ICARP TAC Resilience Metrics Workgroup: Framing and Overview

NUIN-TARA KEY, JENN PHILLIPS, BRETT COZZOLINO

ICARP TAC WORKGROUP ON RESILIENCE METRICS

JUNE 10 2020

Agenda

Item 1 | Welcome and Roll Call

Item 2 | Overview of Resilience Metrics and Measurable Outcomes

Item 3 |Lightning Round Talks on Climate Change Indicators and Resilience Metrics

Item 4 | Draft Scope of Work and Goals for Resilience Metrics Work Group, and Roles of Work Group Members

Item 5 | General Public Comment

Item 6 |Wrap up & Meeting Adjourned

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February TAC workgroup discussion

- This priority is key to the TAC's charge and role; state needs uniform metrics and measurable outcomes to track progress, program effectiveness, manage investments in line with priorities.
- Identifying resilience metrics is hard but worth starting and can be improved upon over time; evolving and iterative process.
- We can learn from mitigation and look for proxies to start.
- There are experts we should reach out to and partner with, as well as resources to review and aggregate.
- In order to understand investment and policy decisions relative to urgency of action, we could outline how and when the metrics might be used.

April TAC meeting discussion

- Support for the resilience metrics priority and plan and the 2020 work plan
- This metrics effort will be key for defining/executing the meanings of resilience, adaptation, timelines, etc.
- Will help identify gaps in information and research that can be capitalized on for future state efforts like California climate assessments, Safeguarding, etc.
- Need to make sure metrics discussions consider and link short-term COVID-19 and climate priorities to middle and longer-term priorities and pathways

Resilience Metrics and Measurable Outcomes Priority

Quarter 1	Quarter 2	Quarter 3	Quarter 4
Metrics work introduced and scoped at April TAC meeting Kickoff of work group on resilience metrics	Presentation on resilience metrics work to date, with invited experts and report out from work group on initial findings	Potential public, community workshop to get feedback on metrics Potential presentation from Sierra Nevada Conservancy ecosystem services dashboard and Tahoe Conservancy on metrics work	Final technical and research report on state of resilience metrics developed and delivered to decision-makers and end users

Key Questions Ahead

- What have we learned from climate change mitigation that should be applied to how we approach tracking progress on climate resilience?
- What resources do we have on resilience metrics and what is the current state of practice on resilience metrics?
- What are the major gaps in information and our understanding?
- How do we best leverage existing discussions and frameworks to advance this metrics and outcomes discussion?
- Metrics to do what…?

TAC Vision: Key Components

- **All people and communities** respond to changing average conditions, shocks, and stresses in a manner that minimizes risks to public health, safety, and economic disruption and maximizes equity and protection of the most vulnerable.
- **Natural systems** adjust and maintain functioning ecosystems in the face of change.
- **Infrastructure and built systems** withstand changing conditions and shocks, including changes in climate, while continuing to provide essential services."

TAC Definition of Vulnerable Communities

"Climate vulnerability describes the degree to which **natural, built, and human systems** are at risk of exposure to climate change impacts. Vulnerable communities experience heightened **risk** and increased **sensitivity** to climate change and have less **capacity** and fewer resources to cope with, adapt to, or recover from climate impacts.

These disproportionate effects are caused by physical (built and environmental), social, political, and/or economic factor(s), which are exacerbated by climate impacts. These factors include, but are not limited to, race, class, sexual orientation and identification, national origin, and income inequality.

Climate Vulnerability

TAC Definition of Climate Vulnerability

TAC Vision

Climate Impact	Risk	Sensitivity	Adaptive Capacity
Human and social system	Climate vulnerability describes the degree to which natural, built, and human systems are at risk of exposure to climate change impacts. Vulnerable communities experience heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts.		
Natural systems			
Built systems			

Adaptive Capacity

Climate Impact	Risk	Sensitivity	Capacity
Human and social systems			
Natural systems			
Built systems			

Adaptive Capacity = the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences

Resilience Metrics Definitions

- **2018 Safeguarding states that metrics should be developed to track progress in:**
  - **Changing Climate Conditions**: Once key risks are identified; metrics should be identified to track the progress and occurrence of change.
  - **Resilience Outcomes**: Metrics should be developed that track the performance of a plan or investment, both in terms of resilience to climate change and in meeting management objectives. Metrics should track proactive action taken by the state to enhance resilience, as well as the effect of past actions.

Resilience Metrics Definitions

Indicator:

An **“indicator”** refers to a characteristic used to describe something.

An indicator can consist of a process, or a condition.

However, given the difficulty of directly measuring many processes, for our discussions we propose (1) using the term “indicator” to refer to a site-specific condition at a given moment, and (2) that using multiple indicators taken together (especially when measured over time) can approximate a process.

Resilience Metrics Definitions

Metrics:

Measuring an Indicator implies the need for a measurement **("metric")** and then a further need to create or utilize a dataset to monitor that indicator through metrics.

- Outcome-based metrics represent a specific, observable and measurable indicator of an outcome.
- Output-based metrics measure the inputs to a given system and may be used to share progress on an outcome-based metric. These two metrics, taken together, may holistically be thought of as **impacts.**

Gaps and Challenges

- Availability of sector or region-wide data is incomplete, depending on the indicator.
- Matching indicators across regions or sectors is difficult (one type of indicator for one sector might not have a positive match in another region.)
- Signal-noise ("fat-tailed uncertainty") in chosen indicators.
- Down-scaling (or up-scaling) indicators from one region to another may result in an aggregation 'trap'.
- Measuring adaptation actions using mitigation actions is challenging depending on whether the adaptation/resilience action fulfills universal applicability and uniform effect.

Natural Systems

Draft Definition of Resilient Natural Systems:

"Natural systems adjust and maintain functioning ecosystems in the face of change."

- March 2019 TAC discussion

Built Systems

Draft Definition of Resilient Built Systems:

"Infrastructure and built systems withstand changing conditions and shocks, including changes in climate, while continuing to provide essential services."

- March 2019 TAC discussion

Social Systems

Draft Definition of Resilient Social Systems:

"All people and communities respond to changing average conditions, shocks, and stresses in a manner that minimizes risks to public health, safety, and economic disruption and maximizes equity and protection of the most vulnerable."

- March 2019 TAC discussion

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Speakers

- Martine Schmidt-Poolman, California Energy Commission
- Carmen Milanes, Office of Environmental Health Hazard Assessment
- Dorian Fougeres, California Tahoe Conservancy
- Adam Parris, NYC Mayor's Office of Resiliency

California
Energy Commission
Research & Development

Tracking historical and projected changes to California's climate

Martine Schmidt-Poolman
Energy Research and Development Division

June 10, 2020

Bridging a Gap

Between regionally downscaled climate projections and adaptation policy & practice

1. Sharing of data and methodologies:
    - Deliver (distill) terabytes of data to a broad user community to support decision-making

2. Development of data and methodologies
    - Higher-resolution data and new methods for assessment

3. Guidance & training
    - Which data and projections to use; when and how; where are caveats?

1. Sharing

Cal-Adapt.org: A publicly available, online resource.

- Provides scientific basis for understanding and managing climate-related risks.
- Conveys **local climate risks:**
  - peer-reviewed science,
  - easy-to-understand format,
  - interactive maps and charts.
- Offers **access to climate change data** for further analysis and research.
- Enables **development of custom decision-support tools.**
- All data was developed as part of the Fourth Assessment.

