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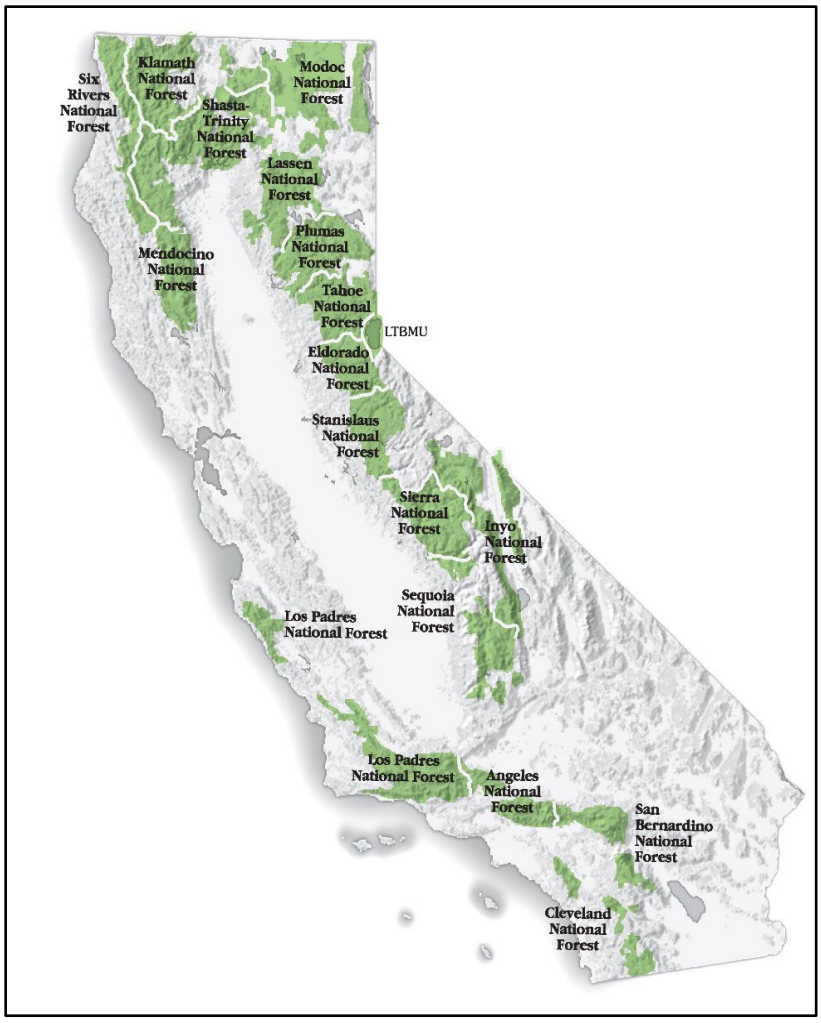

Pacific Southwest Region

Broader-scale Monitoring Strategy

Version 1.0

Forest Service

Pacific Southwest Region

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Region 5 Broader-scale Monitoring Strategy

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Vision

The vision of the Pacific Southwest Region's Broader-scale Monitoring Strategy (hereafter "Strategy") is to:

- Provide a flexible process that will implement the objectives of the 2012 Planning Rule while serving the needs of individual units;
- Promote overall efficiency by monitoring conditions at an appropriate scale across multiple units, gaining efficiencies of scale that will reduce monitoring needs on individual units;
- Support adaptive management by monitoring changes at the landscape level, and relating those changes to desired conditions on management unit land;
- Prioritize the essential portions of the eight monitoring items identified by the planning rule, using focused and efficient questions that aspire to the highest standards of scientific integrity;
- Produce high-quality data and data analysis, using methods that are within the available resources and capabilities of the agency;
- Address uncertainty by monitoring ecosystem characteristics that may change over time and provide early warnings of ecosystem response to climate change and other stressors; and
- Use existing data, internal and external, as appropriate to the objectives of the 2012 Planning Rule.

Introduction

The 2012 Planning Rule requires that Regional Foresters develop broader-scale monitoring strategies (36 CFR 219.12 (b)) to include the following general characteristics:

- Monitoring questions that can best be answered at a geographic scale broader than one plan area;
- Coordinated with the relevant responsible officials, State and Private Forestry, Research and Development, partners, and the public; and
- Within the financial and technical capabilities of the Region and complements other ongoing monitoring efforts.

Implementation Approach

The Strategy is designed to answer monitoring questions at broader scales to inform forest plan monitoring programs (PMPs) that are also a requirement of the 2012 Planning Rule (FSH 12.31). While the Strategy has a broader approach, each PMP is driven by monitoring questions tied to plan components specific to a forest plan. Broad-scale questions connect to forest plan-level monitoring programs through commonalities in science, questions, needs, methods, and scales. Many plan components are similar across forest units and have been used to help formulate the Strategy.

Under the 2012 Planning Rule, forest plan PMPs are required to have questions in eight categories:

(i) Status of select watershed conditions.
(ii) Status of select ecological conditions including key characteristics of terrestrial and aquatic ecosystems.
(iii) Status of focal species to assess the ecological conditions required under 36 CFR 219.9.
(iv) Status of a select set of the ecological conditions to contribute to the recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain a viable population of each species of conservation concern.
(v) Status of visitor use, visitor satisfaction, and progress toward meeting recreation objectives.
(vi) Measurable changes related to climate change and other stressors that may be affecting the plan area.
(vii) Progress toward meeting the desired conditions and objectives in the plan, including for providing multiple use opportunities.
(viii) Effects of each management system to determine that they do not substantially and permanently impair the productivity of the land (16 U.S.C. 1604(g)(3)(C)) (36 CFR 219.12(a)).

Many of the monitoring questions in the Strategy also inform questions across multiple categories in the PMPs of forest plans. Table 1 organizes the monitoring questions in the Strategy under the eight categories required in forest plan PMPs.

Criteria for selecting broader-scale monitoring questions, indicators, and sources of information

Criteria for designing monitoring questions

- Monitoring needs are most efficiently addressed for multiple plan areas at the same time or are beyond the technical feasibility of a single management unit
- Contribute to a broader understanding of the landscape surrounding management units
- Provide information necessary to evaluate plan implementation
- Are within the financial and technical capabilities of the Region

Criteria for selecting indicators and supporting sources of information

- Use the same attributes and measures as standardized data to the extent possible
- Are based on the best available science
- Are useful for answering multiple questions

Monitoring questions, indicators, and adaptive management elements

The Strategy incorporates the following elements:

- **Rationale for selecting monitoring question/indicator**—logic for incorporating a question or indicator into the Strategy.
- **Monitoring question(s)**—questions that are best answered at a broader geographic scale.
- **Indicators**—performance measures used to gauge or track progress toward achieving desired outcomes.
- **Data collection**—measurable quantitative or qualitative parameters.
- **Data application**—results applied to forest management.
- **Alert**— benchmark, trigger, threshold or trend that indicates conditions are moving away or departed from desired outcomes.
- **Adaptive management**—systematic approach to improve resource management.
- **Scale of analysis**—describes the level of analysis with respect to land size or level of application.

Region 5's Broader-Scale Monitoring Strategy plan components are **in table 1** and **appendix A.**

Best available scientific information

The Strategy is a living document addressing environmental uncertainty and responses to management actions at multiple scales. The best available scientific information is used to develop monitoring questions and indicators. Strategy components may be adapted as the best available scientific information (new science, resource specialist information, technologies, ideas, or collaborations) identifies efficiencies to achieve desired outcomes. During the 5-year annual review, the Strategy will be evaluated and may be modified due to changing conditions, emerging issues, relevancy of monitoring questions and indicators, or financial and technical constraints.

Roles and responsibilities

Regional Office (RO)

1. The RO Planning Staff will coordinate implementation of the Strategy.
2. The RO will facilitate the review and interpretation of these results by relevant subject matter experts.
3. The RO will coordinate with the Pacific Southwest Research Station and other research partners when research needs exist.
4. The RO will facilitate the transfer of broad-scale results to Forest Supervisors in coordination with forest plan revision and biennial monitoring at the unit level so that Forest Supervisors can review unit-level findings in the context of the broader landscape.
5. Results of the Strategy will be published and made available to the public on a 5-year reporting cycle.

Partnerships and coordination

Collaborations between the Forest Service, other Federal agencies, Pacific Southwest Research Station, universities, Tribal governments, states, communities, non-governmental organizations, and citizen scientists will continue to support cross-boundary management and pursuit of integrated social and ecological objectives in the Region's broader-scale Strategy.

Partners

1. Partners may provide information needed to address indicators and answer monitoring questions identified in the Strategy.
2. Partners will be encouraged to actively engage in the ongoing implementation of the Strategy.
3. Partners will be given the opportunity to provide feedback on Strategy results.

