Sierra Cascade Dialog - #14 – Monitoring: why and how the Forest Service can monitor economic, social and ecological systems to inform forest management

THURSDAY, JANUARY 22, 2015

Overview

The tables on pages 1-11 reflect notes taken by facilitators from break-out session discussions.

The following tables present information that participants shared during the small group work sessions on the various resource themes. The information relates to possible monitoring efforts for categories of indicators. The headers of the tables consist of the indicator description, why the indicator is important, resources or expertise required to do monitoring, and could the data be collected by volunteers and user groups? Additional comments and discussions topics that the group noted are provided after the table of indicators. The six resource theme tables are:

- Terrestrial Ecosystems
- Aquatic Ecosystems and Watersheds
- Focal Species and Ecosystem Diversity
- Recreation Including Visitor Use and Visitor Satisfaction
- Climate Change as it Relates to Forest Health and Productivity
- Social, Cultural and Economic Monitoring Indicators

Resource Themes and Comments – Small Group Work

Terrestrial Ecosystems

Table 1 - Resource Theme: Terrestrial Ecosystems

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Bird Diversity (or other animal class or group).	• Ability to observe a whole community. • Habitat extent and distribution. • Seral stages—loss of forest. • Indicates absence or presence of specific forest ecosystem features. • Exhibits habitat diversity. • Exhibits vegetation diversity.	• Good vegetation maps. • Avian biologists or ornithologists. • Partnerships. • Spatial Scales—data. • Range of sizes of species. • Vegetation ecologists.	Yes, it's already being done.
Habitat and Vegetation.	• Definition of terrestrial. • Types and arrangements and connectivity are critical determinants of which species are able to utilize an area. • Determines species.	• Sound definition of terrestrial. • Vegetation ecologist. • GIS analysts. • FIA data. • Remote sensing. • Land-use data. • Fire perimeter data. • Habitat modeling expertise. • Models—habitat connectivity models. • LIDAR. • Vegetation and fire models. • A sound structure composition measuring process to integrate information into a synthetic network (approach) to help judge changes over time in habitat, composition, structure, and function; disturbance regimes.	Yes, with good oversight and partners including USFS, academics, state and local agencies, NGOs, and private consultants.

Terrestrial Ecosystems Discussion Topics

Diversity:

Diversity is a key component for measuring/monitoring terrestrial ecosystems. Although the group chose to use bird population diversity for the worksheet and for the report, other groups such as butterflies, fungi, deciduous trees, etc. could be chosen as representative of an area.

Heterogeneity:

Very important. Currently, there is no agreement or metrics to determine what is good or what would signal that we are moving in the right direction. What changes are occurring over spatial and temporal scales—what is the baseline? There is a need to resolve these questions as indicators are developed.

List of other indicators identified by the group:

- Habitat connectivity for old growth or mature forests for wildlife species.
- Amount and distribution of complex early seral forests.
- Forest natural communities seral stage distribution within an assumed range of natural distribution.
- Area and distribution of habitat type over space and time, including attribution of causes of changes that occur over time.
- Vegetation condition/fire regime condition class – how fire impacts this value.
- Trail widening and trail braiding over time.
- Numbers of multiple species of birds, including groups (composition).
- Predator levels.
- Presence/absence of forest insects and diseases (Native and non-native).
- Fire as an ecological process.
- Distribution and extent of fire severity and extent of fire effects.
- Post fire effects equal floristic diversity, small mammals, birds and vegetation conditions.
- Invasive plants and animals.
- Illegal marijuana grown acreage distribution.

Table 2 - Resource Theme: Aquatic Ecosystems and Watersheds

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Physical habitat including hydrologic connectivity, status and changes to.	This indicator is important because it influences the following: • Recreation. • Wildlife species. • Aesthetics. • People. • Groundwater. • Flood attenuation. • Clean water (quality). • Sediment movement.	• Multi-disciplinary expertise. • Expertise exists in agencies. • Need inter-agency partnerships and with volunteers.	Yes.
Vegetation, distribution, disturbance, especially water table species.	This indicator is important because it influences: • Composition and structure of habitat. • Wetland delineation. • Soils. • Stream channel stability. • Carbon storage. • Forest products. • Water quality. • Riparian shading. • Water table maintenance. • Forest health.	• Aerial survey expertise. • On the ground expertise. • Software programs for mapping. • University partnerships with agencies, inter-agency partnerships, and partnerships with volunteer groups.	Yes.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Water- quality (including temperature), quantity (flow), macro-invertebrates.	• For potential energy purposes. • Economics. • Recreation. • Compliance with laws and regulations. • Base-flow time series. • Ecosystem servicing. • Fisheries. • Climate. • Supply to downstream users.	• State and federal agencies have the expertise. • It is fairly easy for volunteers to collect water samples.	Yes.

Aquatic Ecosystems and Watersheds Discussion Topics

List of other indicators identified by the group:

- Hydrological connectivity such as channel and floodplain.
- Precipitation such as rain and snow.
- Sediment such as source, end place.
- Effective riparian shading.
- Fisheries management such as diversity and abundance.
- Aquatic macro-invertebrates.
- Presence of bacteria such as e. coli, and other pathogens.
- Management responsiveness.
- Stream bank stability.
- Physical fish habitat.
- Vegetation issues such as disturbance and water table species, kind and distribution.
- Water flow.
- Water temperature.
- Time series imagery—general.