Cal-Adapt (*ongoing*)

- Initial and current funding from California Energy Commission for energy-related components.
- Follow-on funding from the Strategic Growth Council's Climate Change Research Program.

Stages of development:

- Cal-Adapt 1.0: Web-based resource to showcase California's innovative climate change research (*2011 – 2015*).
- Cal-Adapt 2.0a: Scenarios for energy sector research and planning (*2016 – mid 2018*).
- Cal-Adapt 2.0b: Expanding data infrastructure and development of enhanced visualization and custom tools *(mid 2018 – 2021)*.

Ongoing Enhancements – Cal-Adapt

Energy-related research grants (California Energy Commission) include support for**:**

- **Sea-level rise tool** to present results of California's Fourth Climate Change Assessment, aligning w/ Ocean Protection Council guidance.
- **Enhanced wildfire scenarios**: wildfire seasonality, severity, emissions, and extremes;
- **Pre-processing of data** to facilitate custom analyses.
- **Visuals and analyses** showing "climate anomalies" relative to historical baseline.

Strategic Growth Council Climate Change Research Program grant:

- *Address "non-energy" needs (e.g., local & regional governments, public health);*
- *Supported by climate change investment funds.*

2. **Development** of data and methodologies

Higher-resolution data and improved/new methods to assess and identify:

- climate threats to infrastructure,
- risks associated with compound events,
- climate "hot-spots" of risk to operations and/or infrastructure.

Examples:

- Downscaling Methods and Products
  - Downscaled weather, climate and hydrology data from multiple climate scenarios are needed to translate global climate model (GCM) climate projections to spatial and temporal details that are relevant to decision makers.

White Paper from May 2020: https://efiling.energy.ca.gov/GetDocument.aspx?tn=232882

- Hourly temperature
  - Generation of future projections over California at 29 meteorological stations used for energy demand forecasting in the state.
  - Curated repository of hourly weather observations at 39 locations for the period 1973-2019 was produced after careful data quality review.

Staff workshop Dec 18, 2019: https://www.energy.ca.gov/event/workshop/2019-12/staff-workshop-hourly-temperature-data-cal-adapt

3. Guidance and Training

- To aid users from different backgrounds to use the data.
  - Cal-Adapt has API and the data download tool for those who want raw(er) data.
  - Cal-Adapt has visualizations to aid everyone.
- To provide insight in data: sources, limitations, parameters, etc.
- Insight in (expected) updates to data.

Use of Cal-Adapt

Cal-Adapt has affected adaptation practice, policy, and planning in California.

- Publicly available and utilized by many stakeholders.
- Recognized as a key resource by existing legislation and guidance.
- Supports climate policy by providing a point-of-access for data adopted by the state.
- Provides a resource used by state agencies.

Use of Cal-Adapt (2)

- State resources refers or direct local governments, planners and staff to Cal-Adapt:
  - General Planning Guidelines (2017 update), §65302(g)(4),
  - Adaptation Clearinghouse,
  - Resolution (no. 2017-0012) on "Comprehensive Response to Climate Change" (State Water Resources Control Board),
  - Caltrans' Transportation Adaptation Planning Grant Program.
- Noted in Rulemaking, Legislation and the State's Adaptation Strategy:
  - Legislation (SB 379) requiring integration of climate-related risks into local hazard mitigation planning,
  - Safeguarding California (2018 update) notes Cal-Adapt as a resource,
  - CPUC Adaptation Rulemaking (R-18-04-019).
- Government Agency Applications.
- Used by independently owned utilities (IOUs) to support:
  - vulnerability assessments,
  - on-the-ground resilience efforts.

Future of Sharing, Development and Guidance

- Higher-resolution data and new methods needed (from 4 km, daily resolution to 2 km, hourly resolution).
- Vigorous outreach to enable **collaborative development** of decision support tools.
- **Training** and ongoing assistance in how to use climate projections for resilient planning and operations is needed.

Future of Sharing, Development and Guidance (2)

Proposed agreements *(awaiting approval June Business Meeting - Natural Gas Program (PIER) funded)*

- *Development and Evaluation of a High-Resolution Historical Climate Dataset*
  - Development of two separate regional models to produce a spatially and temporally detailed historical climate record.
  - Reconstructions of California's past climate will extend to the immediate past (through 2019) and focus on capturing extreme weather and compound events of concern to the natural gas sector.

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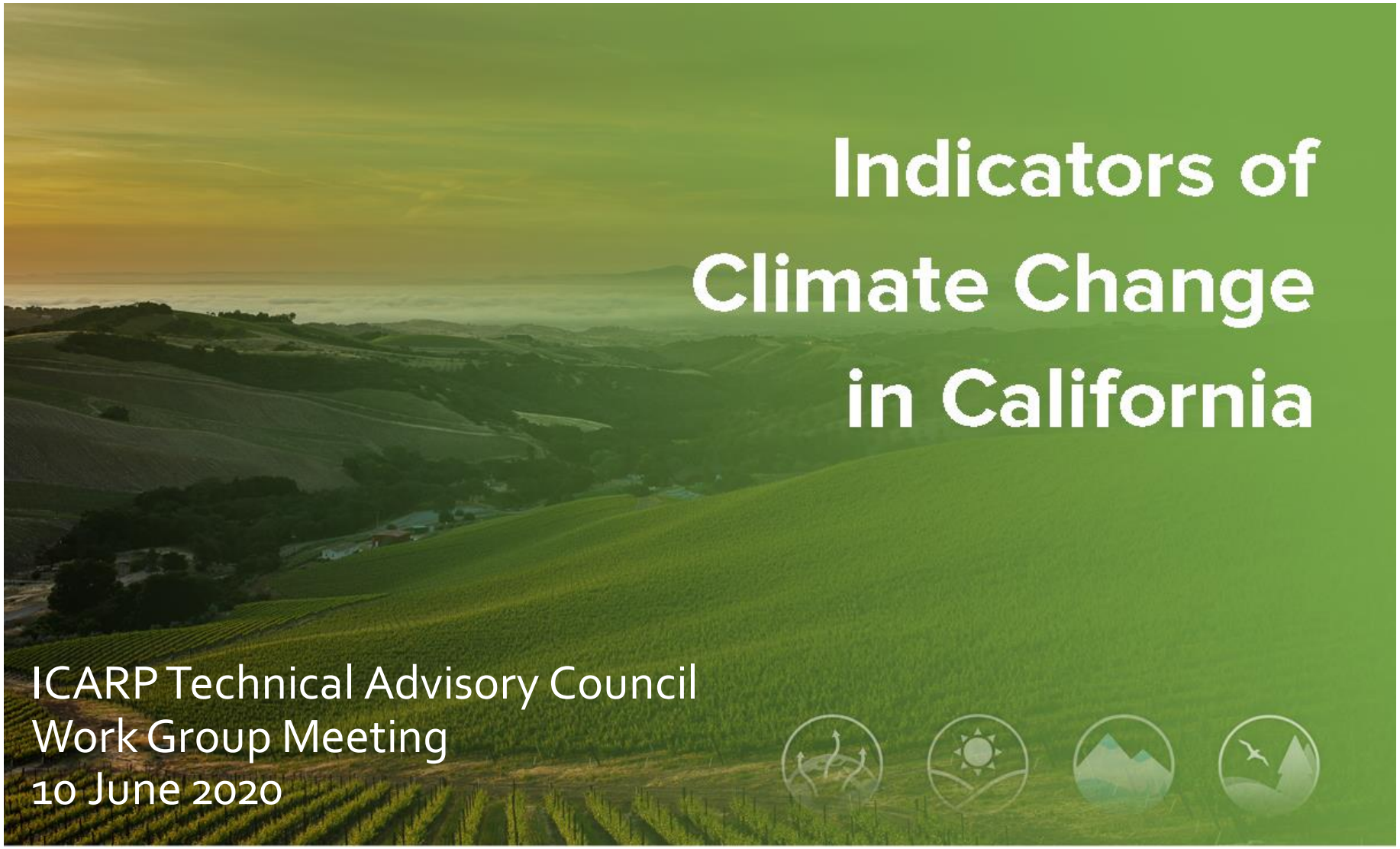
- *Climate Analytics to Support Natural Gas Sector Utilities*
  - Development of a web-based data assimilation platform.
  - Provide for central access of multiple, quality-controlled data streams of significance to the natural gas sector, including weather observations, remote sensing and modeled historical climate data.