Public engagement

The Strategy was shared with stakeholders on July 26, 2018. Comments received were incorporated in the Strategy, where feasible. Suggestions that were not included in the Strategy are in **appendix B** and may be considered for future updates of the Strategy. Indicators were not included in the Strategy because they either lacked available data, had an unclear relationship between information and strategy goals, or limited resources were available.

The RO will publish results of the Strategy on the Region's website. During each 5-year reporting cycle, the public will have an opportunity to review monitoring results and provide feedback. The RO will consider revisions to the Strategy based on external feedback.

Region 5 monitoring – managing for vast landscapes

Region 5 is the largest region of the Forest Service with 18 forest units, covering approximately 20 million acres, from the arid Southwest to the temperate rain forests of the Pacific Northwest. The Region has adopted a strategic approach in establishing efficiencies of scale by selecting monitoring questions and indicators that can be tiered to the monitoring needs of multiple forests to address the eight items set out in the Planning Rule at 36 CFR 219.12(a)(5). The Strategy supports adaptive management by monitoring changes at the landscape level and relating those changes to desired conditions on the forest units.

History of Region 5 monitoring

Region 5 has a long history of monitoring. Since the mid-1990s, Region 5 has implemented a plan revision strategy based on collaborative bio-regional planning of the four geographic subregions in California: the Pacific Northwest, the Sierra Nevada range, southern California, and northeastern California Plateaus. **Appendix C** identifies the date of the most recent monitoring program for all Region 5 forests. Historically, the northeastern California Plateaus (Modoc and Lassen National Forests) were included in either the Pacific Northwest Forest, the Sierra Nevada Range, or both subregions. Because the California Plateaus have a distinctive system with dry pine and juniper forestland, as well as sagebrush shrublands, a need for a science synthesis was identified for this region and was initiated in 2016.

In 1994, the Northwest Forest Plan Amendment was developed for the Pacific Northwest subregion, which includes portions of Region 5 and Region 6. The Northwest Forest Plan created an interagency regional monitoring program for Federal land management addressing threatened and endangered species, and social and economic sustainability. The monitoring program monitors the status and trends of late-successional and old-growth forests; northern spotted owl habitats and populations; marbled murrelet habitats and populations; watershed conditions; socio-economic conditions; and Tribal-Federal relationships.

In 2001 and 2004, the forest plans for the national forests in the Sierra Nevada were amended by the Sierra Nevada Forest Plan Amendment (Framework). Specific monitoring was initiated in the Sierras on geographic areas larger than one forest, which focused on old forest ecosystems, fire and fuels, aquatic and riparian habitats, meadow ecosystems, lower westside hardwoods, noxious weeds, air quality, soil productivity, and sociocultural conditions (reports). Subsequently, an amendment of the Framework in 2007 identified management indicator species in common for multiple forests, which have been monitored on a bio-regional scale. Management indicator species monitoring will continue to be monitored for forests until they transition to the 2012 Planning Rule through forest plan revision. Under the 2012 Planning Rule, each forest will evaluate species for consideration as a focal species or a species of conservation concern (1909.12, zero code).

Broader-scale monitoring questions and indicators

Table 1. Broader-scale strategy monitoring questions, indicators, alerts, and potential adaptive management

Broader-scale monitoring questions and indicators	
Monitoring Question: How are aquatic resources in Region 5 changing over time?	
(i) Watershed conditions	
Indicator: Benthic macroinvertebrates	
Alert(s)	**Adaptive Management Strategy**
Downward trend in benthic macroinvertebrates conditions for a minimum of 3 consecutive years to account for sampling variability.	Investigate causes for declining trends.
Indicator: Stream physical habitat condition and upslope riparian condition	
Alert(s)	**Adaptive Management Strategy**
Declining watershed conditions from Aquatic and Riparian Effectiveness Monitoring Program monitoring. Aquatic and Riparian Effectiveness Monitoring Program applies to Northwest Forest Plan subregion only.	Investigate whether forest management practices are correlated with declining aquatic and riparian habitat conditions.
Indicator: Impaired waterways 303(d) status	
Alert(s)	**Adaptive Management Strategy**
Increasing trend in the percentage of 303(d) listed sites or sites proposed for listing over a 3-year reporting cycle.	Identify management activities or natural phenomena that may be affecting water quality.
Monitoring Question: What are the trends in occurrence and distribution of key animal species known to occur in Region 5?	
Supports ecological conditions for multiple categories: status and trends of (ii) terrestrial and aquatic ecosystems, (iii) focal species, and the (iv) recovery of federally listed threatened and endangered species, proposed and candidate species, and at-risk species	
Indicators: (ii,iii) California spotted owl, avian assemblages; (iv) northern spotted owl, Pacific fisher, Sierra Nevada yellow-legged frog, distinct population segment of mountain yellow-legged frog, and Yosemite toad	
Alert(s)	**Adaptive Management Strategy**
Declining trends in occupancy or habitat suitability.	Identify where management may help maintain or increase populations or where changes to management actions should be considered.

Broader-scale monitoring questions and indicators	
Monitoring Question: What are the status and trends of vegetation in Region 5?	
Supports ecological conditions for (ii) terrestrial and aquatic ecosystems, (iii) focal species, and the (iv) recovery of federally listed threatened and endangered species, proposed and candidate species, and at-risk species	
Indicator: Spatial extent of major vegetation types including whitebark pine	
Alert(s)	**Adaptive Management Strategy**
Continued loss of major vegetation types in response to disturbance from anthropogenic and environmental stressors.	Prioritize areas for ecological restoration treatments to improve ecosystem resilience to stressors.
Indicator: Forest structure: large trees, basal area, quadratic mean diameter, seral class density	
Alert(s)	**Adaptive Management Strategy**
Trends in forest structure of conifer and hardwoods are departed from desired conditions.	Develop strategies to improve forest health.
Indicator: Meadow condition	
Alert(s)	**Adaptive Management Strategy**
Downward trend in meadow condition or meadows experiencing an increasing trend in bare soil based on a 5-year trend.	Evaluate if trends are in isolated or grouped meadows to determine the magnitude of disturbance.
Monitoring Question: How has the level of satisfaction expressed by forest visitors and users changed over time in Region 5?	
(v) Visitor use, visitor satisfaction, and progress toward meeting recreation objectives	
Indicators: Visitor use and satisfaction and importance-performance ratings	
Alert(s)	**Adaptive Management Strategy**
Declining trends in overall visitor satisfaction in recreation management.	Prioritize areas for improvement based on visitor satisfaction.
Monitoring Question: How have climatic conditions varied across Region 5 over time?	
(vi) Climate change and other stressors	
Indicators: Temperature, precipitation, snowpack, drought	
Alert(s)	**Adaptive Management Strategy**
Downward trends in water availability for forest resources.	Prioritize watersheds for restoration to minimize undesirable effects and facilitate recovery of drought-affected landscapes.

Broader-scale monitoring questions and indicators	
Monitoring Question: What are the status and trends of insects, disease, and invasive species in Region 5?	
(vi) Climate change and other stressors	
Indicator: Tree mortality (acres by severity class, total number of trees affected)	
Alert(s)	**Adaptive Management Strategy**
Increasing trends in tree mortality from insects, disease, and response to stressors.	Evaluate mortality trends to identify risks, impacts to tree species, and potential pest management strategies for management.
Indicator: Sudden oak death: acres by severity class, total number of trees affected	
Alert(s)	**Adaptive Management Strategy**
Increasing trends in sudden oak death.	Identify management options for mitigating and minimizing the disease.
Indicator: Non-native invasive plants – acres of invasive species, acres of invasive species treatment	
Alert(s)	**Adaptive Management Strategy**
Acres of non-native invasive plants are increasing over time.	Work with cooperators and partners to prioritize areas to control, manage, and restore areas with invasive plant infestations.
Monitoring Question: What are the status and trends of air quality across Region 5?	
(vi) Climate change and other stressors	
Indicator: Wilderness visibility	
Alert(s)	**Adaptive Management Strategy**
Wilderness areas are not meeting regulatory standards.	Enact measures to mitigate negative effects to air quality.
Monitoring Question: How have fire regimes varied over time across Region 5?	
(vii) Progress toward meeting the desired conditions, objectives, and other plan components	
Indicators: Fire size, fire severity, fire return interval departure	
Alert(s)	**Adaptive Management Strategy**
Increasing trends of uncharacteristically large-scale high severity fire.	Prioritize areas for ecological restoration and other management actions based on the departure from the natural range of variation.
Monitoring Question: What are the trends in ecosystem services and economic contributions in Region 5 national forests and surrounding communities?	
(vii) Progress toward meeting the desired conditions, objectives, and other plan components	
Indicator: Jobs supported	
Alert(s)	**Adaptive Management Strategy**
Sustained downward trend in economic contributions to communities through forest management.	Foster collaboration with county governments and local stakeholders to discuss factors that may be related to forest management practices.