Focal Species and Ecosystem Diversity

Table 3 - Resource Theme: Focal Species and Ecosystem Diversity

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Suite of primary excavators or black-backed woodpeckers.	• Association with high severity fire. • Primary excavator. • Association with complex early seral habitat. • Indicator of snag density. • Indicator of how fire moves across the landscapes (fire is primary disturbance factor).	• The Forest Service spends about $100,000 annually on BBO monitoring. • Crews to indicator species—training. • Quality assessment quality control e.g. citizens overview—scientist verification. • Levels of complexity. • Habitat data needed. • Overtime may be less costly as linkages established between factors.	Data could be collected in by the following: • Training volunteers. • Forest Service staff. • Scientists. • Other Partners.
6-10 bird species that are meadow obligates (guild). ***There is a concern if migratory does not fulfill role years, and use of this indicator may be influenced by non-forest changes.**	Indicator of health of meadows ecological function/integrity.	Field observers to measure (See BBO).	Data could be collected by the following: • Training volunteers. • Forest Service Staff. • Scientists. • Other partners.
Invertebrates Distribution.	• Bees/butterflies. • Flower forbes. • Need to identify habitats of concern.	• Quick surveying. • Great sunflower project. • Leverage what is in existence.	Data could be collected by the following: • Volunteer surveying. • No traps.

Focal Species and Ecosystem Diversity Discussion Topics

Indicator Ideas:

- Types of species characteristics habitat.
- Acres, distribution and connectivity of critical habitat.
- Presence or absence of species.
- Amounts and types of fire.
- Water quality and availability.

- Energy movement.
- Population across range and distribution.
- Connectivity across and or among focal species.

Grouping 1: (Focal Species Habitat).

- Snag density at various scales.
- Structural.
- Large Woody Debris (LWD).
- Brush and forest density.

Grouping 2:

- Bird habitat diversity.
- Pollinators by types and kinds.
- Suites or groups for focal species/multiple metrics for resources/focal species.

Characteristics:

- Beavers and Bats.
- Black-backed woodpeckers.
- Keystone species such as species whose influence beyond their numbers.
- Relationship to ecological integrity factor.

Recreation Including Visitor Use and Visitor Satisfaction

Table 4 - Resource Theme: Recreation Including Visitor Use and Visitor Satisfaction

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Number of days facilities exceed or are at capacity.	• Measures better programming to improve site. • Captures more/greater visitor satisfaction. • Reflects protection of resources. • Specifies diversity and protection of habitat. • Measures watershed protection. • Promotes sound development/scale of site.	**People:** Observers, recorders, analysts, GIS specialists. **Other Resources:** GIS data, surveys, electric monitors, questionnaires, campsite registration data.	Yes, NGO partners for example.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Visitor satisfaction with primitive experience.	• Reflects access to wilderness experience. • Assesses wilderness characteristics. • Evaluates species diversity. • Captures capacity or patterns of use. • Evaluates commercial use of wilderness area. • Measures water quality.	**People:** surveyors, monitors, scientists, maintenance crews. **Other Resources:** surveys, user permits.	Yes, partners can conduct trend analysis and trail management.
Youth access to recreation and transportation from urban areas.	• Measures access of under-represented population to forest experience. • Increases stewardship of natural resources. • Measures self-reliance. • Measures variety of recreational opportunities. • Facilitates diversity among users. • Promotes social justice. • Measures self-discovery. • Evaluates physical and mental health.	**People:** community partners and schools. **Other Resources:** marketing materials, transportation, baselines, programming, funding.	Yes, research partners.
Trail erosion and use.	Determines recreational use and impact on habitat.	**People:** environmental scientists, GIS, specialists, volunteers, trail crew, associations.	Yes, visitors, trail user groups, interpretive educational NGOs and associations.

Recreation Including Visitor Use and Visitor Satisfaction Discussion Topics

List of other indicators identified by the group:

- Number of users per forest: day, type, length of stay.

- Visitor satisfaction of trail (condition, availability, type).
- Number and location of parking slots for dispersed recreation and for white water rafting.
- Number of re-opened 4x4 trails as indicators of visitor use/demand and concentration/patterns.
- Fees collected.
- Trail suitability on landscape.
- Trail use.
- Number of unauthorized trails.
- Type of recreation use within a forest.
- Proportion of ecosystem represented by wilderness.
- Habitat degradation or level of overuse in a specific area; habitat health.
- Level of erosion, bare soil, disturbed vegetation.
- Number of volunteer trails.
- Species diversity.
- Habitat health near trails.
- Number of incidents (safety).
- NVUM data.
- Census data comparison.
- Number of open vs. closed areas.
- Developed campground use/density.
- Dispersed use/density.
- General forest access.
- Trail and road access.
- Quality of trails.
- Number of days in the forest.
- Number and availability of permits.
- RV, OHV equipment sales.
- Gateway community information.
- Sustainability of campgrounds and facilities.
- Balance of use.
- Damage to campsite.
- Access to transportation/public transit.

