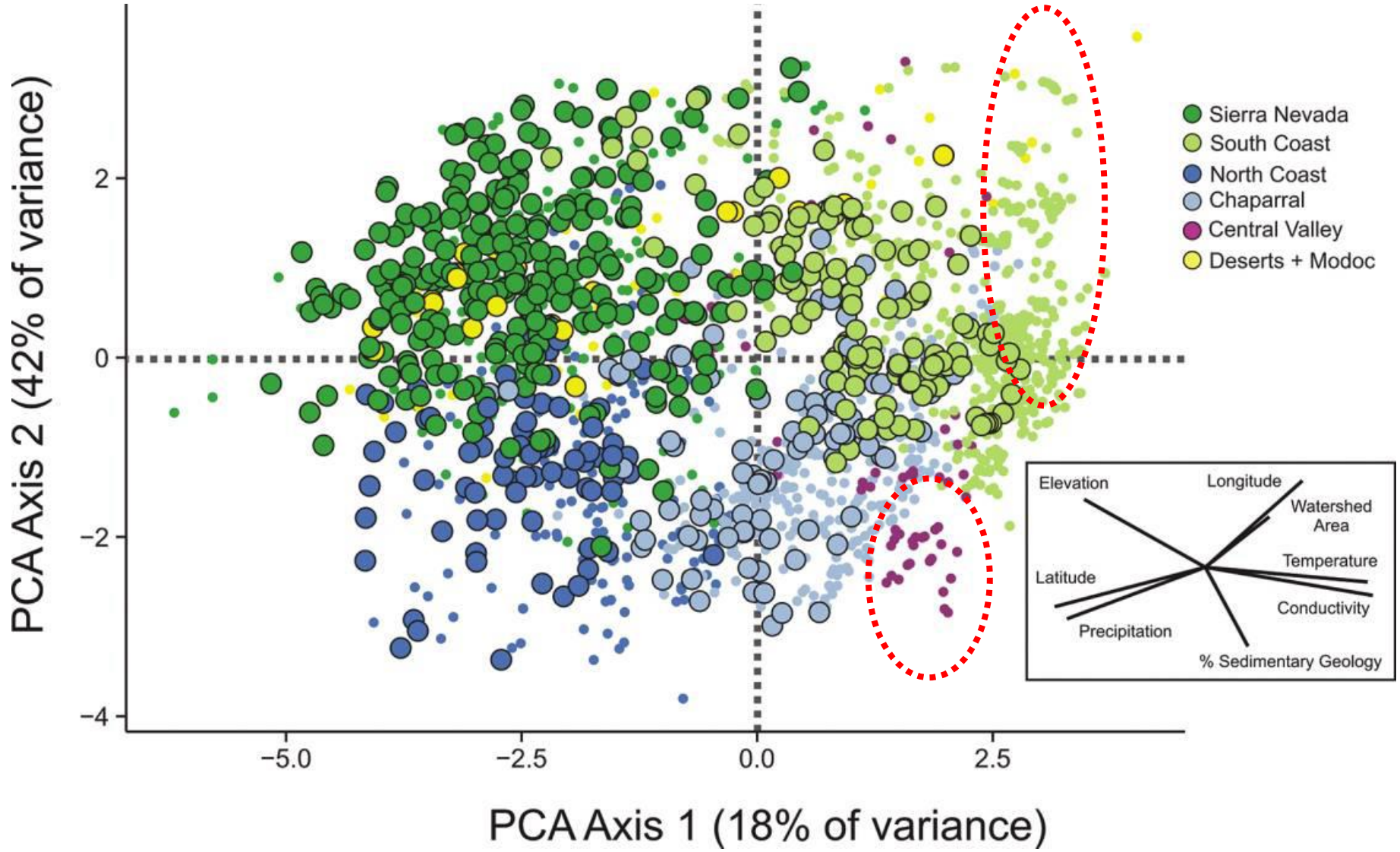


Final reference sites have broad geographic coverage

REGION	n
North Coast	75
Central Valley	1
Coastal Chaparral	57
Interior Chaparral	33
South Coast Mountains	85
South Coast Xeric	34
Western Sierra	131
Central Lahontan	114
Deserts + Modoc	27
TOTAL	**586**



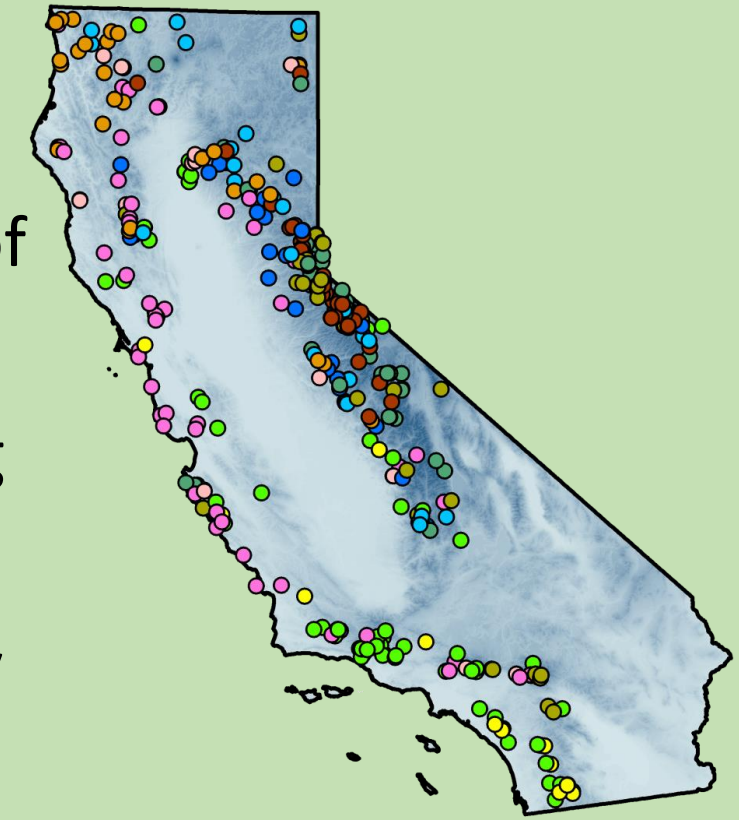
Full range of environmental settings well represented



The California Stream Condition Index (CSCI) scores the health of a site in two ways