Broader-scale monitoring questions and indicators	
Indicator: Environmental justice	
Alert(s)	**Adaptive Management Strategy**
Increasing low income and minority communities near national forests.	Identify if forest management could be contributing to a change in community income given the complexity of other contributing factors.
Indicator: Forest Products – cut volume	
Alert(s)	**Adaptive Management Strategy**
Cut volume targets are not consistently achieved.	Evaluate the capability of achieving targets.
Indicator: Forest carbon stocks and flux	
Alert(s)	**Adaptive Management Strategy**
Trends indicate regionwide or forest-level decreases in pools and increases in fluxes in carbon resources over time.	Promote forest management activities to increase carbon sequestration and reduce greenhouse gas emission.
Monitoring Question: What is the status of ecological restoration goals identified in the Region 5 Leadership Intent document?	
(viii) Productivity of the land – management system sustainability	
Indicator: Forest resilience: acres of fires managed for resource objectives, acres of prescribed fire, acres of mechanical fuels reduction, acres where mechanical fuels reduction and burning co-occurred.	
Alert(s)	**Adaptive Management Strategy**
Trends indicate that the pace and scale of restoration are not on a trajectory to achieve goals.	Evaluate trends to develop strategies to increase the pace and scale of restoration to meet desired goals.
Indicator: Meadow resilience: acres of meadow restoration by project type and normalized differential vegetation index anomalies.	
Alert(s)	**Adaptive Management Strategy**
Treated meadows are not meeting restoration goals. Restored meadows are experiencing degradation.	Evaluate meadow treatment effectiveness to improve future restoration efforts.

Appendix A. The Broader-scale Monitoring Strategy Questions and Indicators

How have aquatic resources in Region 5 forests changed over time?

Rationale for selecting monitoring question: Many activities on National Forest System lands have the potential to affect water quality. National forests in California provide almost half of the state's surface water, are of high quality, and provide beneficial uses. Region 5's ecological restoration leadership intent document recommends targeting fuel reduction activities in key watersheds to protect aquatic species and municipal watersheds (USDA 2015). The Forest Service has also developed a National Fish and Aquatic Strategy, which has a goal to conserve fish and aquatic resources.

The question *"How have aquatic resources in Region 5 forests changed over time?* dovetails with several monitoring questions in the Strategy to inform the status and trends of watersheds, ecological conditions of ecosystems and at-risk species, and climate change.

Given the role that aquatic resources play in providing beneficial uses, the Region's ecological restoration goals to protect water for multiple uses, and the Forest Service's potential management impacts on water quality, the Region has selected the monitoring question *"How have aquatic resources in Region 5 forests changed over time*?"

Data collection: Benthic macroinvertebrates, stream and riparian conditions, and 303(d) listing status.

Data application: Results may apply at Region, subregion, or forest-level scales depending upon the indicator.

Alerts: Downward trends in aquatic resource condition.

Adaptive management: Adaptive management strategies will vary depending upon the indicator.

Benthic Macroinvertebrates

Rationale for selecting indicator: Benthic macroinvertebrates are a diverse group of aquatic insects, crustaceans, mollusks, and worms that live at the bottom of rivers and streams. Benthic macroinvertebrates are used to evaluate aquatic health because they make small movements and are predictable in their response to a variety of environmental stressors.

Data collection: Data sources are the California Stream Condition Index, an overall measure of stream health based on the species of benthic macroinvertebrates in a stream, and the State of California Surface Water Assessment and Monitoring Program, which produces bioassessment scores (California Stream Condition Index Scores Map).

Data application: Results will summarize the proportion of samples on National Forest System lands with good, moderate, and low condition.

Alerts: Continued downward trend in sampling for at least 3 years in a row to account for sampling variability. Samples in good condition are declining or repeated sampling locations are moving to a less desirable condition.

Adaptive management: Declining trends will be evaluated to determine if they relate to specific sampling locations or to management actions that degrade aquatic ecosystem integrity. An action plan will need to be developed to provide mitigation for forest management actions correlated with decreasing conditions.

Scale of analysis: Regionwide where sample size is sufficient.

Stream physical habitat condition and upslope riparian condition

Rationale for selecting indicator: Stream physical habitat condition and upslope riparian condition were selected as watershed condition indicators because they have been monitored for more than in 25 years in the Northwest Forest Plan Aquatic and Riparian Effectiveness Monitoring Program. The Aquatic and Riparian Effectiveness Monitoring Program evaluates whether the Northwest Forest Plan Aquatic Conservation Strategy is achieving the goal to maintain and restore the condition of watersheds.

Data collection: The Aquatic and Riparian Effectiveness Monitoring Program is a long-term monitoring program. Region 5 results are incorporated into the High cascade, Klamath Siskiyou, and Franciscan regions of the report, which includes portions of Region 6.

Data application: The Aquatic and Riparian Effectiveness Monitoring Program has substantial baseline data and past monitoring reports can be used as a template to evaluate monitoring results.

Alerts: Declining status and trend of watershed condition.

Adaptive management: The Aquatic and Riparian Effectiveness Monitoring Program has evaluation tools and management guidelines.

Scale of analysis: Northwest Forest Plan subregion.

Impaired waterways 303(d) status

Rationale for selecting indicator: There is uncertainty about to what degree management activities performed or permitted by the forest, or activities that visitors engage in, affect water quality. This indicator was designed to address whether forest management or activities occurring on forests affect beneficial uses of water, and the trend in water quality in the Region. This indicator is tied to the Clean Water Act and is monitored by the Environmental Protection Agency (EPA), and the California Water Quality Control Boards.

Data collection: Data source is the 303(d) impaired waterbody list for the State of California, maintained by the EPA's Impaired Waters and TMDLs monitoring and assessment reporting. Results will be summarized to include the following: (1) total number of 303(d) listed and proposed waterbodies; (2) the trend in the number of proposed and listed streams, and when manageable; (3) a table identifying what streams have been added or removed since the last

reporting period; and (4) a list of the waterbodies with the contaminants and contaminant source if known.

Data application: The desired conditions are to minimize the potential of adding new waterbodies to the 303(d) list and remove waterbodies currently listed from 303(d) status.

Alerts: An increase in the percent of proposed or listed 303(d) waterbodies over three report periods.

Adaptive management: If the percentage of proposed or listed 303(d) waterbodies increases over three reporting periods, look for commonalities or forestwide management, or natural phenomena that could be leading to the increase. Work with forests to evaluate if management might be contributing to the 303(d) listed status.

Scale of analysis: Regionwide.

What are the trends in occurrence and distribution of key animal species known to occur in Region 5?

Rationale for selecting monitoring question: The Regional Forester included species in the Strategy based on existing monitoring programs, Forest Service conservation strategies, specific plan components, Endangered Species Act status or species of conservation concern status, and the role a species plays as an ecosystem indicator.

Data collection: Trends in occupancy, distribution, or habitat use over time.

Data application: Comparing trends in occupancy, distribution, or habitat use with forest management to inform plan monitoring effectiveness, status toward meeting desired conditions of the Strategy, and to support analysis for environmental planning.

Alerts: A condition that a monitoring measure may indicate a need for additional assessment, modifications to the monitoring program, or a need to change plan direction.

Adaptive management: Results may identify where management may help maintain/increase populations or where changes to management actions should be considered.

California spotted owl

Rationale for selecting indicator: Forests that support California spotted owl *(Strix occidentalis occidentalis)* populations are dynamic ecosystems operating at multiple scales with diverse vegetation types, structures, functions, and processes that vary over space and time. California spotted owl prefer large and tall tree high canopy cover for nesting and roosting and heterogenous habitat for foraging (North et al. 2017). California spotted owl can be negatively impacted by reductions in habitat quality (e.g., density- and canopy-reduction treatments) that may be minimized by maintaining or increasing the highest quality large-tree habitat (Wood et al. 2018). Treatments in California spotted owl habitat in the short term may be balanced by long-term gains when the treatments result in increased persistence/sustainability of habitat elements over time (Jones et al. 2017; Stephens et al. 2014; Tempel et al. 2014, 2015).

In 2019, the U.S. Fish and Wildlife (USFWS) determined that the California spotted owl was not warranted to list as an endangered or threatened species under the Endangered Species Act (USFWS 2009a) partially because of existing regulatory mechanisms such as Forest Service LMPs. Primary threats to California spotted owl persistence are habitat loss from large scale high-severity disturbances, increased tree mortality, drought, effects of climate change, and barred owl invasion.