Comments

It may have been helpful to have the SME provide examples of some of the current indicators (e.g., recreation opportunity spectrum), in order to set the tone and guide the conversation.

Table 5 – Resource Theme: Climate Change as it Relates to Forest Health and Productivity

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Water- soil moisture, precipitation, snow pack, migration in snow levels, transpiration, temperature, water quality and quantity.	Water is vital to life and ecosystem viability. The forest needs water to sustain and keep trees alive. Southern Sierra is getting drier and it is important to know about these dryer conditions as it relates to vegetation and wildlife health and composition, recreational uses and down-stream users.	State and federal agencies (CA Department of Water Resources (DWR) and Natural Resources Conservation Service (NRCS)) have weather and water monitoring stations, as well as high elevation snow pack and water monitoring data.	Forest Service partnership with volunteer groups to purchase weather station equipment with grant funds and then deploy with volunteer effort. Also collect data from stations with volunteers. Work with agencies (DWR and NRCS) to compile data, but work crowd-sourcing to process data into workable format for deeper assessment.
Landscape and ecotone changes.	Southern Sierra is getting drier. Species migration to follow habitat, as well as to understand current land, forest and habitat conditions and possible future conditions. Although need to be clear as to whether biological or physical is of value to track. Need long term data to establish baseline. Monitoring is necessary across the whole forest/region to see interconnected baseline.	Remote sensing – aerial, LIDAR or satellite.	Use experts to provide volunteer training to do trail monitoring, and use grant money to purchase equipment.
Carbon sequestration, emissions, and storage.	To protect and understand air quality in the forest as well as in neighboring areas, and the overall health/condition of the forest.	Remote sensing—aerial, LIDAR, or satellite. Really need on the ground/ in forest testing and monitoring by scientists.	Use citizen scientists for code/analysis of existing data.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Disturbance: **changes in desired functions of an ecosystem or landscape.**	• Developing a baseline and measuring deviation. • Plant and animal species monitoring assist in predicting changes in tree ranges, vegetation and species communities. • Help in determining ecosystem variability. • Help determining whether transitions are occurring on an individual or community level. • Help understanding the adaptability of species and what type of habitat requirements should be priorities to maintain heterogeneity. • Demonstrate system changes. • Assist in developing successful management strategies.	• Foresters and ecologists. • USFS Climate Change Assessment. • Climate vulnerability standards within a region. • Bioregional baseline data. • Snow pack data. • Stream level data. • Remote Sensor Lab data. • Forest Inventory Analysis data.	While analysis of monitoring results requires the expertise of foresters and ecologists, there are a variety of ways that volunteers and user groups could provide data. Speaking with local communities and Tribes about historical observations and using visitor photographs to record changes. Volunteers require training and coordination. It is of particular importance to coordinate these efforts and collection protocols to avoid data overload/ useless data.
Disturbance: Ecosystem stressors such as invasive species, pests and disease, tree mortality, drought.	Same as above.	Same as above.	Same as above.
Disturbance: Upslope migration of species.	Same as above.	Same as above.	Same as above.
Disturbance: Intensity and frequency of wild land fires.	Same as above.	Same as above.	Same as above.

Climate Change as it Relates to Forest Health and Productivity Discussion Topics

This group underscored the importance of determining how these indicators help make management decisions. It is important to ask why something is being monitored before delving into it for the sake of monitoring.

Social, Cultural and Economic Monitoring Indicators

Table 6 – Resource Theme: Social, Cultural and Economic Monitoring Indicators

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Jobs associated with the Forest.	Forest is a large part of the community.	County administrators and USFS staff.	Not Applicable.
Financial impact on rural communities from all forest uses.	Financial health of community and state.	County administrators, chambers of commerce, visitors bureaus, hotel and lodging associations.	Yes.
Water output (quality and quantity).	Municipal needs (e.g., power generation, agriculture, fish).	Hydrologists/equipment.	Yes.
Demographic information on users of the Forest.	Population increase, social justice issues, long-term conservation.	Survey/interviews at multiple scales.	Yes.
Cluster of indicators: school drop- out rates; level of education; income distribution.	Community resiliency.	USFS staff, school districts.	Yes.
2 part indicator: Number and type of conflicts; conflicts resolved among users.	Determine effectiveness of Forest Plan and multi-use management Best Management Practices.	Records of existing/past conflicts, social surveys.	Yes (partnerships).

Social, Cultural and Economic Monitoring Indicators Discussion Topics

Before discussion indicators, a few members of the group said that, particularly for social and economic health issues, the Forest Plan does not yet identify clear goals. This, they said, is problematic. Establishing such goals would make an exercise about indicators much more fruitful. The group discussed a broad goal of maintaining healthy, fire resilient and vibrant forests. Additional points raised in the conversation:

- Clear goals, strategies and desired conditions (relative to social and economic health) needs to preface exploration of monitoring indicators.
- These things are non-existent as of yet for this particular topic (relative to decision-making).