- Species composition component
- Ecological structure component

Species composition component

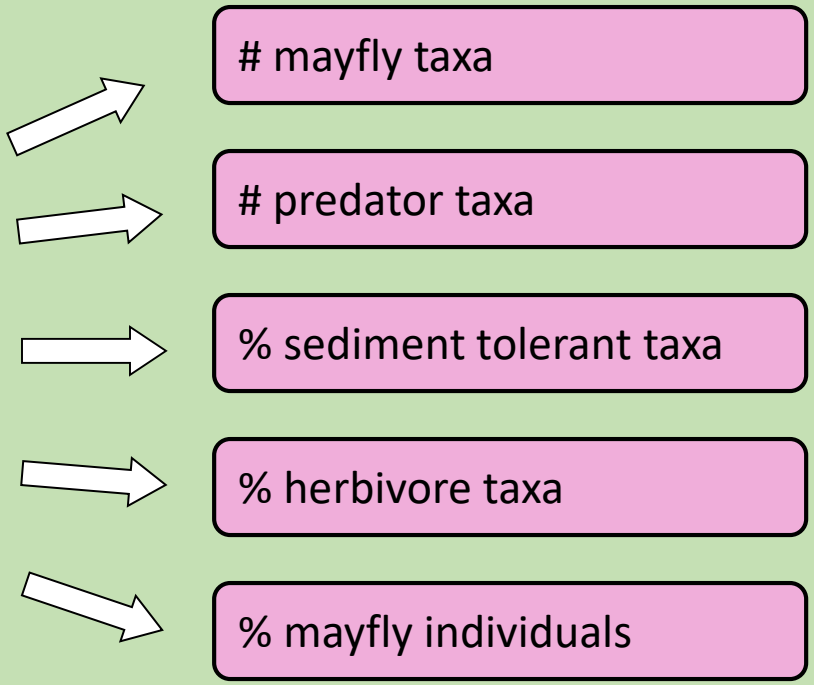


- Compare **number of observed taxa (O)** to number of expected taxa (E)
- **"E" is modeled** = predict the likelihood of observing different species at similar healthy sites
- Which sites to compare to? Environmental similarity is modeled based on 5 natural gradients: latitude, elevation, precipitation, temperature, watershed area
- Similar sites may not be close geographically

Ecological structure component

Species list is converted into “metrics” representing diversity, ecosystem function, and sensitivity to stress

Organism Name	Count
Mayfly species 1	43
Mayfly species 2	12
Mayfly species 3	2
Beetle species 1	1
Beetle species 2	1
Midge genus 1	65
Midge species 1	3
Midge species 2	10
Midge genus 2	3
Dragonfly species 1	2
Stonefly species 1	1
Stonefly species 2	14
Worm species 1	9
Worm species 2	2



Expected metric values are modeled to adjust for environmental setting

CSCI combines species composition and ecological structure components (metrics) into a single score

- Location – elevation, latitude, longitude
- Watershed size
- Climate – precipitation, temperature
- Geology – mineral content, soils

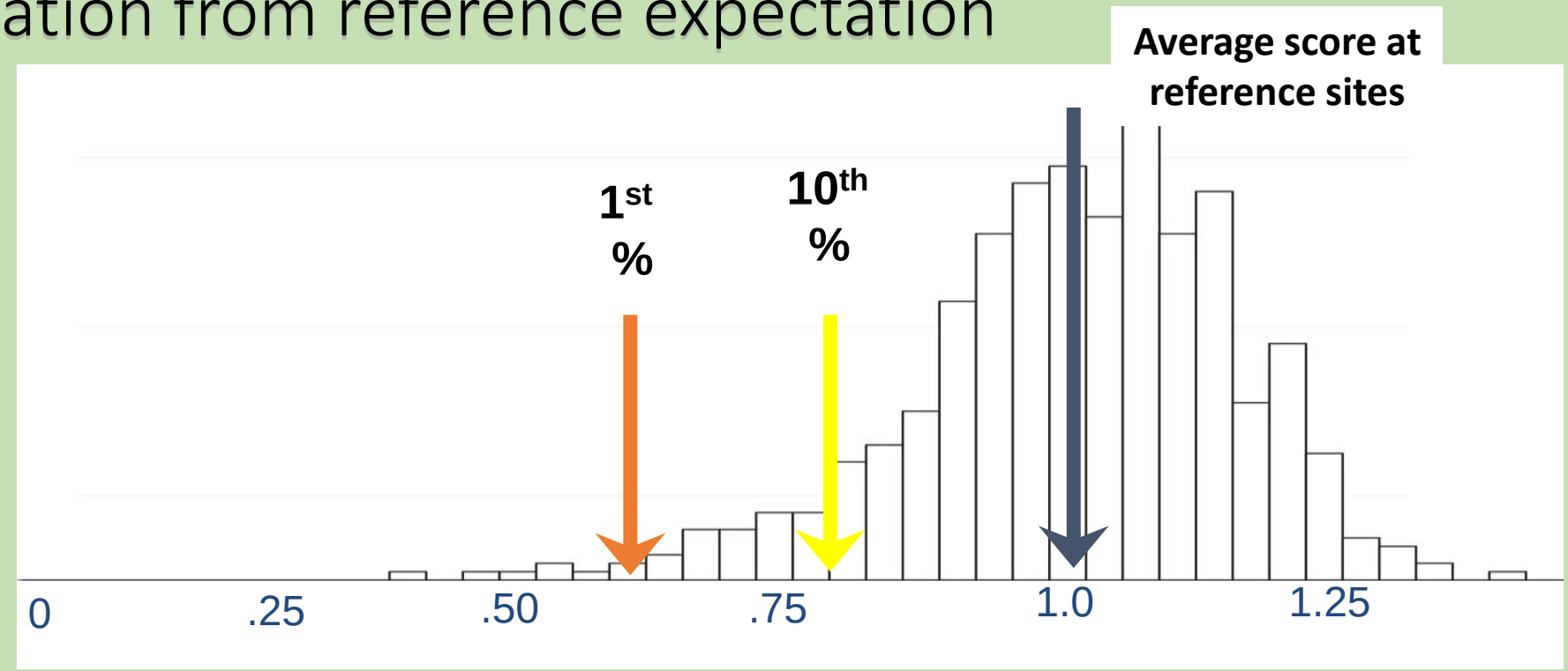
species and metrics **measured** at test site = **Observed**

species and metrics **predicted** at site = **Expected**

If O/E is ~1.0, biological integrity is intact

If O/E << 1.0, biological integrity is altered

Statistical properties of the index allow us to measure deviation from reference expectation