For more than a quarter of a century, the Forest Service has been actively involved in California spotted owl conservation focusing on retaining suitable habitat and minimizing disturbance to breeding owls. In 2019, Region 5 developed a strategic framework for strengthening the Region's proactive conservation of the California spotted owl on the 10 Sierra Nevada National Forests (Modoc, Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Sierra, Inyo, Sequoia, and the Lake Tahoe Basin Management Unit) within the Pacific Southwest Region (USDA California Spotted Owl Strategy (2019)). The conservation strategy for California spotted owl in the Sierra Nevada has been developed to achieve three main goals across the species' range: (1) promote and maintain well-distributed owl habitat by developing key habitat elements and connectivity; (2) promote California spotted owl persistence by enhancing habitat resilience to multiple disturbances, considering climate change; and (3) maintain a well-distributed and stable California spotted owl population by minimizing impacts from non-habitat threats. A 2004 Conservation Strategy also exists for managing California spotted owl populations and habitat on four national forests (San Bernardino, Angeles, Los Padres, and Cleveland) in southern California (USDA Forest Service 2004a).

Given that the Region manages substantial California spotted owl suitable or occupied habitat throughout multiple forests in the Sierra Nevada and parts of southern California and the Region's long history of monitoring and commitment to owl conservation, the California spotted owl has been selected as an indicator to address the monitoring question *"What are the trends in occurrence and distribution of key animal species known to occur in Region 5?"*

Data Collection: Data are currently provided from long-term demography studies, three of which occur primarily on national forests in the Sierra Nevada (Lassen, Eldorado, and Sierra), and also recent acoustic monitoring deploying automated recording units. In the future, the Region will be transitioning the California spotted owl monitoring program from demography studies to bioregional acoustic monitoring. Currently pilot studies for bioregional acoustic monitoring are underway and results will inform the Region on how to strategically, effectively, and efficiently expand the monitoring program throughout the range of the California spotted owl in California. Data are collected and analyzed by Region 5 with research partners and universities.

Data application: Results can be used to compare changes in habitat suitability and quality, and to trends in occupancy and distribution. Data can also be used in environmental assessments to determine if actions may reduce habitat quality in the context of local conditions. Results can be compared to desired conditions and identify where management may help maintain/increase populations, and or where changes to management actions should be considered to increase the pace and scale of California spotted owl habitat restoration.

Alerts: Declining trends in California spotted owl occupancy or habitat suitability.

Adaptive management: The California Spotted Owl Conservation Strategy contains several sections applicable to adaptive management:

1. Climate adaptation and partnerships (Section 9: Approaches and Recommended Conservation Measures, pp. 25–35)
2. Management approaches for habitat threats and non-habitat threats (Section 10: Monitoring and Adaptive Management, pp. 35–39)
3. Adaptive management process (Adaptive Management, p. 39)

Scale of analysis: Sierra Nevada range and southern California range.

Pacific fisher

Rationale for selecting indicator: Fisher (*Pekania pennanti*) depend on structurally complex, mature forest conditions. Widespread tree mortality observed between 2014 and 2016 has caused significant habitat loss (Thompson et al. 2020). Continued fisher monitoring of the southern Sierra Nevada has been identified as essential to track occupancy and genetic connectivity patterns, assess population response to the recent tree mortality event, and ensure the population is responding to habitat conservation measures (Spencer et al. 2016, 2017). Fisher are potentially impacted by forest vegetation and hazardous fuels reduction. In the short term, fisher can be negatively impacted by reductions in habitat quality, the loss of critical structures, or changes in microclimate; however, in the long term, fisher populations benefit from resiliency-based restoration work that reduces the risk of large-scale habitat loss from wildfire, drought, and other large-scale disturbances (Spencer et al. 2016). In 2020, the USFWS listed the Southern Sierra Nevada Distinct Population Segment of fisher in California as an endangered species under the Endangered Species Act (USFWS 2020).

In 2002, Region 5 began a long-term carnivore monitoring program encompassing eight forests using remote camera station data collection. The program systematically monitors fisher occupancy and genetics in the southern Sierra Nevada forests annually and conducts periodic sentinel monitoring of the central and northern Sierra forests to monitoring for potential population expansion.

Given the complexity of managing fisher habitat, the USFWS's listing of fisher as an endangered species under the Endangered Species Act, and the long history of the Region's forest carnivore monitoring, the Pacific fisher has been selected as an indicator to address the monitoring question *"What are the trends in occurrence and distribution of key animal species known to occur in Region 5?"*

Data collection: The long-term Region 5 carnivore monitoring program uses repeated surveys at non-invasive monitoring stations (trail cameras, track plates, and hair snares) to provide data on occupancy and genetic diversity at systematic survey locations across the landscape. Data and reports can be obtained by working with the Sierra Nevada Carnivore Monitoring Program Leader for the Region 5 Carnivore Monitoring Program. In 2006, a monitoring program using similar methods was initiated on a study area of the Klamath National Forest managed by Oregon State University (Green et al. 2019). Since 2007, fisher ecology research on the Sierra National Forest has helped inform monitoring needs and design, and have helped expand the scope of ongoing monitoring efforts (Sweitzer et al. 2016, Green et al. 2019). Currently, the Region 5 Carnivore Monitoring Program is pilot testing new technology and methods to inform a revised future broad-scale fisher monitoring plan for the southern Sierra Nevada, and depending on the results of these pilot studies, monitoring may be expanded to additional areas.

Data application: Monitoring occurs at fixed locations to observe changes in fisher occupancy and can be correlated with changes in environmental conditions over time, such as wildfire, drought, and tree mortality. These results can help inform plan components, desired conditions, and effects analysis for project planning. Monitoring can also identify where management may help maintain/increase populations, and or where changes to management actions should be considered. Results can be incorporated into the ecological conditions for supporting the plan-level monitoring program's desired conditions, objectives, or other plan components.

Alerts: Declining trends in fisher occupancy or habitat suitability.

Adaptive management: Monitoring data can identify areas on the landscape where fisher occupancy is persisting after tree mortality. Results can inform where management should focus efforts to retain and protect remaining habitat such as by targeted fuels reduction treatments in the surrounding landscape to reduce the risk of high-severity wildfire. Results may also indicate whether and how fisher are adapting to post-mortality conditions. As the southern Sierra fisher population has been shown to be characterized by very low genetic diversity and high genetic subdivision (Tucker et al. 2014, 2017), genetic monitoring data can help identify important linkage areas needed to maintain population connectivity as a focus for future management and conservation actions.

Scale of analysis: Monitoring will occur throughout the fisher-occupied area of the southern Sierra Nevada Range subregion, including the Sierra and Sequoia National Forests, and portions of the Inyo and Stanislaus National Forests from approximately 2,500 to 10,000 feet in elevation. Potential monitoring may expand to other national forests in the Region in 2021. When available, data from Oregon State University's fisher monitoring on the Klamath National Forest will also be assessed.

Northern spotted owl

Rationale for selecting indicator: Northern spotted owl (*Strix occidentalis caurina*) rely on mature and old-growth forest habitats containing the structures and characteristics required for nesting, roosting, and foraging (USFWS 2011). In Region 5, the northern spotted owl inhabits structurally complex forests from the Cascade Mountains and coastal ranges of California, to Marin County, California. Northern spotted owl are managed under the 1994 Northwest Forest Plan on six national forests (Six Rivers, Klamath, Modoc, Lassen, Mendocino, and the Shasta-Trinity National Forests) in California.

In 1990, the USFWS listed the northern spotted owl as a threatened species under the Endangered Species Act (USFWS 1990). Northern spotted owl populations have continued to decline even though land managers have reduced the loss of older-growth forests. Threats to the persistence of northern spotted owl populations include the invasion of nonnative barred owls, the uncertainty of climate change effects, and fire exclusion in naturally fire-prone forests that result in abnormally larger patches of high-severity fire and less diverse forest vegetation (Spies et al. 2018).

Region 5 has participated in northern spotted owl conservation since 1985, focusing on retaining suitable and occupied habitat and minimizing disturbance to breeding owls. In 1994, the Northwest Forest Plan Federal Interagency Regional Ecosystem Office has overseen the northern spotted owl monitoring program, a rangewide monitoring program that conducts long-term monitoring of populations and habitat conditions. The main objectives of the program are:

1. Track status and trends of northern spotted owl populations and demographic rates on Federal lands within its geographic range in the United States
2. Track status and trends in the amount and distribution of northern spotted owl forest cover types and habitat on Federal lands.