- Understanding of this theme will be informed by successful management results of all other resource themes being explored.
- A comprehensive social survey could address all of these indicators (again, needs to be informed by well-articulated management goals, strategies and desired conditions.
- This resource theme needs more citizen science/partnerships.

List of other indicators identified by the group:

- Purchasing authority.
- Forest reserve revenues—increase back to counties.
- Financial trends.
- Incoming elementary/middle school children in area.
- New business growth or decline—business openings, closures, expansions.
- Snow pack depth/water content.
- Forest absorption—forest and "downstream" conditions.
- Sense of place/attachment.
- Value mapping assessment.
- Trends in objections.
- Number of projects, programs with Native American tribes.
- Number of reports to State Historical Preservation Office.
- Visitor expenditures.
- Trends in Resource specialists/jobs.
- Number of children on school lunch programs.
- Growth of catastrophic fires/costs.
- Deferred maintenance—more accurate.

Compilation of Monitoring Indicator/Characteristic Worksheets Submitted by Individual Participants

The following information on pages 12-29 is unedited from the worksheets provided.

The following tables present information from individual participant worksheets they shared to support the small group discussions.

Terrestrial Ecosystems

Table 7 - Resource Theme: Terrestrial Ecosystem

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Seral stage spatial distribution in forest natural communities within an assumed natural range of variation.	Forest seral stages, including associated key habitat elements, provide habitat for stable and resilient species population.	LIDAR and other remote sensing data, expertise to analyze and process data.	Yes, especially observation of species.
Age-class distribution.	Indication of stand structural diversity and thereby habitat diversity.	Methodology, field work, sampling.	With limited training, volunteers/citizens could aid in the data collection.
Multiple species of birds. 100+ bird species can be monitored with one, standardized approach. That as a group and individually.	Birds can indicate a range of conditions across forest structure, burned areas, chaparral, etc. Birds can be used for effectiveness monitoring and for long term trends	Standardized protocols and study design exists along with expertise. It just takes money	Potentially.
Fire effects monitoring.	Since fires are increasing in size and severity, it is important to examine how fire behavior has affected ecosystem recovery and opportunities to change how we manage fires and appreciate fire in the Sierra ecosystem.	Not sure, USFS Region 5 Ecology programs likely have protocols.	Probably not but groups such as Trout Unlimited and California Native Plants Society may have the expertise.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Presence/Absence types of forest insects and disease.	Insects and disease are major forest disturbance/change factors. They can help us understand how forests are likely to change, identify reasons for susceptibility, what steps might be needed to reduce spread.	None.	None.
Area and distribution of habitat types over space and time, including attribution of the causes of change that occurs over time.	Habitat types, arrangement, connectivity are critical determinants of which species are able to successfully utilize an area for meeting their various life function needs.	Remotely sensed vegetation data, Forest Inventory and Analysis (FIA) data, land use data, fire perimeter data, habitat modeling expertise (e.g., WHR-Wildlife Habitat-Relationships models), GIS hardware, software, expertise.	Limited, may be able to help provide some information on causes of change in habitat.
Acreage extent of established forest.	To measure the status of forest expansion/ contraction.	Remotely sensed data procured and analyzed by the Remote Sensing Laboratory (RSL).	Possibly, in part (for young forests).
Forest habitat connectivity for old forest associated wildlife species.	Providing landscape connectivity for key terrestrial wildlife species to maintain key habitat components such as canopy cover, large trees, etc.	Forest connectivity models for various species, good vegetation maps, LIDAR (Light Detection and Ranging); need vegetation ecologist, wildlife biologists, models and modeling experts.	Unknown.
Snag density at various scales.	Dead wood is critical to ecological function, patch size, diameter distributions, decay- class.	Plots installed at different scales, before and after treatment monitoring.	Yes, minimal training needed to recognize and measure snags.
Primary Cavity Excavators (PCE).	Ecological engineers create habitat for other followers.	Skilled survey crews using broadcast calls, observations or habitat observations.	Experienced volunteers would be needed.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Amount of habitat lost each year to wildfire or escape prescriptive fire.	Tells the number of individual species habitat and connectivity corridors lost due to not having a strategy that addresses this loss and the results of then taking more general forest acres out of management production.	GIS mapping on a region-wide scale at the end of each fire season to track individual and multiple species losses.	Work with CSU Chico and other university GIS certificate programs.
Acres of additional general forest zone that is designated each year to replace individual and multiple species habitat loss due to wildfire.	The additional acres that are removed from general management that would allow economic gain and community stability. This could highlight reasons why we cannot increase pace and scale of restoration needs.	Report through GIS database the additional acres that are designated as replacement for species habitat lost due to wildfire.	Work with CSU Chico and other university GIS certificate programs.
Increase in water yield.	This increase would show how increase in acres treated and reduction of over stocked stands can lead to increase in water yield. Maintaining or enhancing water yield by reducing the number of acres converted to brush fields vs. forest stands due to wildfire.	Work with researchers who are currently doing water yield studies.	UC Merced, UC Berkeley, PSW, local water agencies.
Protection of water quality through reduction in wildfire loss and increase in forest restoration (including in pace and scale).	Would display economically and socially how reduction in intense wildfire loss reduces impacts to water resources facilities.	DWR, PG&E, SoCal Edison, East Bay MUD, local water districts.	