Future of Sharing, Development and Guidance (3)

Grant Funding Opportunity

- GFO-19-311: "Development of next-generation climate projections to support electricity sector resilience **and** delivery of data in a manner that informs energy sector planning and research through stakeholder engagement, development of rigorous analytics, and development of a data platform."
- Released June 1, 2020. Applications due: August 31, 2020
- Application workshop June 18, 2020 10am -12pm

(https://www.energy.ca.gov/solicitations/2020-06/gfo-19-311-climate-scenarios-and-analytics-support-electricity-sector)



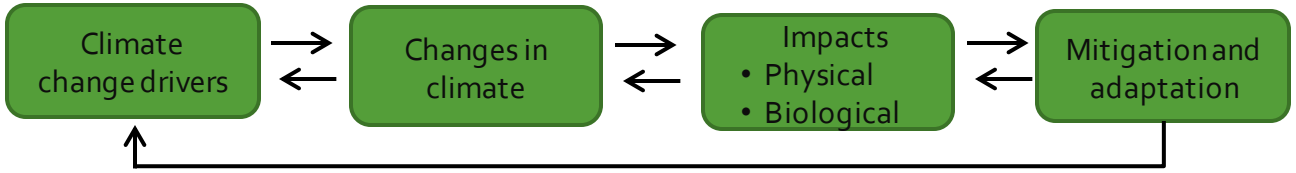
Carmen Milanes
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

OEHHA
SCIENCE FOR A HEALTHY CALIFORNIA

Background

- Environmental Protection Indicators for California (2002) intended to be used by CalEPA for:
  - reporting on trends/state of the environment
  - tracking progress, supporting a "results-based management" system

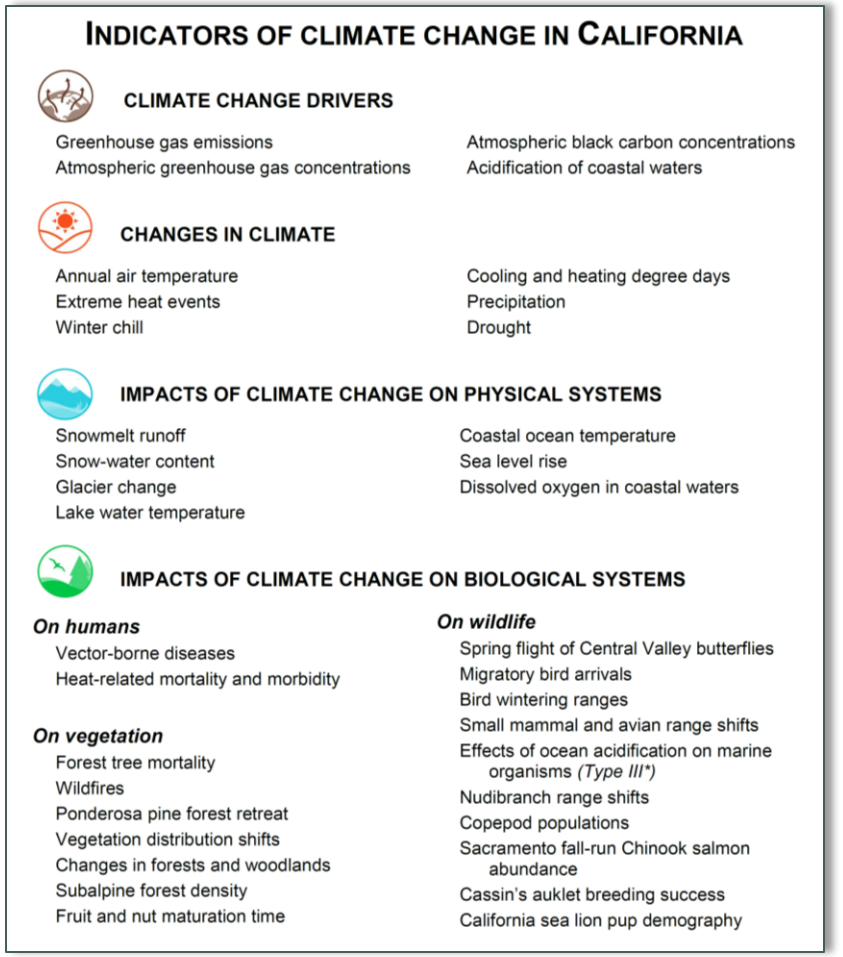
- Indicators of Climate Change reports (2009, 2013, 2018)



OEHHA
SCIENCE FOR A HEALTHY CALIFORNIA

Indicators of Climate Change in California

- Collectively present California's climate change story
  - Trends based on observations, monitoring data
  - Evidence of how our climate is changing and how these changes have impacted the state
  - Context for mitigation and adaptation
- Prepared in close collaboration with other state agencies, federal government, and academia/research institutions



INDICATORS OF CLIMATE CHANGE IN CALIFORNIA

CLIMATE CHANGE DRIVERS

- Greenhouse gas emissions
- Atmospheric greenhouse gas concentrations
- Atmospheric black carbon concentrations
- Acidification of coastal waters

CHANGES IN CLIMATE

- Annual air temperature
- Extreme heat events
- Winter chill
- Cooling and heating degree days
- Precipitation
- Drought

IMPACTS OF CLIMATE CHANGE ON PHYSICAL SYSTEMS

- Snowmelt runoff
- Snow-water content
- Glacier change
- Lake water temperature
- Coastal ocean temperature
- Sea level rise
- Dissolved oxygen in coastal waters

IMPACTS OF CLIMATE CHANGE ON BIOLOGICAL SYSTEMS

On humans

- Vector-borne diseases
- Heat-related mortality and morbidity

On vegetation

- Forest tree mortality
- Wildfires
- Ponderosa pine forest retreat
- Vegetation distribution shifts
- Changes in forests and woodlands
- Subalpine forest density
- Fruit and nut maturation time

On wildlife

- Spring flight of Central Valley butterflies
- Migratory bird arrivals
- Bird wintering ranges
- Small mammal and avian range shifts
- Effects of ocean acidification on marine organisms *(Type III*)*
- Nudibranch range shifts
- Copepod populations
- Sacramento fall-run Chinook salmon abundance
- Cassin's auklet breeding success
- California sea lion pup demography

Next steps

- Workshop: *Exploring California's Climate Change Connections*
  - Last quarter of 2020?
- Next edition of report scheduled for release in 2021
  - Tribal impacts are missing from previous reports: aim to fill this gap
  - Update existing indicators
  - Add new indicators

For more information:
https://oehha.ca.gov/climate-change/document/indicators-climate-change-california
Carmen Milanes, carmen.milanes@oehha.ca.gov