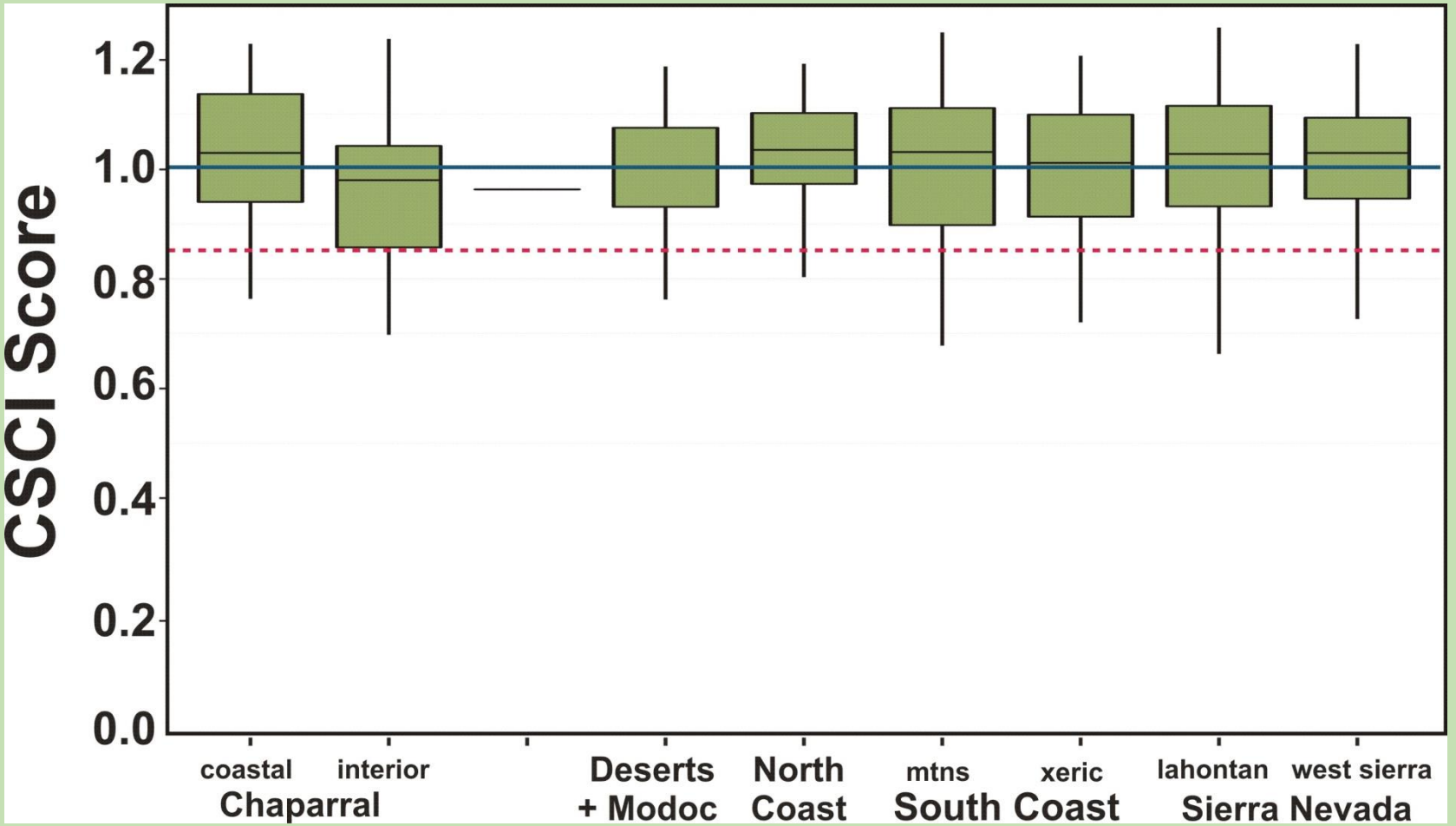
Index attributes

Characteristic	Description
Accuracy and bias	Index rates sites the same way in different environmental settings
Precision	Index scores are repeatable
Responsiveness	Index scores change in relation to stress
Sensitivity	Index scores detect change when they should