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Reduced forest health.	• Increased tree mortality or infestation by bark beetles. • Large Wildfire Areas. • Trees spaced too close together. • Proactive management needed to nip these issues as early as possible in order to reduce costs and minimize negative environmental impacts.	Silvaculture.	Environmental grants.

Aquatic Ecosystems and Watersheds

Table 8 - Resource Theme: Ecosystems and Watersheds

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Water output	Given the data is becoming available that different timber management practices can have significant changes on water released downstream and water has incredible value for agriculture, municipalities and fisheries.	Hydrologists, and appropriate monitoring stations.	Yes.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Sediment	This is important to water quality and particularly benthic macro-invertebrates and fisheries productivity. Sediment can come from a variety of different sources, so having a robust approach will help provide information to guide management actions. Simply put, sediment is a major limiting factor for fisheries.	• State Water Resources Control Board. • DWR. • Citizen-Science, establish programs to collect basic info and trends. • Private Groups, academic institutions and non-profits.	Absolutely.
Fisheries—effectiveness and status/trend monitoring • **Rare or imperiled species** • **Population assemblage, abundance (relative).**	Fisheries management is important to address population trends over time, which can inform management actions and species response to management actions (i.e., restoration, adaptive management). This can lead to de-listing rare or imperiled species, inform restoration approaches and ultimately increase recreation opportunities (fishing) on USFS lands.	1. Collaboration with state and federal agencies (CDFW, USFWS) • Combine on management plans for individual species • Coordinate on strategies to implement projects 2. Citizen-Science • Establish programs at Forest-level to collect data 3. Partner with private groups—incorporate academics and non-profits to get work done (particularly agreements).	Absolutely.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Pertaining to Threatened and Endangered Species and Species of Special Concern— • **Water Quality, Turbidity, Sediment and other water quality indicators.** • **National BMPs.**	• Shows extent and availability of habitat. • Meets state, federal and tribal requirements for clean water. • Shows if meeting policy and regulations. • Provides for clean drinking water and reduces potential costs of treatment. • Monitors implementation and effectiveness of Best Management Practices.	• Water quality monitoring equipment. • Personnel trained in monitoring techniques.	Yes.
Turbidity.	Sediment in water body indicates channel morphological changes, habitat stress, etc.	• Resources= continuous monitoring stations and samples. • Expertise= not much.	Yes!
• **Precipitation.** • **Temperature.** • **Snow Water Equivalent.** • **Solar Radiation.** • **Flow.** • **Storage.** • **Elevation.**	Helps estimate runoff for water supply and flood concerns.	Automated gaging stations, Operations and Management, expertise needs to use data for applications and modeling.	Both. • California Data Exchange Center (CDEC). • Community Collaborative Rain, Hail and Snow Network (CoCoRahs).
Stream and Riparian Shade.	Sensitive to management/use stability/watershed stability.	Transects established/monitoring repeated every 5 + years.	Yes - with new technology.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Streambank stability and percentage of bare riparian bank vegetation area—measured at most vulnerable wet meadow stream sites at three representative locations in each national forest.	Sloughing, chiseled streambanks crumble or slough into streams creating wider, shallower streams with warmer water temperatures, often increased levels of algae, and reduced critical habitat for aquatic species—especially Threatened and Endangered amphibians.	Very minimal tools and or supplies, with minimal agency staff commitment: camera, quadrat, ruler, etc.	This monitoring is fully appropriate for engaging volunteers as long as there is training, mentoring and oversight.
Use remote sensing to identify percentage of bare soil vs. vegetation in either recent treatment areas within a national forest area or, if pertinent, a recent large wildfire burn area.	Bare soil increases potential for watershed degradation through runoff, erosion, etc.	Skilled FS GIS or soil scientist staff but minimal amount of actual time and expense required.	May be appropriate for college or university research or class project engagement.
E.coli presence vs. state standard in water samples of selected grazed meadow sites taken 5 times per site spread over a summer-fall grazing season on each national forest.	Represents compliance or exceedance of water quality threshold with pathogenic bacteria contamination in selected forest streams.	Forest staff or trained volunteers follow State Water Board sampling protocols—minimal supplies needed. Cost for 50 samples per national forest at laboratories would be $2,500 per year—drop in the bucket as budget cost.	Yes, where mentored with agency hydrologists or biologists for oversight and coordination.
Macroinvertebrates	Responsive to water quality, temperature, habitat type, overall, respond quickly to health of aquatic ecosystem.	Funding to conduct sampling could be at Regional or project level. Analysis of samples done at one or two labs. Cost of samples can be costly if done broadly across a wide landscape.	Additional data on stream characteristics can be collected.
Effective Riparian Shade.	Connection with Stream Temperature.	Relatively low cost common.	Yes.
Turbidity.	Effects on Aquatic life.	Some hardware and technical expertise.	Yes.
Groundwater levels/Recharge.	Groundwater connectivity to surface waters.	Hydrology expertise.	Yes.