OEHHA
SCIENCE FOR A HEALTHY CALIFORNIA

Resilience Metrics in the Lake Tahoe Basin

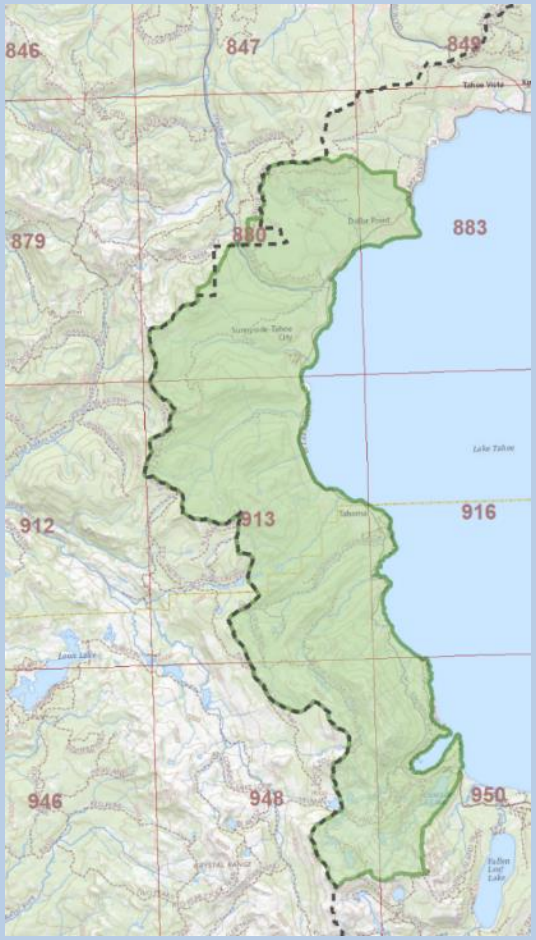
Dorian Fougères, PhD, Chief of Natural Resources

June 10, 2020

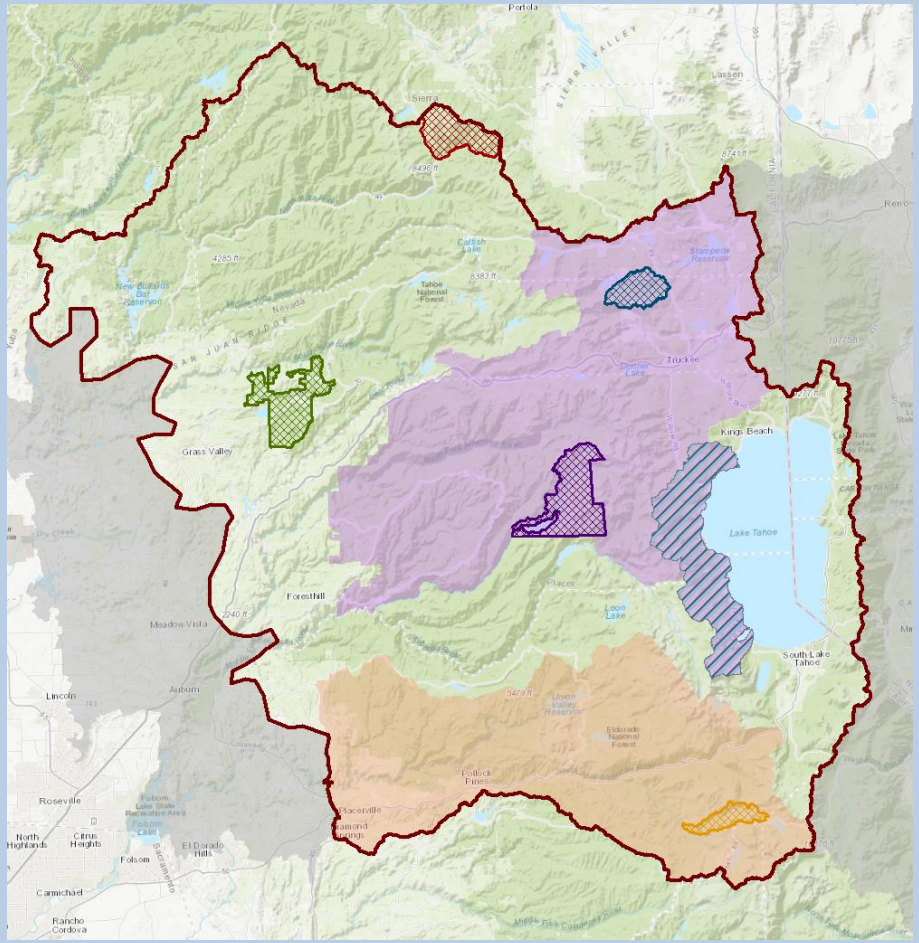
Lake Tahoe West and Tahoe-Central Sierra Initiative