- See Mazor et al. 2016 for details

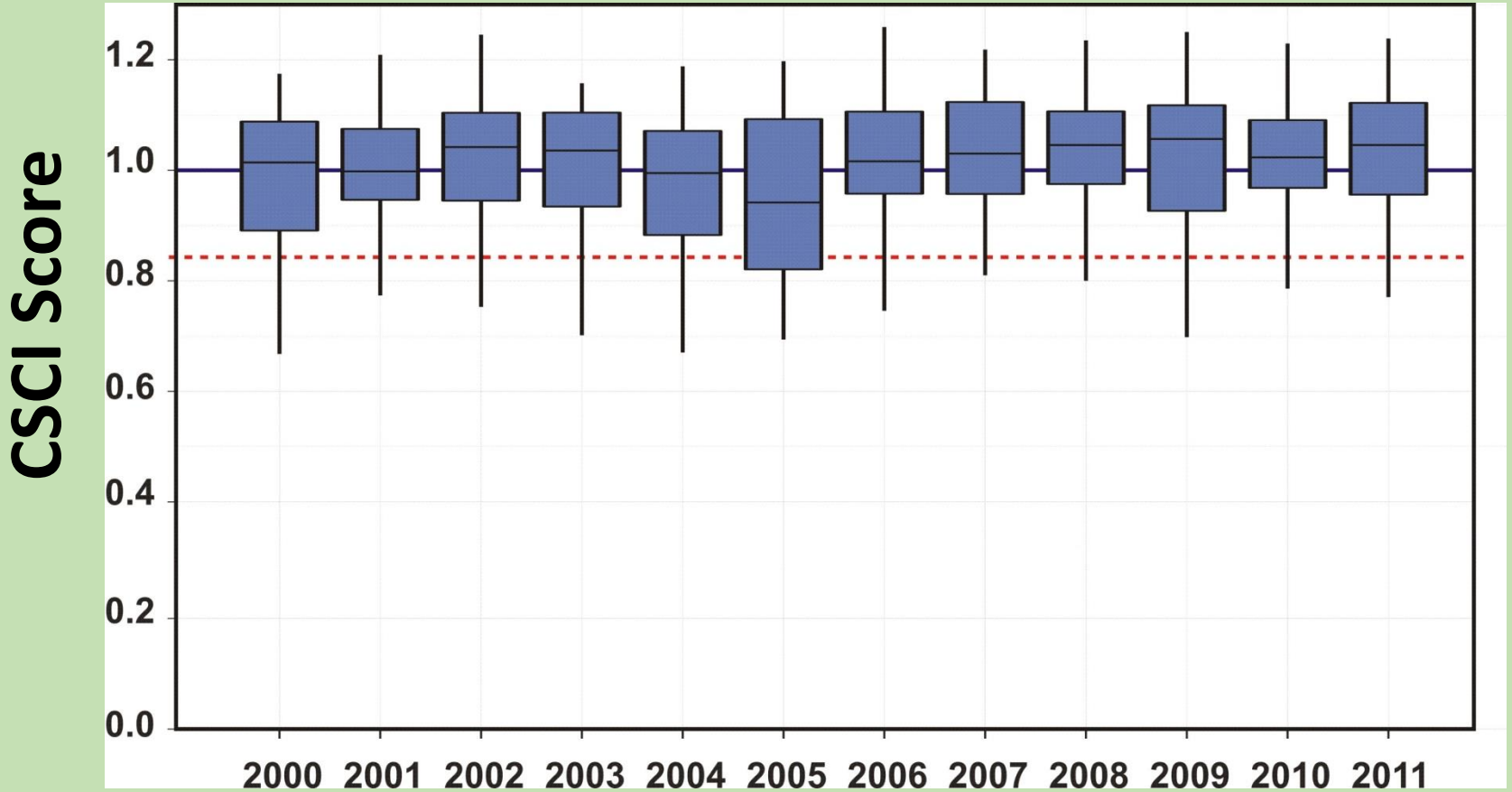
Index rates sites consistently throughout CA