Given that the Region manages substantial northern spotted owl suitable or occupied habitat throughout the Northwest Forest Plan area, the Northwest Forest Plan Federal Interagency Regional Ecosystem Office's long-term history of monitoring, the Region's commitment to owl conservation, and the emerging non-habitat threats to owl persistence, the northern spotted owl has been selected as an indicator to address the monitoring question *"What are the trends in occurrence and distribution of key animal species known to occur in Region 5?"*

Data collection: The northern spotted owl monitoring program tracks status and trends of populations and habitats in demography study areas throughout the species' range. Region 5 has one long-term demography study area, the Northwest California Demography Study Area, on six national forests within the Northwest Forest Plan area.

In the future, the northern spotted owl population monitoring program will be transitioning from mark-recapture demography studies (phase I) to a random sample design (phase II) using passive bioacoustics survey methods throughout the species' range. Currently, pilot studies for bioregional acoustic monitoring are underway and results will inform the northern spotted owl monitoring program on how to strategically, effectively, and efficiently transition the monitoring program from demography to occupancy studies.

Northern spotted owl monitoring designs and protocols are outlined in PNW-GTR-440 (Lint et al. 1999). Data analyses are published in peer-reviewed scientific journals and general technical reports that are published every 5 years. The reports and publications produced by this program serve as the best available science information used by Federal, State, and private stakeholders.

Data application: The revised Recovery Plan for the Northern Spotted Owl (2011) contains a wide array of recommendations including protecting high-quality and occupied habitat, actively managing forests for forest health, and managing competition from the encroaching barred owl (USFWS 2011).

Alerts: Declining trend in northern spotted owl occupancy or habitat suitability.

Adaptive management: Management guidance can be found in Section II-10 Habitat Conservation and Active Forest Restoration of the Northern Spotted Owl Recovery Plan. Results can be applied to forest management to determine the effectiveness of forest management on maintaining and restoring habitat conditions necessary to support viable populations on federally administered lands throughout its range. Estimates of species' vital rates and an understanding of the factors affecting those parameters over time and space, can provide crucial information for management and conservation (Dugger et al. 2016). If data indicate a decoupling of population trends from habitat trends, this information can be used to inform adaptive management to address other, non-habitat threats.

Scale of analysis: Northwest Forest Plan area.

Avian assemblages

Rationale for selecting indicator: Data on avian community richness, diversity, and composition can be used to inform management activities at multiple scales and for multiple purposes. The use of species groups or communities can inform our understanding of ecological integrity. Because individual species are closely associated with specific vegetation or forest conditions, the relative abundance of different guilds or suites of species has been shown to be closely related to landscape structure and patterns of heterogeneity as well as abundance and distribution of specific habitat types and components. For example, black-backed woodpeckers are considered post-fire specialists with potential sensitivity to changing fire regimes and post-fire vegetation management and can be monitored individually and as part of a broader suite of species.

Given the diversity of avian habitats managed by the Region, the importance of diversifying habitats to increase heterogeneity and resilience, the ability to monitor multiple species at a regional scale, the ability to evaluate occupancy and distribution responses to management practices, and the Region's long-term monitoring history, avian assemblages and key species such as black-backed woodpeckers have been selected as indicators to address the monitoring question *"What are the trends in occurrence and distribution of key animal species known to occur in Region 5?"*

Data collection: Region 5, with the Point Blue Sierra Nevada Avian Monitoring Information Network, has been conducting biennial monitoring of multi-avian species across 10 national forests since 2010. The Institute for Bird Populations has been monitoring black-backed woodpeckers on national forests in California. Since 2008, Region 5 has partnered with the Institute for Bird Populations to monitor black-backed woodpeckers across 10 national forests in the Sierra Nevada subregion. Other monitoring efforts in the birding community include Breeding Bird Survey data and Christmas Bird Counts.

Data application: Results have been used for a variety of analyses including sensitive species assessments, evaluating impacts of fuel reduction on avian communities, looking at post-fire changes in avian communities, and interpreting the effects of management activities such as aspen regeneration and meadow restoration. Trends in species richness or diversity of avian communities can help determine whether desirable levels of landscape heterogeneity are being achieved, or whether desired vegetation components are abundant enough on the landscape to maintain communities, and whether community integrity remains intact. Should concerns arise over the status of individual species during monitoring efforts, more focused efforts to evaluate species' status can be initiated. Monitoring data can be used to assess the impacts of management actions, as well as to help balance fuel and fire management objectives (prescribed fire, fire suppression, early seral stages, timber harvest prescriptions) with the needs of fire-dependent species.

Alerts: Declining trend in occupancy or habitat suitability in avian assemblages.

Adaptive management: Shifts in multi-species distributions or composition can be used to inform management decision making, changes to desired conditions or ecological integrity metrics, as well as informing more targeted monitoring or research where necessary. Monitoring data can also be used to help balance fuel and fire management objectives (prescribed fire, fire suppression, early seral stages, timber harvest prescriptions) with the needs of fire-dependent species.

Scale of analysis: Sierra Nevada subregion.

Yosemite toad, Sierra Nevada yellow-legged frog, and Northern Distinct Population Segment of the mountain yellow-legged frog

Rationale for selecting indicators: Amphibians are imperiled worldwide. Amphibians are indicators of functioning aquatic, riparian, and upland ecosystems and are sensitive to habitat degradation, habitat fragmentation, climate change, disease and other stressors. These variables can work in combination to make persistence of these species precarious.

In 2014, the USFWS listed the Yosemite toad (*Anaxyrus canorus*) as a threatened species, and the Sierra Nevada yellow-legged frog (*Rana sierra*e) and the Northern Distinct Population Segment of the mountain yellow-legged frog (*Rana muscosa*) as endangered species under the Endangered Species Act (USFWS 2014a). Region 5 manages suitable or occupied habitat for these species on nine national forests in the Sierra Nevada subregion (Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Sierra, Inyo, Sequoia, and the Lake Tahoe Basin Management Unit).

In 2002, Region 5 initiated a bioregional monitoring program, Sierra Nevada Amphibian Monitoring Program, to monitor these amphibian species on National Forest System lands led by the Region 5 Sierra Nevada Monitoring Strategy Amphibian Monitoring Team. The team quantifies changes in occupancy across the Sierra Nevada ranges of the three species and changes in the demography of the Yosemite toad in select watersheds (Brown et al. 2012, Brown et al. 2014). The monitoring program is a statistically robust and probabilistic design with the following objectives: (1) collect data at a metapopulation scale, (2) provide occupancy data for taxa with overlapping ranges using similar methods, (3) provide occupancy estimates applicable to the entire study region, and (4) incorporate information from historical occupancy records. Region 5 results are published in peer-reviewed papers.

Additionally, forests conduct habitat assessments and surveys for project planning in compliance with the terms and conditions under the Programmatic Biological Opinion in the Sierra Nevada of California for Yosemite toad, Sierra Nevada yellow-legged frog, and the mountain yellow-legged frog (USFWS 2014b), and as amended for designation of critical habitat (USFWS 2016). Data collected at the national forest level are entered into the Natural Resource Management Natural Resource Information System Forest Service corporate database.

Given that habitat for these species occurs throughout the Sierra Nevada subregion, the Federal listing status of the three amphibian species, the ongoing amphibian monitoring at both regional and unit-level scales, the Yosemite toad, the Sierra Nevada yellow-legged frog, and the mountain yellow-legged have been selected as indicators to address the monitoring question *“What are the trends in occurrence and distribution of key animal species known to occur in Region 5?”*

Data collection: The Sierra Nevada Amphibian Monitoring Program collects species occupancy data in lakes, wet meadows, and streams in 134 watersheds for the Yosemite toad and 208 watersheds for the combined Sierra Nevada range for the Sierra Nevada yellow-legged frog and mountain yellow-legged frog on National Forest System lands across the species range using protocols described in Brown et al. (2012), Brown and Olsen (2013), and Brown et al. (2014). Trends in rangewide occupancy will be updated annually and fully analyzed every 5 years at the completion of each 5-year monitoring cycle. The Sierra Nevada Amphibian Monitoring Program also collects population abundance, survival, recruitment, and other demographic data for the

Yosemite toad annually at approximately five to seven meadows in two watersheds using capture-mark-recapture methods (Brown et al. 2014).

Alerts: Declining trends in occupancy or habitat suitability for the federally listed amphibians.

Adaptive management: Results can set management priorities, inform biological determinations and forest plan revisions, and evaluate whether proposed management will achieve stated objectives.

Scale of analysis: Sierra Nevada range subregion.

What are the status and trends of vegetation in Region 5?