Project

Landscape

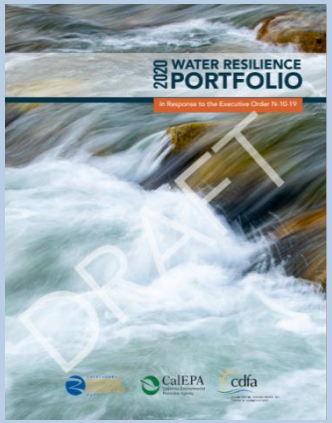


Region

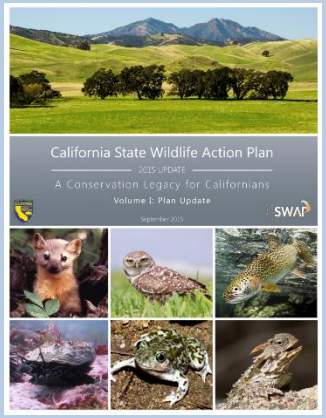


Integrated Vulnerability Assessment and Adaptation Portfolio

WATER



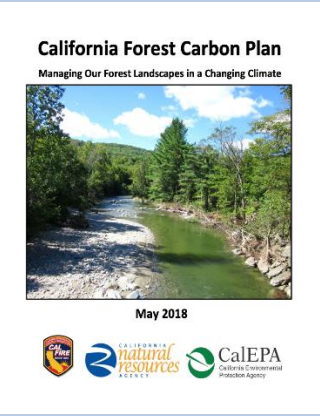
WILDLIFE



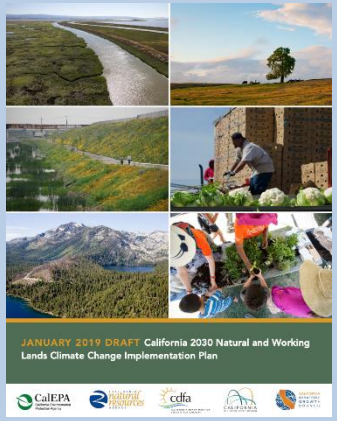
COMMUNITIES

TRANSPORTATION

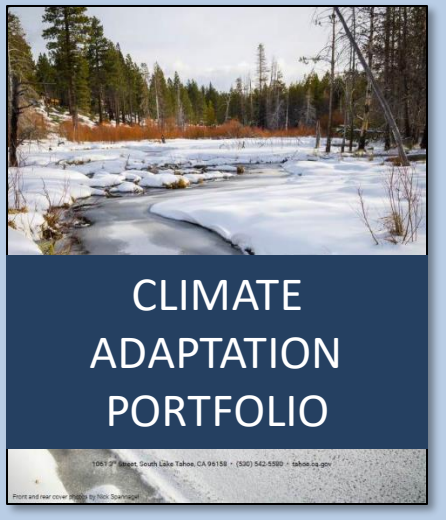
FOREST CARBON



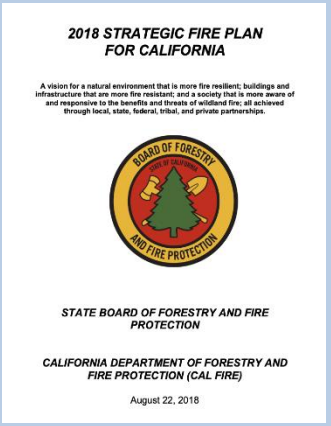
WORKING LANDS



CLIMATE ADAPTATION PORTFOLIO



FIRE



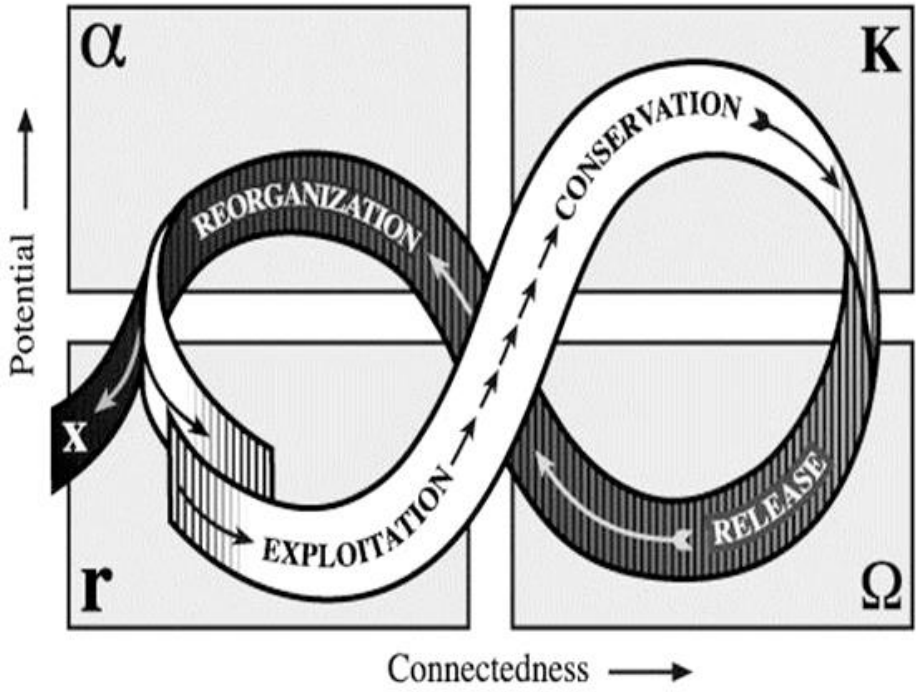
Frames

1. Metaphor
2. Qualitative system property
3. Quantitative system property

Complex Adaptive Systems (CAS)

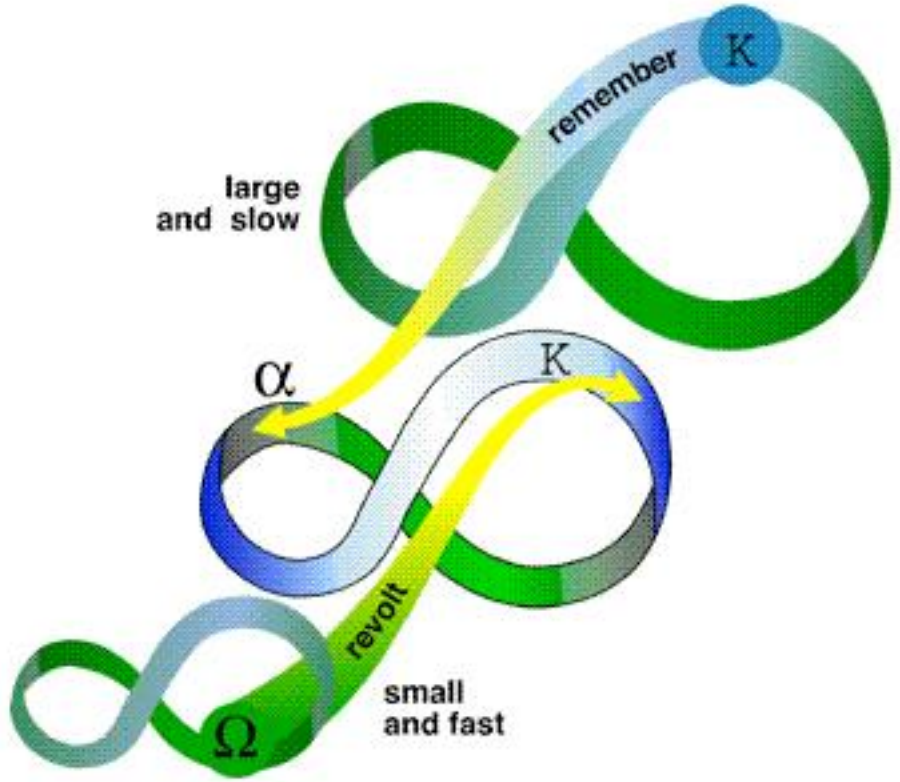
1. Characteristics

2. Adaptive Cycle



Gunderson & Holling 2002
https://islandpress.org/books/panarchy

3. Panarchy



Social-Ecological Resilience

1. Linked rather than binary systems

2. Adaptability and adaptive capacity

3. Transformability

Practical Starting Points

1. Orientation – Resilience *of* what *to* what?
2. Values – For whom?
3. Process
4. Qualitative and quantitative
5. Utility