Focal Species and Ecosystem Diversity

Table 9 - Resource Theme: Focal Species and Ecosystem Diversity

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Sustainable populations and distribution over range/suitable critical habitat.	Fundamental to health of species. Considerations: Consider hierarchy of choices? Effective? Of greatest concern? Choice of focal species? General indicators or other side plus indicators for each species?	A wide range, interactions with other monitoring themes.	Possibly.
Bird habitat guild diversity: guilds equals sets of 5 or more species that are reliant upon habitat integrity for population viability. Can be a different guild for virtually ANY habitat or resource of interest.	Single species can work but are subject to population pressures; more species= more reliable. Plus more species are tied to particular habitat features which might be useful.	Field observers, many existing methods and projects already exist.	Yes! Many citizen-science and volunteer programs already exist.

Recreation Including Visitor Use and Visitor Satisfaction

Table 10 - Resource Theme: Recreation Including Visitor Use and Visitor Satisfaction

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Visitor use—are we reaching intended audience? Outreach.	None	None	None.
Public transit/Frequency.	None.	None.	None.
Marked increase in OHV purchases. Changing demographics in people purchasing Off Highway Vehicles.	None.	None.	None.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
• **Acres of roadless areas protected through recommended wilderness area designation.** • **Proportion of ecosystems protected by wilderness areas.** • **Visitor satisfaction with primitive recreation experience.**	• Provide for primitive recreation experience. • Visitors have a positive experience in wilderness. • Adequate opportunity for wilderness experience.	• Document survey, minimal expense. • Survey of visitor satisfaction, moderate expense.	None.
Visitor Satisfaction: • **Develop Recreation.** • **Dispersed Recreation.** • **General Forest Access and Use.**	Determine customer experience based on use of existing conditions (unsatisfactory experience).	• Customer on-site surveys. • Customer counts • Traffic counts.	Yes, internal and external.
Measure who is using the area for recreation—diversity of ethnic communities; ages.	This information can tell agency if they need more outreach to various communities and demographics. If lower income people want to come, maybe agency need to coordinate public transport to and from nearest cities and towns. In fact, due to climate change and GHG emissions, the agency should start planning access via public transit for all users.	None.	None.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Visitor use (sustainable levels) **When is visitor use too high/at an unsustainable level?** **Examples—no vegetation at campsites, lots of social trails, polluted water, etc.**	Damaging the resource is undesirable and will impact people's perceptions of a good experience.	None.	None.
For wilderness areas-measure permits and how often they are available/where there are quotas and how often additional permits are left unused. **Permit use and available types.**	It would help inform recommendations for additional wilderness areas or even just inform the need for new trails into wilderness areas. It would assist in maintaining an appropriate balance of use/impact.	None.	None.
Economic Data from Gateway Communities.	Who is spending money and level of demand?	Census Data.	Yes.
Campsite facility conditions.	Necessary to keep setting a standard.	USFS volunteers with expertise and local wisdom.	Yes.
Trail widening or trail braiding.	• Trail capacity has been exceeded for the existing Trail Management Objective. • Need to expand the trail system in order to disperse use, reduce environmental impacts and maintain Trail Management Objective.	• Trail Management Objectives. • Trail Class Compliance. • National Quality Standards for Trails. • Trail Fundamentals FSM 2353.13. • Recreation Opportunity Spectrum.	• Recreation organization. • Volunteers are extremely motivated to build new sections of trail as well as perform maintenance. • Environmental grants. • Motorized grants.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Off Trail Travel.	• Lack of education about staying on the trail and/or trails lack the challenge users seek or lack of sufficient trail system to keep user on the trail. • May need to consider expanding the trail system in order to provide a trail system that the public will stay on.	Routes.	• Tread Lightly. • Recreation Organization. • Environmental grants. • Motorized grants.
Archaeological Point of Interest.	Public wants to see archaeological point of interest. Need to address how to allow this or reroute public away from resource.	Arch Sites.	Recreation Organization. Environmental grants. Motorized grants.
Archaeological issue on or near trail.	Where it is not a point of interest the trail should be rerouted so that it no longer directly crosses an arch site. Mitigation to move trail should be done prior to closing existing route since the impact is existing and closure would only increase other impacts on remaining trails.	Arch Sites.	Recreation Organization. Environmental grants. Motorized grants.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Botanical issue on or near trail.	Trail should be rerouted so that it no longer directly crosses the botanical site. Mitigation to move trail should be done prior to closing existing route since the impact is existing and closure would only increase other impacts on remaining trails.	Botanical.	Recreation Organization. Environmental grants. Motorized grants.
Wildlife issue on trail.	Disperse use so that the number of users would not have an effect on Wildlife. Expand trail system to disperse use and lessen impact on wildlife.	Wildlife.	Recreation Organization. Environmental grants Motorized grants.
Riparian issue on trail.	Does the route cross the creek without rutting? Can the tread be hardened? Mitigating by hardening or realigning route.	Riparian.	Recreation Organization. Environmental grants. Motorized grants.
Healthy wildlife and or presence of endangered or threated species in or around trail system or management area.	Lack of wildlife issue with current uses in area	Wildlife survey.	None.
Conflict of use.	Conflict of use between different forms of recreation on forest trails indicates a need for more trails to disperse use and reduce conflict. Forest recreation manager needs to determine if claimed conflict of use is valid or just intolerance.	Trail Management.	Recreation Organization. Environmental grants.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Deferred Maintenance.	Deferred Maintenance numbers need to be updated to more accurately reflect the cost of bringing the trail or facility up to standard. For example, if a trail has not been maintained for twenty years it will not take twenty years of maintenance costs to bring it back, only a small portion of that. If camp buildings are planned to be painted every ten years but have not been painted for 30 years, they need to be painted once not three times.	Facility Maintenance and Cost Records.	None.
Reduction in recreational use due to wildfire.	Tells what the impacts are due to wildfire impacts and subsequent impact on local communities and businesses.	Study of before and after recreation uses of such areas as PCT, local trails, campgrounds, lakes, etc.	Work with county or local chambers, local recreational groups, FS, BLM and others to record data changes.