Rationale for selecting monitoring question: Region 5 has identified a goal of ensuring the retention and sustainability of forests, forest resources, and forest carbon over the long term, even as climates change (USDA 2015). The 2012 Planning Rule (36 CFR 219.1(c)) is focused on maintaining biological diversity on Forest Service units and ensuring the "integrity of the compositional, structural, and functional components comprising…ecosystems." Ecological integrity is defined as: "The quality or condition of an ecosystem when its dominant ecological characteristics (e.g., composition, structure, function, connectivity, species composition and diversity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence (36 CFR 219.19 p 21272)." The 2012 planning directives recommend that the Strategy incorporate monitoring of vegetation communities likely to be among the first to be affected by climate change in order to identify opportunities for managing their adaptation (Forest Service Handbook (FSH) 1909.12.32.13b). In addition, the directives suggest selecting indicators designed to show effects of stressors to establish thresholds of change to provide early warnings of ecosystem response to stressors.

Forest Service directives under the 2012 Planning Rule (36 CFR 219.12(a)(5)) identify that monitoring plans shall incorporate monitoring questions and indicators that track the status of ecological conditions of terrestrial and aquatic ecosystems and at-risk species, contribute to the recovery of federally listed, proposed and candidate species, and monitor changes to climate and other stressors (Forest Service Manual 1909.12.32.1).

Given the multiple categories this question addresses under the 2012 Planning Rule, the Region's focus on ecosystem integrity, and the availability of natural range of variation assessments to compare existing vegetation conditions with desired conditions, the Region has selected *"What are the status and trends of vegetation types in Region 5?"* as a monitoring question.

Data Collection: Indicators are the spatial extent of major vegetation types (including whitebark pine), and forest structure (large trees, basal area, quadratic mean diameter, seral class, density)

Spatial Extent of Major Vegetation Types

Rationale for selecting indicator*:* Significant changes in California's terrestrial fauna and flora have occurred and are projected to occur over the next century. Comparisons of the 1930s Wieslander vegetation inventories and maps with modern vegetation maps and inventories

show large changes in the distribution of many Sierra Nevada vegetation types over the last 70 to 80 years (Bouldin 1999, Thorne, Morgan and Kennedy 2008). The principal trends are (1) loss of yellow pine-dominated forest, (2) increase in the area of forest dominated by shade-tolerant conifers (especially fir species), (3) loss of blue oak woodland, (4) increase in hardwood-dominated forests, (5) loss of subalpine and alpine vegetation, and (6) expansion of subalpine trees into previous permanent snowfields. Trends (4) through (6) appear to have a strong connection to climate warming, while trends (1) through (3) are mostly the product of anthropogenic causes including logging, fire suppression, and urban expansion. Future climate modeling suggests that vegetation will continue to change. Lenihan et al. (2008) suggest that there will be a decrease in alpine/subalpine forests, evergreen conifer forests, woodlands and shrublands, and an increase in mixed evergreen forest due to hardwood expansion and grasslands.

Given the significant current and projected trends of changing vegetation communities in the Sierra Nevada, and the drivers influencing those changes (urban expansion, forest management practices, warming climates), the spatial extent of vegetation has been selected as an indicator to address the monitoring question *"What are the status and trends of vegetation in Region 5?"*

Spatial Extent of Whitebark pine

Rationale for selecting indicator: Whitebark pine (*Pinus albicaulis*) is considered a keystone species because it regulates runoff by slowing the progress of snowmelt, reduces soil erosion by initiating early succession after fires and other disturbances, and provides seeds that are a high-energy food source for some birds and mammals. Whitebark pine forests are declining across most of their range in North America, because of mountain pine beetle (*Dendroctonus ponderosae*) outbreaks, fire exclusion policies, and the exotic pathogen *Cronartium ribicola*, which infects five-needle white pines and causes the disease white pine blister rust (USDA 2012). The loss of this high-elevation tree species poses serious consequences for upper subalpine ecosystems, impacts on biodiversity and losses in ecosystem processes.

In 2011, the USFWS determined that Whitebark pine was warranted for listing as an endangered or threatened species under the Endangered Species Act, but was precluded for listing because of higher priority actions (USFWS 2011b). The USFWS will be releasing a species status assessment of the best available scientific information and commercial information on whitebark pine to improve implementation of the Endangered Species Act and to enhance conservation success. Currently, the Region is coordinating with the USFWS Sacramento and Reno Field Offices to develop a California Whitebark Pine Conservation Strategy.

Given the concern over the loss of high-elevation tree species in upper-high alpine ecosystems, the drivers influencing habitat loss (mountain beetle outbreaks, white pine blister rust, warming climates), and the USFWS's proposed listing of this species under the Endangered Species Act, the spatial extent of whitebark pine has been selected as an indicator to address the monitoring question *"What are the status and trends of vegetation in Region 5?"*

Data collection*:* Vegetation data sources include the Existing Vegetation Data (EVeg), the California Wildlife Habitat Relationship data, and the Region 5 Remote Sensing Lab F3 product, which is currently available for the Sierra Nevada and is anticipated to be developed regionwide.

The Remote Sensing Lab's Ecosystem Disturbance and Recovery Tracker system (eDaRT) uses Landsat imagery and monitors landscape disturbance and cumulative effects (Koltunov et al. 2019).

The Remote Sensing Lab produced a distribution map of whitebark pine in California. The Region 5 Ecology Program in collaboration with the Remote Sensing Lab has been monitoring whitebark pine across the state to determine the pattern of mortality, regeneration, and recruitment in whitebark pine populations in the Sierra Nevada, southern Cascades, and other focal whitebark pine populations.

Historic reference conditions are found in the Region 5 Ecology Natural Range of Variation assessments for the Sierra Nevada (Sierra Nevada NRV documents). LANDFIRE data can be modeled to also help inform trends and departures from the natural range of variation. Natural range of variation assessments are being developed for other subregions.

Data application*:* A map of the current extent of major vegetation types and the total acres by vegetation type, can be used to track spatial and quantitative changes over time for the Region and for individual forests and develop restoration priorities. Data may transcend across ownerships providing information that can support collaborations with neighboring landowners and partners to develop strategies to improve conditions of targeted watersheds. Historic natural range of variation assessments can be used as a reference point to help guide the process.

Alerts: Continued loss of major vegetation types in response to anthropogenic and environmental stressors. Loss of spatial extent in high-elevation white pine in areas considered to have a high magnitude of change.

Adaptive management: Determine if ecosystem response is correlated with Forest Service management or other factors (e.g., shifting priorities due to major mortality events focusing management on safety rather than restoration). Priority areas could be targeted for ecological restoration treatments (e.g., prescribed fire or managed wildfire) to improve ecosystem resilience to stressors.

Scale of analysis: Regionwide. Whitebark pine is regionwide where the species exists.

Forest structure: large trees, basal area, quadratic mean diameter, seral class, density

Rationale for selecting indicator: Monitoring forest structure can be an indicator of forest health and a system's resilience and response to stressors.

Data collection: A data source is the gradient nearest neighbor (GNN) produced by the Landscape Ecology, Modeling, Mapping & Analysis group (LEMMA), which uses the Forest Service's Forest Inventory and Analysis inventory plot data and Landsat imagery. GNN structural models can be used to map vegetation composition and structure for forest and woodland areas. Reference conditions can be compared to natural range of variation assessments. LiDAR and F3 data may be used as more products are developed regionwide. Data outputs provide information across land owners within an area of interest.

Data application: Current conditions in vegetation structure can be used to inform an ecosystem's resilience to climate change and other stressors including altered fire regimes, drought, and flooding in riparian systems.

Alerts: Trends in the forest structure of conifer and hardwoods are departed from desired conditions.

Adaptive management: If trends are moving further away from the Region's goals and objectives for forested ecosystems, the Region can develop strategies to improve forest health by increasing the pace and scale of restoration. This information can support Forest Service collaborations with partners to improve watershed conditions. Natural range of variation assessments can be used as a starting point to move toward a future range of variation desired by the Region or national forest.

Scale of analysis: Regionwide.

Meadow condition

Rationale for selecting indicator: Meadows represent only 1 percent of the ecosystems in the Sierra Nevada; however, these ecosystems are of high ecological importance (Fryjoff-Hung and Viers 2012), play a significant role in carbon and nitrogen storage (Norton et al. 2011), mediate surface water flows, groundwater recharge, and sediment filtration (Ratliff 1982, Weixelman et al. 2011), and serve as refugia for numerous species (Knopf and Samson 1994, Kattelmann and Embury 1996). Meadow ecosystems are highly vulnerable to changing hydrologic regimes and processes associated with climate change (Hauptfeld, Kershner and Feifel 2014).

Meadows also provide suitable or occupied habitat for the federally listed amphibian species: Yosemite toad, the Sierra Nevada yellow-legged frog, and the mountain yellow-legged frog, which are indicators to address the trend in occurrence and distribution of key animal species known to occur in Region 5.