CSCI scores at reference sites in major CA ecoregions

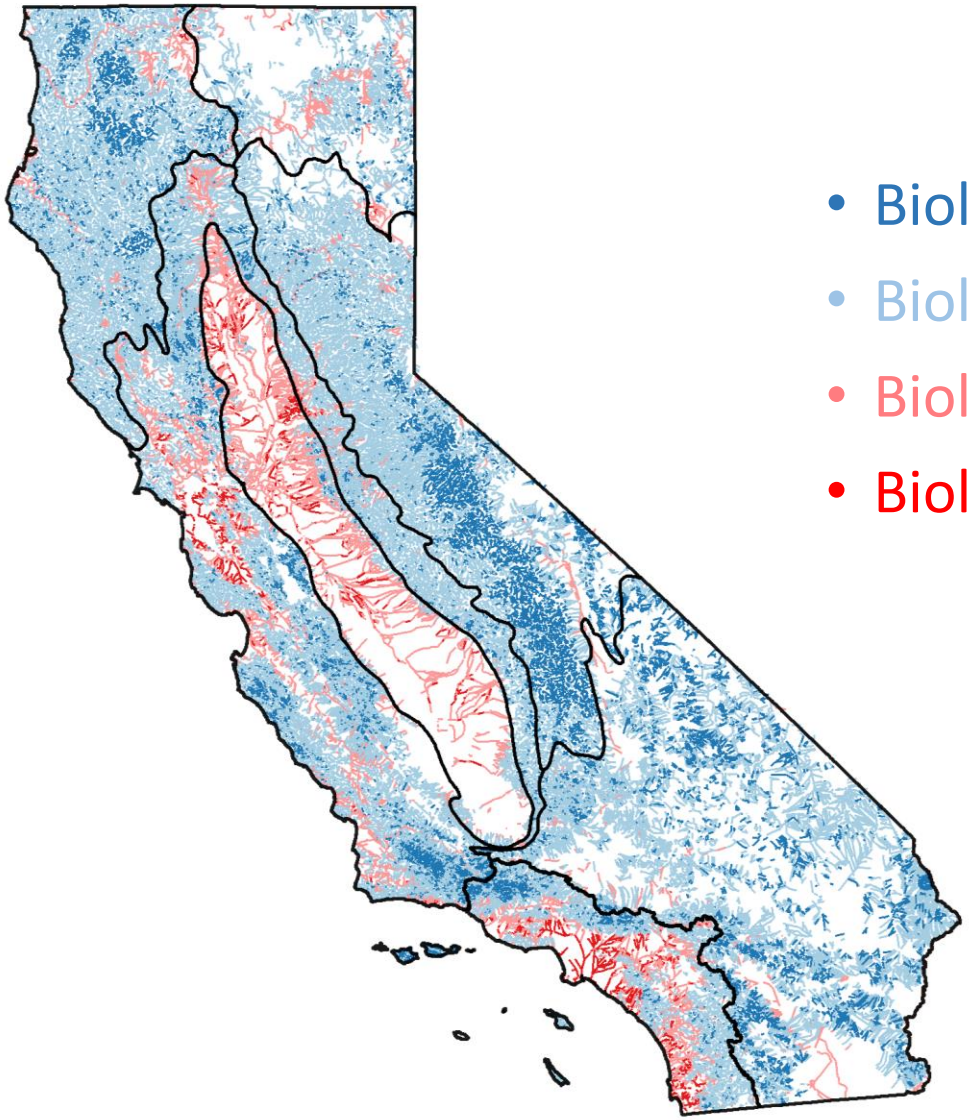


Index rates sites consistently over time

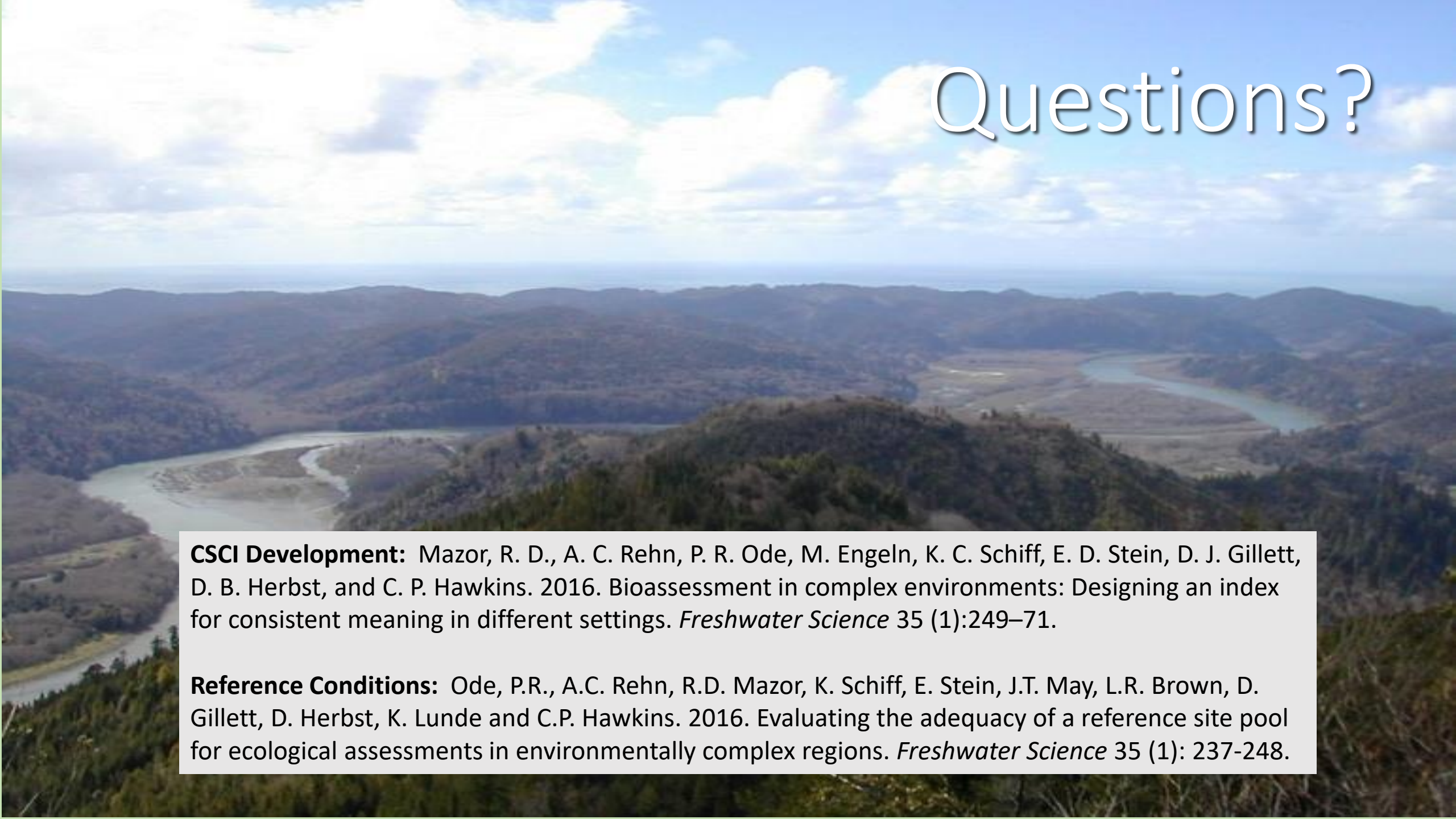
CSCI scores at reference sites 2000 - 2011



Example output: predicted stream condition scores based on relationships between landuse and biological condition



- Biology likely unaltered
- Biology possibly altered
- Biology possibly altered
- Biology likely altered



Questions?

CSCI Development: Mazor, R. D., A. C. Rehn, P. R. Ode, M. Engeln, K. C. Schiff, E. D. Stein, D. J. Gillett, D. B. Herbst, and C. P. Hawkins. 2016. Bioassessment in complex environments: Designing an index for consistent meaning in different settings. *Freshwater Science* 35 (1):249–71.

Reference Conditions: Ode, P.R., A.C. Rehn, R.D. Mazor, K. Schiff, E. Stein, J.T. May, L.R. Brown, D. Gillett, D. Herbst, K. Lunde and C.P. Hawkins. 2016. Evaluating the adequacy of a reference site pool for ecological assessments in environmentally complex regions. *Freshwater Science* 35 (1): 237-248.

Developing a Causal Assessment

- Causal assessment to link indicator condition with causal stressors to evaluate regulatory/program performance.