Climate Change as it Relates to Forest Health and Productivity

Table 11 - Resource Theme: Climate Change as it Relates to Forest Health and Productivity

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Boundaries of eco-tones/forest types (boundaries may change over time, e.g. move upslope and leading vs. trailing edge of habitats may move at different rates).	Shows availability of resources (e.g., more or less coniferous forest available). Those resources are important to wildlife and have economic value.	Remote sensing as well as on the ground observations.	Yes, especially for on the ground.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Soil carbon and moisture content.	Helps measure sequestration in forests Helps measure fire risk.	Soil carbon may be harder to monitor. It is a significant data gap that would be good to gather to see how much carbon is stored or lost in forests over time and changing conditions.	None.
Long term climate variables like snowpack, precipitation, temperature, soil moisture, run-off.	Predicts water supplies and indicates trends in climate.	Automated and manual measurement, agency cooperation. USFS can cooperate with other agencies who have established monitoring programs on USFS land such as with DWR and the NRCS snow and survey program.	Not really, data are most valuable when long-term and standardized.
Water: quality, quantity (yield), timing, type (rain vs. snow).	• Essential component of ecosystem integrity (terrestrial or aquatic). • Directly relevant to FS land management (e.g., meadow restoration, grazing management. • Directly relevant to community socioeconomics.	Much of it already exists for example, snowpack measurements and streamflow gauges, but should evaluate whether we have key locations covered, such as, lower elevation passes in the Sierra that see the effects of reduced snowpack first. Need to better understand status of groundwater and role in water timing and yield.	Yes, good opportunity for multi-party monitoring and training for measurements to be taken by citizen volunteers.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
• **Stand density.** • **Fuel loading.** • **Tree mortality.** • **Size and severity of wildfires.** • **Species (vegetation) composition, changes over space and time.** • **Vegetation communities (e.g., forest type), spatial distribution of elevation.**	Indicate whether changes in the Forest Plan are needed, e.g., changes to desired conditions as defined by natural ranges of variability or changes in management strategies and/or standards and guidelines. Also, helps to design appropriate restoration/rehabilitation actions in suitable areas.	Remote Sensing Data (satellite imagery, LIDAR, aerial photos) Mapping, FIA. Analysis of Data.	Yes, particularly historic photos over time. Requests for photos or other information from the public must be well-coordinated and focused so it can be used to inform FS management.
Trend of temperature over past centuries.	Winter temperature: • regulates precipitation as water or snow. • regulated growth rates, development of vegetation. • regulates some insect/plant development.	NAO reporting RAWS reports.	No, because lots of other groups (with lots of technology) are already collecting this information.
Vegetation/Animal.	Migrations/shifts in the landscape due to vegetation changes caused by climate change.	None.	Can be coarsely measured by public.
Weather.	All forms of measures will drive results/effects on stressors.	None.	Can be coarsely measured by public.
Disturbance.	Non-natives, wildfires (frequency and intensity), outside of NRV spread, utility, displacement.	None.	Can be coarsely measured by public.
Hydrology.	All forms of water delivery and quality. First recognize geomorphic and geologic shifts.	Can be easily measured; can use more measures at finer scales.	Can be coarsely measured by public.
Snow water equivalent.	Identifies shifting trends in forest hydrology and water availability.	Snow gages; hydrologist or water resource specialist.	Maybe.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Maximum temperature, precipitation.	Direct measure of changing climate.	Weather gages; downscaled climate data from global climate models (GCM).	Yes.
Cumulative Water Deficit (CWD).	Provides a measure of impact from prolonged drought.	Water balance model; hydrologist.	No.
Species Range Shifts.	Identifies tree and plan species most vulnerable to changing climate.	Tree plots; history information on species; vegetation and climate data.	No.
Forest Carbon Storage.	Describes the capacity of forests to mitigate climate impacts.	Tree plots; forest inventory data (FIA); forester.	No.
Wildfire extent and severity.	None.	None.	None.
Forest Health (disease and pests).	None.	None.	None.