Lake Tahoe West Restoration Partnership

LANDSCAPE VALUES & SERVICES - *WHAT WE WANT TO BE RESILIENT*

DISTURBANCE TYPE - *WHAT WE WANT VALUES & SERVICES TO BE RESILIENT TO*

	Upland Ecosystems including vegetation, wildlife*, water quality (lake clarity), water supply, soils, and carbon	Meadow / Riparian Ecosystems including vegetation, wildlife, water quality (lake clarity), water supply, soils, and carbon			Aquatic Ecosystems incl. wildlife, water quality (lake clarity), water supply	Public Health and Safety			Cultural Landscapes includes ecosystems, archaeological sites, as well as associations with places	Recreation Including Wint as well as Summ
	Forests including shrub communities	**Meadows and Marshes**	**Aspen Forests**	**Riparian Areas**	**Streams and Lakes**	**Life and Property**	**Water Quality and Supply** (municipal use, fire-fighting)	**Air Quality**		
A. Fire, including fire-related smoke *affects the following values: vegetation, wildlife, water quality (lake clarity), soils and carbon, as well life & property, water quality & supply, air quality, and recreation*	Mean condition class Fire severity Trees per acre Seral stage (P) Vertical & Horizontal heterogeneity (P) Vegetation type (O) Treatment type (O) (R) Terrestrial wildlife connectivity	Mean condition class Fire severity Roads & trails linked to water channels Human access	Mean condition class Fire severity Trees per acre (desire primarily aspen)	Fire severity Trees per acre Seral stage (P)	Not primary disturbance for the above value	Fire risk index	Fire risk index Water quality	(R) Air quality	*to be developed with the Washoe Tribe*	Fire severity Fire risk (R) Air quality
B. Flood *affects vegetation, wildlife, water quality (lake clarity), water supply, soils, carbon, life & property, water quality & supply, and recreation*	Not primary disturbance for the above value	Roads & trails linked to water channels Floodplain condition	Not primary disturbance for the above value	Roads & trails linked to water channels Floodplain condition (R) Stream channel stability	Floodplain condition (R) Stream channel stability	Roads & trails linked to water channels Floodplain condition	Water quality Floodplain condition	Not primary disturbance for the above value	*to be developed with the Washoe Tribe*	Roads & trails link water channel
C. Drought (linked to Tree Mortality) *affects vegetation, wildlife, water supply, water quality & supply, and recreation*	Trees per acre Climatic water deficit Snowpack Bark beetle predators Seral stage (P) Treatment type (O) (R) Terrestrial wildlife connectivity	Meadow refugia Meadow connectivity Climatic water deficit Snowpack Floodplain condition Vegetation type (O)	Trees per acre Snowpack Floodplain condition Vegetation type (O)	Trees per acre Snowpack Floodplain condition Vegetation type (O) (R) Stream channel stability (R) Stream complexity	Snowpack Floodplain condition Aquatic organism passage Native fish diversity (R) Stream channel stability (R) Stream temperature	Not primary disturbance for the above value	Snowpack	Not primary disturbance for the above value	*to be developed with the Washoe Tribe*	Snowpack
D. Insects and Disease (linked to Tree Mortality) *affects vegetation, life & property, and recreation*	Trees per acre Climatic water deficit Bark beetle predators Seral stage (P) Treatment type (O) Vegetation types (O) (R) Terrestrial wildlife connectivity	Not primary disturbance for the above value	Trees per acre Climatic water deficit Seral stage (P)	Trees per acre Climatic water deficit Seral stage (P)	Not primary disturbance for the above value	Trees per acre (large amt. of hazard trees)	Not primary disturbance for the above value	Not primary disturbance for the above value	*to be developed with the Washoe Tribe*	Trees per acre (large amt. of ha trees)
E. Climate Change (other than A,B,C, so warming temperatures and changes in the timing and form of precipitation) *affects vegetation, wildlife, and recreation*	Fire severity Trees per acre Thermal tolerance Climatic water deficit Snowpack Bark beetle predators Seral stage (P) Treatment type (O) Vegetation type (O) (R) Terrestrial wildlife connectivity	Meadow refugia Meadow connectivity Thermal tolerance Climatic water deficit Snowpack Floodplain condition	Thermal tolerance Snowpack Floodplain condition	Thermal tolerance Snowpack Floodplain condition (R) Stream channel stability (R) Stream complexity	Snowpack Floodplain condition Native fish diversity (R) Stream channel stability (R) Stream complexity (R) Stream temperature	Not primary disturbance for the above value	Not primary disturbance for the above value	Not primary disturbance for the above value	*to be developed with the Washoe Tribe*	Human acces (R) Air quality
F. Erosion (other than B, so improperly engineered or maintained roads & trails, and mechanical vegetation treatments) *affects water quality (lake clarity), soils, carbon, and recreation*	Water quality	Roads & trails linked to water channels Human access Floodplain condition	Not primary disturbance for the above value	Roads & trails linked to water channels Human access Floodplain condition	Roads & trails linked to water channels Human access	Not primary disturbance for the above value	Not primary disturbance for the above value	Not primary disturbance for the above value	*to be developed with the Washoe Tribe*	Roads & trails link water channe Human acces
G. Air Pollution other than A (e.g., ozone) *affects vegetation, air quality, and recreation*	*No current indicator, needs future investigation*	Not primary disturbance for the above value	Not primary disturbance for the above value	Not primary disturbance for the above value	Not primary disturbance for the above value	Not primary disturbance for the above value	Not primary disturbance for the above value	*No current indicator, needs future investigation*	*to be developed with the Washoe Tribe*	*No current indica needs future investigation*
H. Human Presence and Activity (other than A and F, so noise, vegetation manipulation, & invasive species) *affects wildlife and vegetation*	Human access (R) Terrestrial wildlife connectivity	Human access Floodplain condition	Human access Floodplain condition	Human access Floodplain condition	Roads & trails linked to water channels Human access	Not primary disturbance for the above value	Not primary disturbance for the above value	Not primary disturbance for the above value	*to be developed with the Washoe Tribe*	Not primary disturb for the above va

Lake Tahoe West Restoration Partnership

Resilience of What – uplands, meadows, aquatics, public health & safety, cultural landscapes, recreation

To What – fire & smoke, flood, drought, insects & disease, other climate impacts, erosion, air pollution, human activity

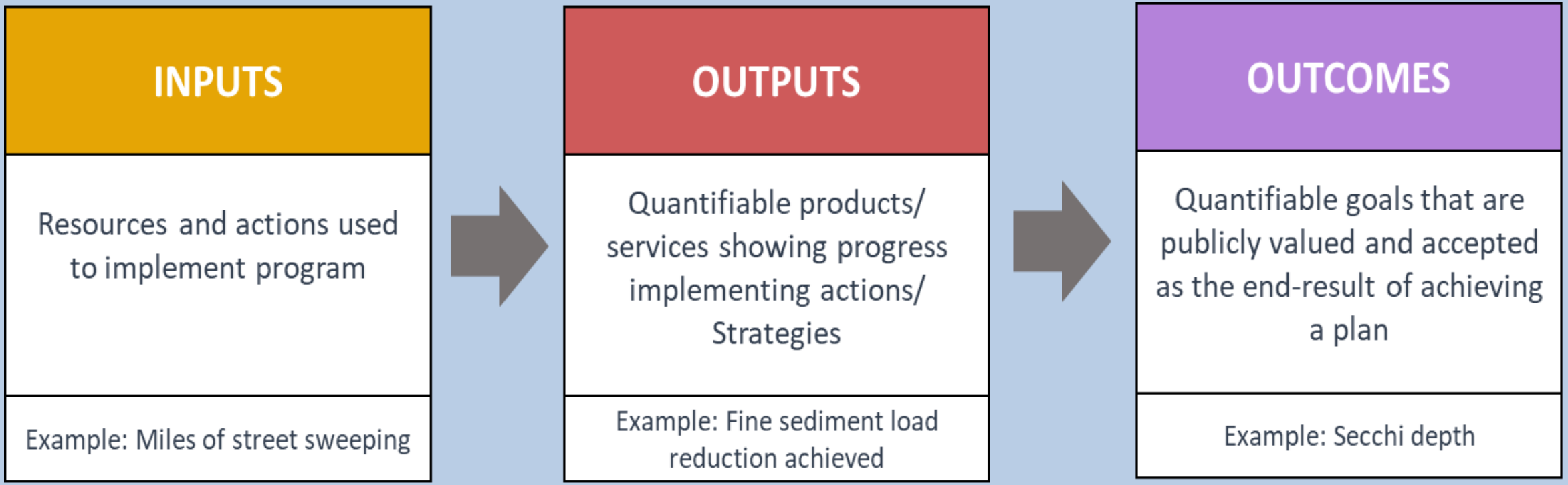
For Whom – residents, business, Washoe Tribe, and recreationists