Given that meadows have high ecological value, their role in carbon and nitrogen sequestration, their significance in the recovery of federally listed species, and the Region's long-term monitoring program, meadow condition has been selected as an indicator to address the monitoring question *"What are the status and trends of vegetation in Region 5?"*

Data collection: Sources include Region 5 range data and the Region 5 Long-Term Range Monitoring Plots, which have data collected on meadow conditions since 1999. Data collection focuses on species composition and ground cover (Weixelman 2011). Meadow condition is based on the Ratliff rating (Ratliff 1982), a condition score, for each meadow: excellent, good, fair, or poor. The normalized differential vegetation index anomaly data based on eDaRT is being developed by the Remote Sensing Lab and can be a future data source when available.

Data application: Meadow condition can be used to inform maintenance, restoration, and management of meadow ecosystems. Degraded meadows can be evaluated to determine approaches and solutions for restoration. Meadow monitoring can be beneficial in determining suitable conditions to maintain occupied habitat and to develop aquatic and riparian habitat for endangered amphibians and other species.

Alerts: Declining trend in meadows rated in excellent or good condition or meadows with an increasing trend in bare soil for more than 5 years.

Adaptive management: Further evaluation should determine if trends are in isolated or grouped meadows. Isolated trends may indicate site specific changes are occurring which could

trigger a forest evaluation. Grouped trends may indicate occurrence of a large-scale disturbance (e.g., fire) or change in external stressors (e.g., changes in hydrologic regime due to climate).

Scale of analysis: Regionwide.

How has the level of satisfaction expressed by forest visitors and users changed over time in Region 5?

Rationale for selecting monitoring question: A critical element of outdoor recreation program delivery is the evaluation of customer satisfaction with the recreation setting, facilities, and services provided. Information about the quantity and quality of recreation visits is required for national forest plans; Executive Order 12862, Setting Customer Service Standards; and implementation of the National Recreation Agenda. The agency's Strategic and Annual Performance Plans describe the required measures of user satisfaction and use level. Visitor satisfaction information informs managers where and how to allocate resources more efficiently to improve customer satisfaction. Satisfaction is a core piece of data for national and forest-level performance measures. Recreational opportunities in Region 5's forests provide local economies with tourism dollars.

The 2012 planning directives (FSH 1909.12.32.12(d)) identify that monitoring questions should be developed to address the status of visitor use, visitor satisfaction, or progress toward meeting recreation objectives. Region 5 has identified a goal of restoring landscapes affected by unmanaged recreation (USDA 2015).

Given the role that the Region plays in the public's recreation and visitor satisfaction, the projected growth in recreational use on forests in the Region, and the 2012 directives to incorporate visitor satisfaction in forest planning, "*How has the level of satisfaction expressed by forest visitors and users in Region 5 changed over time?*" was chosen as a monitoring question.

Data collection: Data source is the Forest Service National Visitor Use Monitoring program, which collects data for each forest based on a 5-year rotation. Indicators evaluated are visitor use and satisfaction, and the importance-performance ratings.

Visitor use and satisfaction

Rationale for selecting indicator: Long-term changes in visitor use patterns and satisfaction metrics can indicate the need for greater access to specific recreational activities or the need to improve the quality of services and opportunities available to the visiting public. Recreation opportunities provide a high level of visitor satisfaction.

Importance-performance ratings

Rationale for selecting indicator: The importance-performance ratings are based on the average importance and satisfaction scores. Visitors evaluate forests on several categories (developed sites, overnight developed sites, undeveloped areas, and wilderness).

Data application: Visitor satisfaction elements and performance ratings are evaluated to determine if they are consistently identified as items needing improvement. Areas identified as insufficient should become a priority focus for recreation management.

Alerts: Downward trends in visitor satisfaction or importance-performance ratings for the Region or individual forests.

Adaptive management: Declining trends in visitor satisfaction can be broken down into individual metrics to identify what specific areas of recreation management the Region or a forest should focus on to improve visitor satisfaction. Potential actions will depend on the specific component of visitor satisfaction that indicates a need for action (parking availability, trail condition, restroom cleanliness).

Scale of analysis: Regionwide.

How have climatic conditions varied across Region 5 over time?

Rationale for selecting monitoring question: Climate and landform processes (e.g., soils, topography, geomorphology) influence flora and fauna patterns on the landscape (Turner and Dale 1998) and also affect the way people use the land (e.g., changes in recreation, infrastructure). The composition, structure, distribution, and function of California's forests and shrublands are ultimately shaped by water availability over short or long periods of drought, and long (e.g., climatic changes) temporal scales (Lutz, Wagtendonk and Franklin 2010, Kane et al. 2015). Water availability and disturbances can also interact across the landscape to determine the trajectories of vegetation over time (Kane et al. 2015). It is critical to understand life history and ecological responses to changes in climate to guide planning at both the forest and regional scales (Rapacciuolo et al. 2014). However, the practical understanding of how changes in climate indicators interact to drive individual ecosystem and species responses is lacking (Rapacciuolo et al. 2014).

The 2012 planning directives (FSH 1909.12.32.13b) identify that monitoring questions should be developed to address uncertainty and provide early warnings of ecosystem response to climate change. The Region also has a commitment to reduce agency greenhouse gas emissions by reducing daily consumption and costs in water, energy, fleet, waste, and purchasing.

Given the concern about future water availability to maintain resilient forests and shrublands, the uncertainty of managing ecosystems under warming climates, and the complexity of interacting climate indicators and their influence on ecosystem processes, the Region has selected *"How have climatic conditions varied across Region 5 over time?"* as a question of the Strategy.

Data collection: Data sources include the Google Earth Climate Engine, Region 5 Ecology Climate Change Trend Summary documents, and the Basin Characterization Model. Detailed information regarding these data sources are described below.

Data application: The Strategy indicators (temperature, precipitation, and snowpack) can identify general trends across the Region and provide context for plan-level monitoring program interpretation.

Alerts: Downward trends in water availability for forest resources due to climate-driven factors affecting recreational use, causing earlier fire seasons, and expanding forested areas prone to fire.

Applied management: Trends in climate change can inform managers on potential impacts to ecosystem services and provide information for future management decisions.

Temperature: mean, minimum, and maximum, precipitation (5-year coefficient of variation), snowpack, and drought

Rationale for selecting indicators: Precipitation patterns that have been observed across the western United States since the mid-1900s include: more rainfall and less snowfall (Knowles, Dettinger and Cayan 2006), decreased snow depth at lower, transitional elevation sites (Grundstein and Mote 2010, Barnett et al. 2008, Mote et al. 2005), and decreased snow-water-equivalent (SWE) (by 2 to 8 percent per decade with the exception of high-elevation areas like the Southern Sierra Nevada) (Mote et al. 2005, Barnett et al. 2008). The magnitude and direction of precipitation changes are variable across the state and depend on the time series and geographic scale in question. For example, there was an order of magnitude increase in warming between 1970 and 2006 compared to 1918 to 2006, indicating accelerated warming in the last 35 years in California (Cordero et al. 2011). Rapacciuolo et al. (2014) reported an average statewide temperature increase of 0.45 ° C (0.81 °F) between historic (1900 to 1939) and modern (1970 to 2009) times. Changes in precipitation can lead to shifts in other climatic variables (snowfall and drought). While climate models agree that temperature will increase across the majority of the state, changes in precipitation are more uncertain.

California has experienced a record-setting drought between 2012 and 2016, with the lowest yearly precipitation on record in 2014 (Griffin and Anchukaitis 2014) in the last 1,200 years (Griffin and Anchukaitis 2014). Drought and insect attacks combined have caused the mortality of over 100 million trees. The impact from drought caused the Governor to sign drought bills (drought fact sheet), and an emergency proclamation that established the tree mortality task force. Drought in combination with temperature and precipitation can provide a larger picture related to ecosystem stress. Drought information can help prepare the Region and forests for the next drought event by comparing management effectiveness to impacts from drought (Vose et al. 2019, Restaino et al. 2019).

Given recent droughts in California, the projected future accelerated trends in warming, the uncertainty of managing ecosystems under warming climates, and the complexity of interacting climate indicators influencing ecosystem processes and forest management practices, the Region has selected the climate indicators (temperature, precipitation, snowpack, and drought) to address the monitoring question *"How have climatic conditions varied across Region 5 over time?"*

Data collection: Data sources include Region 5 Ecology Climate Assessments and the Google Earth Climate Engine. Region 5 Ecology Climate Assessments synthesize the best available scientific information to provide summaries of climatic conditions of past, present, and future projections at ecoregional rescales for groups of three to four national forests. The Google Earth Climate Engine is a web-based dynamic tool that tracks current and past weather conditions. Future climate scenarios are based on a specific time period and are developed using the Basin Characterization Model—a mathematical computer model that calculates the hydrologic inputs and outputs of a landscape using specific climate data inputs, such as precipitation and air temperature.