  - Use science-based methods to disentangle effects from their causes

Identifying Drivers of Change

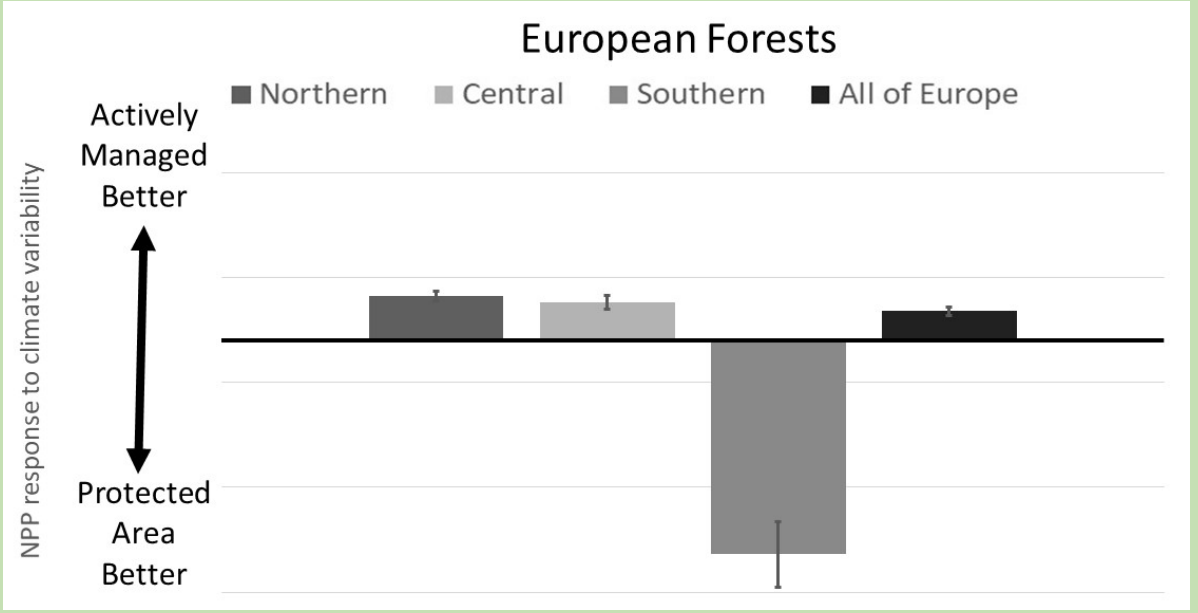
Adam Moreno

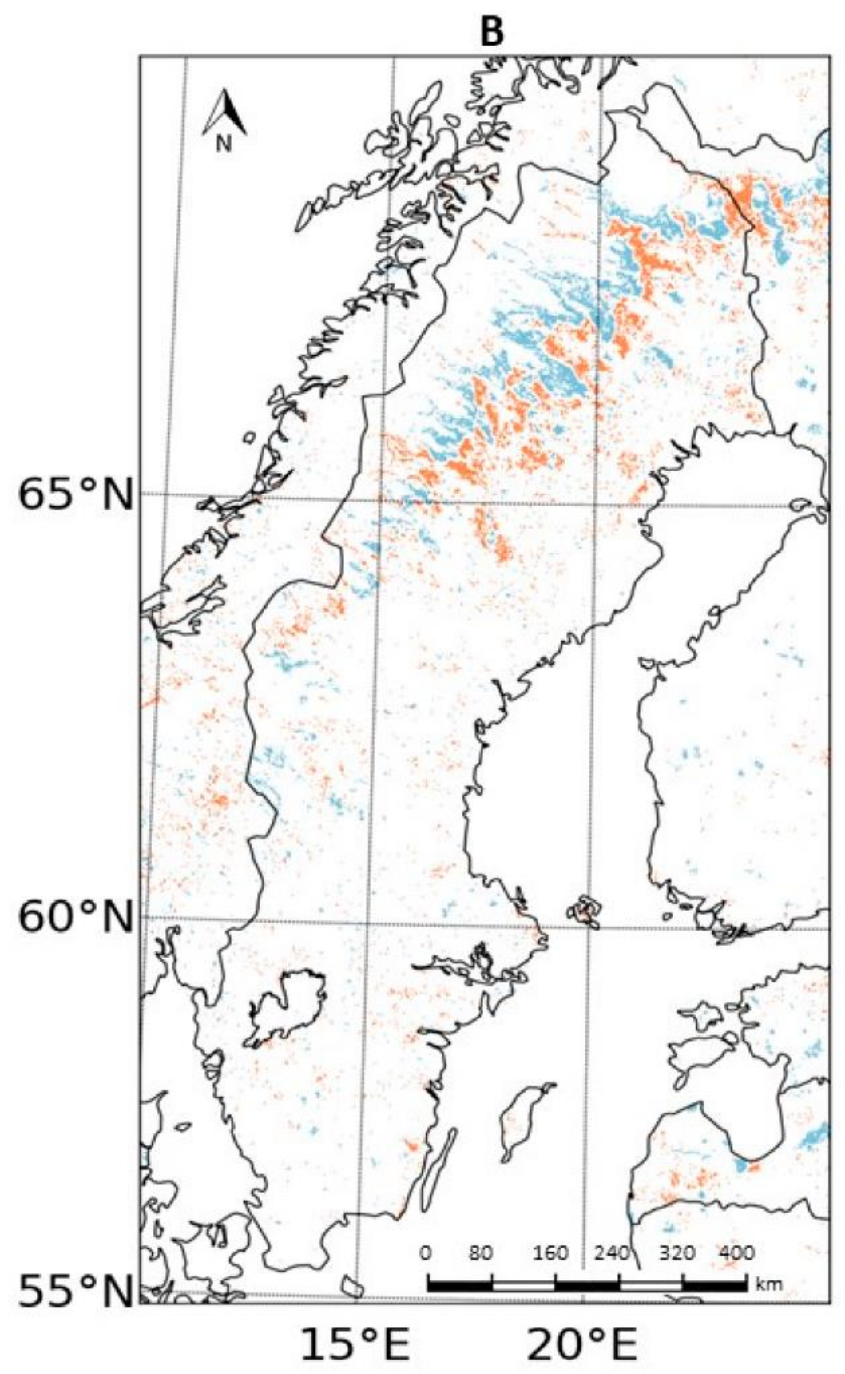
Methods of teasing out drivers of change

- Experimental design (control and experimental groups)
- Detrending
- Modeling
- Machine learning
- Multivariate Analysis (Principal component analysis, MANOVA, etc.

An example

- How does conservation impact productivity stability (an indicator of biodiversity)
- A quasi-experimental design through resampling





remote sensing

MDPI

Article

The Continental Impact of European Forest Conservation Policy and Management on Productivity Stability

Adam Moreno [1,*], Mathias Neumann [2], Phillip M. Mohebalian [3], Christopher Thurnher [2] and Hubert Hasenauer [2]

Resampling results. Zoomed into Sweden.

Blue = conserved forests.
Red = actively managed forests

Proximate Next Steps

October 2018 – January 2019 Develop EPM Methods	White Paper review by WG and stakeholders (workshop). Assemble all input and finalize methodology for EPM development process.
January 2019 - April 2019 Working Group and Public Screening of EPMs	Commence EPM selection screening in consultation with EPM WG. Stakeholder workshop to solicit input on EPM screening results (candidate indicators). By April select final candidate EPMs for further analysis.
April – June 2019 EPM Data Availability Evaluation	Work through EPM data availability and technical challenges in consultation with WG. Develop recommended final eligible (feasible) EPMs for monitoring and assessment.
June 2019 Final EPM Selection	Present draft final EPMs to stakeholders (workshop)
June- December 2019 Next Steps of Data Gathering, Processing, etc.	Commence technical steps of accessing and processing data, etc. Begin to refine plan for Assessment stage of EPM program.