DISTURBANCE TYPE - *WHAT WE WANT VALUES & SERVICES TO BE RESILIENT TO*	LANDSCAPE VALUES & SERVICES - *WHAT WE WANT TO BE RESILIENT*								
	Upland Ecosystems including vegetation, wildlife*, water quality (lake clarity), water supply, soils, and carbon	**Meadow / Riparian Ecosystems** including vegetation, wildlife, water quality (lake clarity), water supply, soils, and carbon			**Aquatic Ecosystems** incl. wildlife, water quality (lake clarity), water supply	**Public Health and Safety**			**Cultural Landscapes** includes ecosystems, archaeological sites, as	**Recreation** Including Winter / Summer
	Forests including shrub comm									
A. Fire, including fire-related smoke *affects the following values: vegetation, wildlife, water quality (lake clarity), soils and carbon, as well life & property, water quality & supply, air quality, and recreation*	Mean condition cl Fire severity Trees per acre Seral stage (P) Vertical & Horizontal heter Vegetation type (Treatment type (C (R) Terrestrial wildlife connectivity									everity risk quality
B. Flood *affects vegetation, wildlife, water quality (lake clarity), water supply, soils, carbon, life & property, water quality & supply, and recreation*	Not primary disturbance for the above value	Roads & trails linked to water channels Floodplain condition	Not primary disturbance for the above value	Roads & trails linked to water channels Floodplain condition (R) Stream channel stability	Floodplain condition (R) Stream channel stability	Roads & trails linked to water channels Floodplain condition	Water quality Floodplain condition	Not primary disturbance for the above value	*to be developed with the Washoe Tribe*	Roads & trails linked to water channels
C. Drought (linked to Tree Mortality) *affects vegetation, wildlife, water supply, water quality & supply, and recreation*		rees per acre Snowpack dplain condition etation type (O)		Trees per acre Snowpack Floodplain condition Vegetation type (O) (R) Stream channel stability (R) Stream complexity	Snowpack Floodplain condition Aquatic organism passage Native fish diversity (R) Stream channel stability (R) Stream temperature	Not primary disturbance for the above value				Snowpack
D. Insects and Disease (linked to Tree Mortality) *affects vegetation, life & property, and recreation*		rees per acre tic water deficit eral stage (P)		Trees per acre Climatic water deficit Seral stage (P)	Not primary disturbance for the above value	Trees per acre (large amt. of hazard trees)				Trees per acre (large amt. of hazard trees)
E. Climate Change (other than A,B,C, so warming temperatures and changes in the timing and form of precipitation) *affects vegetation, wildlife, and recreation*		rmal tolerance Snowpack dplain condition		Thermal tolerance Snowpack Floodplain condition (R) Stream channel stability (R) Stream complexity	Snowpack Floodplain condition Native fish diversity (R) Stream channel stability (R) Stream complexity (R) Stream temperature	Not primary disturbance for the above value				Human access (R) Air quality
F. Erosion (other than B, so improperly engineered or maintained roads & trails, and mechanical vegetation treatments) *affects water quality (lake clarity), soils, carbon, and recreation*		imary disturbance he above value		Roads & trails linked to water channels Human access Floodplain condition	Roads & trails linked to water channels Human access	Not primary disturbance for the above value				Roads & trails linked to water channels Human access
G. Air Pollution other than A (e.g., ozone) *affects vegetation, air quality, and recreation*		imary disturbance he above value	Not primary disturbance for the above value		Not primary disturbance for the above value	Not primary disturbance for the above value				*No current indicator, needs future investigation*
H. Human Presence and Activity (other than A and F, so noise, vegetation manipulation, & invasive species) *affects wildlife and vegetation*	Human access (R) Terrestrial wildlife connectivity	Human access Floodplain condition	Human access Floodplain condition	Human access Floodplain condition	Roads & trails linked to water channels Human access	Not primary disturbance for the above value	Not primary disturbance for the above value	Not primary disturbance for the above value	*to be developed with the Washoe Tribe*	Not primary disturbance for the above value

Practical Starting Points *continued*

6. Prioritization criteria

7. Performance measures



based on Taylor-Powell & Henert '08
https://fyi.extension.wisc.edu/programdevelopment/files/2016/03/lmguidecomplete.pdf

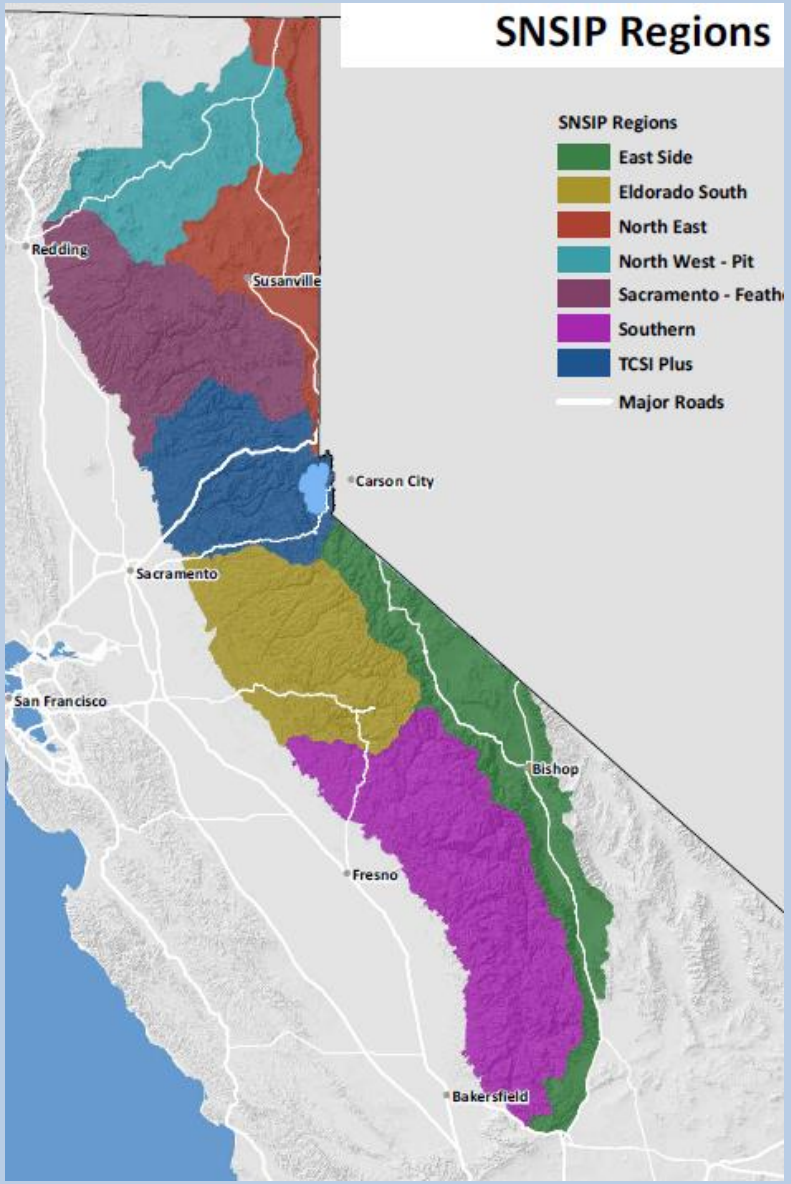
Pillar	Indicators (Outputs)	Outcomes
Forest resilience	• Structure • Composition • Disturbance	• Vegetation composition and structure are in alignment with topography, desired disturbance dynamics, and landscape conditions, and adapted to anticipated climate change effects.
Fire dynamics	• High severity • Low and moderate severity	• Fire burns in an ecologically beneficial and socially acceptable way that perpetuates landscape heterogeneity and rarely threatens human safety or infrastructure
Wetland integrity	• Structure • Composition • Hydrologic function	• Meadow and riparian ecosystems have functional hydrology and biology such that they provide multiple ecosystem services, including water storage, flow regulation, sediment capture, stream bank stability, carbon sequestration, and high biodiversity.
Biodiversity conservation	• Focal species • Species diversity • Community integrity	• The network of native species and ecological communities is sufficiently abundance and distributed across the landscape to support and sustain their full suite of ecological and cultural roles.
Carbon sequestration	• Above-ground carbon • Below-ground carbon • Greenhouse gas flux	• Carbon sequestration is enhanced in a stable and sustainable manner that yields multiple ecological and social benefits.
Water security	• Yield • Quality • Storage	• Water reliability, quantity, and quality are buffered against precipitation variability and disturbance through the integrity of forests and their watersheds.
Air quality	• Particulate matter • Visual quality • Ozone	• Emissions from fires are limited to low and moderate fires in wildland ecosystems. Forests provide a positive contribution to air quality by capturing pollutants.
Fire-adapted community	• Hazard • Preparedness • Management capacity	• Communities live safely with fire, and are accepting of management and natural ecological dynamics. Beneficial fire is supported. There is sufficient capacity to manage desired fire and suppress unwanted fire.
Economic diversity	• Wood product availability • Wood product market • Workforce diversity • Economic health	• Forest and wetland management and outdoor activities support a sustainable natural resource-based economy, particularly in rural communities. Forest products are harvested sustainably, and utilized at their highest and best use, promoting workforce development, revenue, and a market demand for materials generated by forest management activities.
Social and cultural well-being	• Public health • Engagement • Recreation	• Quality environmental conditions that afford a connection to place and nature, recreational opportunities, human health, cultural identities and practices, and shared stewardship.