Social, Cultural, Economic Health of Sierra Nevada and Cascades Communities

Table 12 - Resource Theme: Social, Cultural, Economic Health of Sierra Nevada and Cascades Communities

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Number of incoming elementary and middle school students /year.	Young or new families getting established in the area.	School district records.	Yes.
Partnerships with Tribes on projects and programs.	Utilization of tribal knowledge and utilizing community investment.	Tribal feedback.	Yes—surveying Tribes in rural communities.
Amount of business overturn in rural communities.	Indicate if businesses are stable and thriving, or struggling.	• Input from business owners. • Business license applications. • New SBA applications.	No.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Actual Animal Unit Months (AUMs) compared to permitted AUMs.	If there is a big difference, the limiting factor needs to be discovered and addressed, as in some areas grazing is the biggest private sector component of the local economy.	Rangeland Management Specialist.	Yes.
The health of cultural resources (food) such as: Black oak (acorns); other plants, tools, animals; Increased yields (pounds of acorns; ease in gathering-harvesting (access); types of crafts sold; wood for fuel.	Supports and sustains a cultural way of life; maintains tradition; allows for cultural tourism; honors an ROD commitment; creates social/learning centers.	• Tribal gatherers/elders. • Fire and fuels management. • Communities interested in volunteering.	Yes.
Social justice/Equal access to nature/demographic information.	Poor communities have less access to wildlife.	None.	None.
How many types of activities in individual forest actually tied to tribal, cultural heritage.	Assist multiple uses and foster collaboration and inclusion of cultural knowledge.	None.	None.
Conflicts between Forest Plan requirements and the needs (operation, maintenance, replacement and construction of new facilities) of special use permit holders such as utilities.	To remove obstacles to harmonious coexistence and identify forest plan changes needed early-on that can be addressed through adaptive forest plan changes to improve best management practices.	Perhaps a survey of permit holders to identify issues. This would require someone to distribute the survey, develop a list of stakeholders and to compile results.	Yes.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
• **Change by year in direct and indirect jobs specifically associated with the National Forest.** • **Since 1985 unemployment rate per county.** • **Since 1985 poverty rate by county.** • **Forest health—average number of acres burned in wildfires/years.**	The National Forest constitutes large acreages in most rural CA counties and doesn't pay taxes. It must contribute in outdoor leisure activities, jobs, timber production, water quantity and quality.	County administrator, local Forest Service HR Staff.	Not necessarily.
Number of acres burned annually by burn severity of category—number, size, and intensity of wildfire.	None.	None.	None.
Moderate and high severity of burned pfl restored to forest land.	None.	None.	None.
Resistance to insects and disease.	None.	None.	None.
Percent of pfl meeting defined, desired condition.	None.	None.	None.
Backlog of not done prescribed burns (acres) and rate of change.	None.	None.	None.
Number of jobs in forest management.	Direct relationship to forest management and economic output.	County, state, national figures.	None.
Diversity of multiple use activities.	Same as above.	Forest Service, Recreation NGOs.	None.
Amount of negative declarations to cultural/historic sites supplied to SHIPO.	Need to minimize impacts to cultural sites.	Forest Service, SHIPO.	None.
Snowpack, precipitation.	Critical for water supply forecasting and flood forecasting both important to economic health of communities.	Weather data collection stations, staff to maintain facilities.	Yes. Many public and private entities find this information useful, if not critical, for their operations.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Number of forest related jobs.	Directly related to local economic sustainability.	None.	None.
Level of alignment with management actions.	Actions align with what people care about.	None.	None.
Trends in local objections filed.	Measures the social acceptability of projects and plans.	Develop and include socioeconomic conditions.	None.
Trends in business start-up/closure/expansion.	Measures the financial support of forest resources to the community.	None.	None.
Trend in forest employment.	Measures local economic viability and sustainability.	None.	None.
Reduced tourism. Struggling local economy.	May indicate the closure of roads, trails, campgrounds, or restrictions or fees placed on routes and public access need to be lifted or reopened or mitigated, especially for those forms of recreation which spend the most money. (*Jobs, Economic Development, and Sustainable Communities USDA Rural Development 2010).* Streamline permits for local events on forest lands to increase local jobs and encourage tourism.	Chambers of commerce. Board of Trade. Economic numbers.	State Chamber of Commerce State Board of Trade.

Indicator Description.	Why it's important.	Resources/Expertise Required to Monitor.	Could Data be collected by volunteers and user groups?
Impacts and loss of the human habitat and the food (services) that it takes for it to survive	Why our rural communities are ever decreasing and our rural counties dominated by public land continue to decline in population.	Gathering records from counties and communities as to yearly loss to businesses, school enrollment, hospital closure, shift in population, from families to retired and others.	Work with county chambers, school districts, hospital districts, census bureau.
Health impacts due to catastrophic wildfire.	Tells the amount of days within major urban or rural areas where the 24-hour Av PM 2.5 is at or above unhealthy standard. Can be used to support thinning and restoration projects and decreasing overall health hazards to humans.	Work with local and state/county air boards to determine number of days at the various standards.	Local and state air boards.