EPM Working Group Membership

Invitation for members of the public or nominees to join EPM Working Group

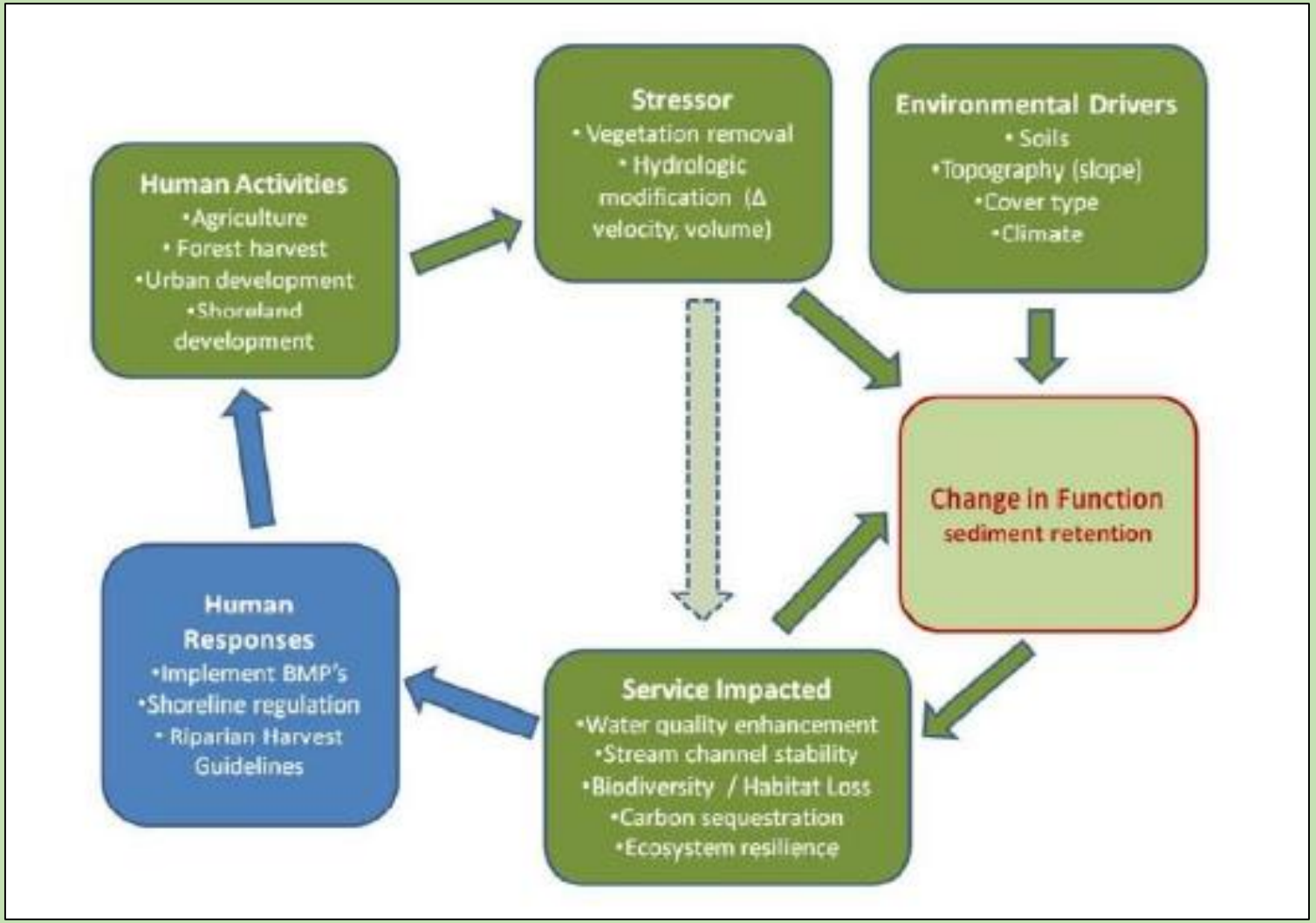
http://resources.ca.gov/forestry/epm/

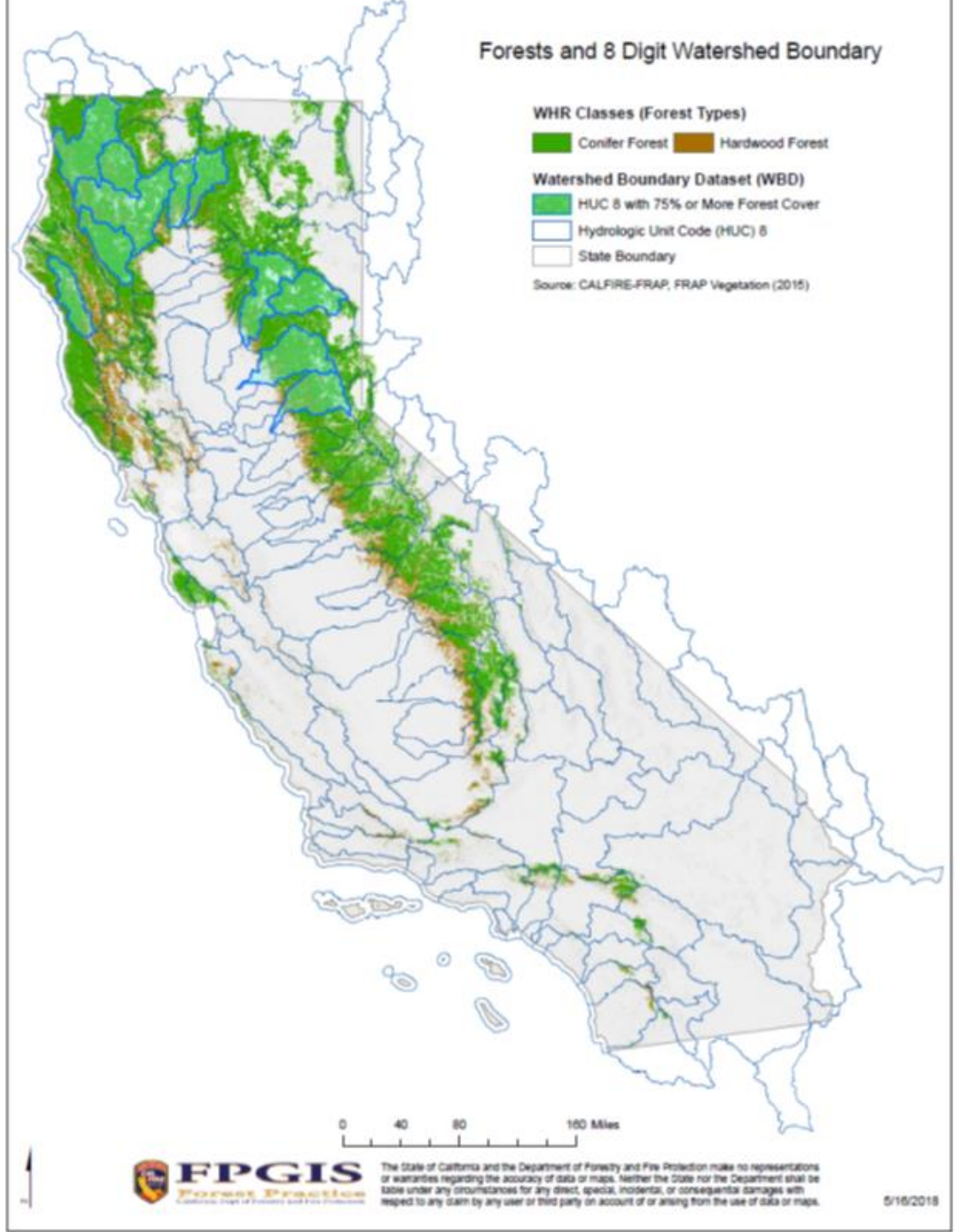
Break 10 Minutes

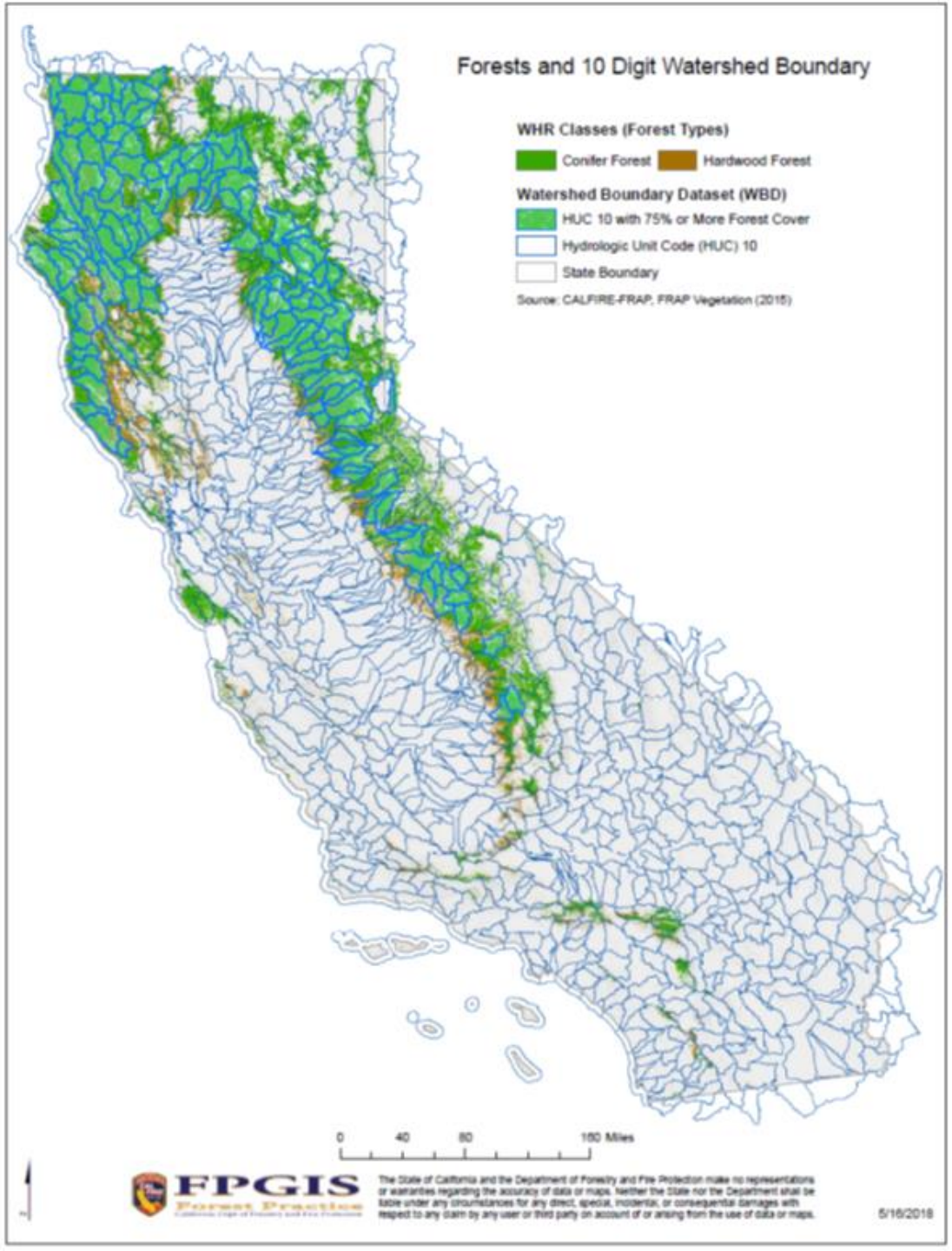
Open Discussion

- Concerns regarding overall program direction/approach, participants, work product
- Is the scope (geographical reach, forest management focus) of the timberland monitoring program adequate? Shortcomings/concerns
- Agreement on core definitions in White Paper: EPMs, Ecosystem Services, Indicators, etc.
- General structure of methods- suggestions to strengthen?
- Additional tools/approaches to bring into the EPM effort

Extra Slides


Stressor
• Vegetation removal
• Hydrologic modification (Δ velocity, volume)
Environmental Drivers
• Soils
•Topography (slope)
•Cover type
•Climate
Human Activities
•Agriculture
• Forest harvest
•Urban development
•Shoreland development
Change in Function
sediment retention
Human Responses
•Implement BMP's
•Shoreline regulation
• Riparian Harvest Guidelines
Service Impacted
•Water quality enhancement
•Stream channel stability
•Biodiversity / Habitat Loss
•Carbon sequestration
•Ecosystem resilience


Forests and 8 Digit Watershed Boundary
WHR Classes (Forest Types)
Conifer Forest
Hardwood Forest
Watershed Boundary Dataset (WBD)
HUC 8 with 75% or More Forest Cover
Hydrologic Unit Code (HUC) 8
State Boundary
Source: CALFIRE-FRAP, FRAP Vegetation (2015)
0
40
80
160 Miles
FPGIS
The State of California and the Department of Forestry and Fire Protection make no representations or warranties regarding the accuracy of data or maps. Neither the State nor the Department shall be liable under any circumstances for any direct, special, incidental, or consequential damages with respect to any claim by any user or third party on account of or arising from the use of data or maps.
5/16/2018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