Tahoe-Central Sierra Initiative

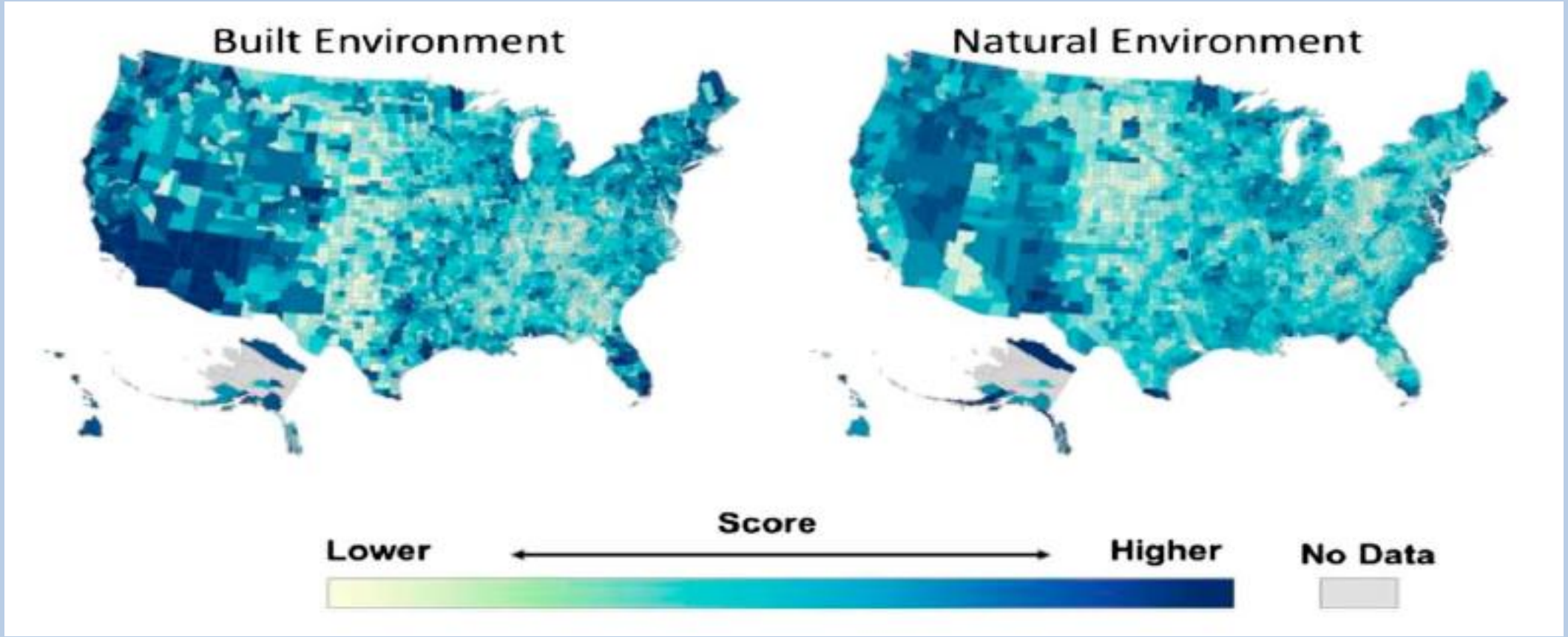
Ten "Pillars" of Resilience

Transferability and Replicability

Sierra Nevada Strategic Investment Plan



Standing on Shoulders



Summers etal ‘18
http://dx.doi.org/10.1029/2018GH000160

Design Principles

1. Diversity and redundancy
2. Connectivity
3. Slow variables and feedbacks
4. CAS thinking

5. Learning
6. Participation
7. Polycentric (and adaptive) governance

Biggs etal '15
https://doi.org/10.1017/CBO9781316014240

Organizational Adaptive Capacity

1. Strategic planning
2. Integrated vulnerability assessment
3. Program assessment and adjustment
4. Staffing models and training
5. Contingency budgeting

Organizational Adaptive Capacity

6. Communications
7. Financial & operational agreements
8. Advocacy for alignment and integration
9. Science technologies and tools
10. Planning for transformation

Agenda

Item 1 | Welcome and Roll Call

Item 2 | Overview of Resilience Metrics and Measurable Outcomes

Item 3 |Lightning Round Talks on Climate Change Indicators and Resilience Metrics

Item 4 | Draft Scope of Work and Goals for Resilience Metrics Work Group, and Roles of Work Group Members

Item 5 | General Public Comment

Item 6 |Wrap up & Meeting Adjourned

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Scope of Work

- Workgroup was formed by TAC at April Meeting to answer key questions:
  - What have we learned from climate change mitigation that should be applied to how we approach tracking progress on climate resilience?
  - What resources do we have on resilience metrics and what is the current state of practice?
  - What are the major gaps in information and our understanding?
  - How do we best leverage existing discussions and frameworks to advance this metrics discussion?
- Goals of the workgroup include:
  - identifying needs for adaptation
  - tracking implementation of actions
  - guiding allocation of resources
  - assessing achieved results for state planning purposes

Discussion Questions

- Does it make sense to structure our work around these three systems?
  - If we do, what are the intersectional issues to think about so that they are in each bucket?
  - How do we handle sectors that cut across systems?
- Do TAC members have input into the draft definitions for each system & definitions of metric and indicator?
- What other gaps do you see?
- Do you have suggestions for experts for each system?
- Are you interested in a particular system for follow-up?

Starting definitions

Resilient Natural Systems: “Natural systems adjust and maintain functioning ecosystems in the face of change."

Resilient Built Systems: "Infrastructure and built systems withstand changing conditions and shocks, including changes in climate, while continuing to provide essential services."

Resilient Social Systems: "All people and communities respond to changing average conditions, shocks, and stresses in a manner that minimizes risks to public health, safety, and economic disruption and maximizes equity and protection of the most vulnerable."

Next Steps…

- OPR will take TAC input to develop revised scope of work and timeline
- Continue working on white paper

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Thank you!

Jenn Phillips and **Nuin-Tara Key**

Governor's Office of Planning and Research

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