Precipitation, temperature and snowpack will be monitored using the Google Earth Climate Engine.

Temperature and Precipitation: Total and 5-year coefficient of variation (measure of interannual variability) are based on the Northern water year (Oct 1: Sept 30).

Snowpack: maximum snow depth, maximum snow water equivalent, 5-year coefficient of variation: maximum snowpack and the 5-year coefficient of variation (measure of interannual variability) are based on the April 1st snowpack. Precipitation will be summarized by the total and the 5-year coefficient of variation (measure of interannual variability) and is based on the Northern water year (Oct 1: Sept 30).

Drought: Data sources are the Office of Sustainability and Climate Drought Summary Tool and the Palmer Drought Severity Index (PDSI).

Data application: Monitoring and assessments can be incorporated into regional, forest, and project-level planning. The Region 5 Ecology Climate assessments can serve as a benchmark providing information on ecological conditions to support terrestrial and aquatic ecosystems. Collectively, these tools can help capture climatic variables throughout the Region that can be used for decision making.

Alerts: Shift in climate trends may trigger longer fire seasons due to increased dryness.

Adaptive management: Other Strategy monitoring questions are also impacted by climate such as tree mortality related to changing fire regimes and large-scale insect and disease outbreaks. Specific drought management strategies to minimize undesirable effects and facilitate recovery of drought-affected landscapes in California are identified in GTR-WO-98 (Fettig et al. 2019). Areas could be identified where proactive management would be beneficial to increase drought resilience as well as identify areas where recovery from past droughts may be a priority.

Scale of analysis: Regionwide.

What are the status and trends of insects, disease, and invasive species in Region 5?

Rationale for selecting monitoring question: Invasive species in any ecosystem can cause harm to the economy, environment, or human health. If left unchecked, invasive species can threaten native species, biodiversity, ecosystem services, recreation, water resources, agricultural and forest production, cultural resources, economies and property value, public safety, and infrastructure. Invasive species can cause massive disruptions in ecosystem function by reducing biodiversity and degrading ecosystem health (Executive Order 13112).

Insects and disease are integral components of ecosystems creating small-scale disturbances that contribute to heterogeneity across the landscape. Many forest pests are part of the natural environment; however, as forest health is impacted by increasing drought and severe weather along with human introduction of pests and pathogens, forests become more vulnerable to pest and insect outbreaks. Native bark beetles such as the mountain pine beetle, fir engraver beetle, western pine beetle, and Jeffrey pine beetle can cause high levels of tree mortality. In California, bark beetle activity can be a proxy for climate change because bark beetle activity is correlated with drought which is associated with hotter and drier conditions. Bark beetle activity is also correlated with stand conditions outside of the natural range of variation that are human

impacted. When there are more trees on the landscape than can be supported by the resources available (water, light, nutrients), trees must compete for available resources and can become stressed. Stress weakens trees leading to increased susceptibly to insects such as bark beetles (Clark et al. 2016). The longer and more extreme the drought, the higher the likelihood of large scale, beetle-mediated tree mortality.

The 2012 planning directives identify that monitoring questions should be developed for climate change and other stressors (FSH 1909.12.32.13(b)). The Strategy incorporates monitoring impacts from insect outbreaks and the spread of invasive species.

Given the threats of uncharacteristically large insect outbreaks or spread of invasive species on forest health and ecosystem services, the Region has selected the question "*What are the status and trends of insects, disease, and invasive species in Region 5?"*

Data collection: Trends in insects, disease, invasive species and their relationship to tree mortality will be evaluated over time.

Data application: If mortality trends are increasing then the Region 5 Forest Health Protection information can be used as a tool to identify risks, impacts to tree species, and potential pest management strategies for management.

Alerts: Increasing trends in tree mortality from insects, disease, and invasive species.

Adaptive management: Invasive species management guidance can be found in Forest Service Manual 2900 Invasive Species Management. The National Strategy and Implementation Plan for Invasive Species Management provides additional management options, identifying key management strategies such as (1) prevention, (2) early detection and rapid response, (3) control and management, and (4) rehabilitation and reforestation.

Scale of analysis: Regionwide.

Tree mortality: acres by severity class, total number of trees affected

Rationale for selecting indicator: Tree mortality is often a response to insects, disease, and pathogens. An estimated 163 million trees have died in California's national forests since 2010. California experienced an extreme drought in 2012–2016, inciting an unprecedented tree mortality event in the central and southern Sierra Nevada (Fettig et al. 2019). This mortality event was large enough to warrant a changed condition from tree mortality on the Sierra and Sequoia National Forests during development of their LMPs. The drought led the governor to issue in 2015 through 2018 Executive Order B-62-18 to protect communities from wildfire and climate impacts and establish the Forest Management Task Force. Region 5 is a member of the team that developed a strategic fire plan focusing on (1) fire prevention and suppression activities to protect lives, property, and ecosystem services; and (2) natural resource management to maintain the state's forests as a resilient carbon sink to meet California's climate change goals and to serve as important habitat for adaptation and mitigation. A revised Strategic Fire Plan for California was issued in 2018.

Given the extensive tree mortality California has experienced in recent years and Region 5's participation in the Forest Management Task Force, tree mortality was selected as an indicator to inform the question *"What are the status and trends of insects, disease, and invasive species in Region 5?"*

Data collection: Data source is the Aerial Detection Monitoring information to calculate acres of tree mortality and total number of trees affected by severity class. Region 5 State and Private Forestry has been collecting Aerial Detection Monitoring data since 1994. The primary purpose of the aerial survey data is to create maps of areas containing current year mortality and damage. Analysis can be conducted by major vegetation data types and by geographic region.

Data application: Apply Region 5 Forest Health Protection information to identify risks, impacts to tree species, and potential pest management to decrease trends in mortality.

Alerts: Increasing trends in tree mortality trends from insects and disease.

Adaptive management: Different strategies may be needed in areas that have experienced high tree mortality and treatments should be prioritized to implement preventative work. Integrated pest management can aid with responding to problems that have occurred in consultation with Forest Health Protection staff.

Scale of analysis: Regionwide.

Sudden oak death: acres by severity class, total number of trees affected

Rationale for selecting indicator: Sudden oak death is identified as a key Region 5 invasive species. Sudden oak death is a fungus-like pathogen (*Phytophthora ramorum*) that causes mortality in hardwood species.

Given the priority in the Region to monitor it as an invasive pathogen, sudden oak death was selected as an indicator to address the question *"What are the status and trends of insects, disease, and invasive species in Region 5?"*

Data collection: Aerial Detection Monitoring identifies sudden oak death as a mortality agent. The University of California, Berkeley, produces a SODmap distribution map of the spatial extent of the pathogen.

Data application: Areas experiencing high levels of sudden oak death can be identified for vegetation treatments.

Alerts: Increasing trends in tree mortality from pathogens and disease.

Applied management: If sudden oak death is increasing, especially in areas identified as zones of infestation, the California Oak Mortality Task Force website can be used as a tool to identify management solutions such as topical bark applications for mitigating the pathogen.

Scale of analysis: Regionwide.

Non-native invasive plants – acres of invasive species, acres of invasive species treatment

Rationale for selecting indicator: Invasive species can threaten native species, biodiversity, ecosystem services, recreation, water resources, agriculture and forest production, cultural resources, economies, property values, public safety, and infrastructure. Region 5 has identified a goal of decreasing the impacts of invasive species through preventative practices, rapid response control, management, rehabilitation and restoration, emphasizing cooperative work with Federal, State, and community partners (USDA 2015).

Non-native invasive grasses threaten ecosystems and habitat for at-risk species. Large areas experiencing decreased fire resilience due to invasion from non-native annual grasses (such as cheatgrass and red brome), increase susceptibility to more frequent fires and disrupt native vegetation composition and structure.

Given that invasive species can affect many ecosystem services and ecological conditions for at-risk species, non-native invasive species have been selected as indicators to inform *"What are the status and trends of insects, disease, and invasive species in Region 5?"*

Data collection: Data source is the Remote Sensing Lab annual summary of annual grass cover and Forest Inventory Tracking System (FACTS) for acres treated.

Data application: Increasing rates of change (compared to baseline trend) in specific vegetation or habitat types or in areas where disturbance or management action would indicate a declining trend or departure from desired condition.

Alerts: Acres of non-native invasive species are increasing over time.

Applied management: This information will help evaluate the Region's progress toward mitigating impacts of non-native invasive species. Prioritizing invasive species weed treatments can be based on (1) prevention, (2) early detection, and (3) rapid response. Cal WeedMapper provides management recommendations based on the current distribution of a species. Forests can further evaluate surveillance targets and eradication opportunities specific to the plan-level monitoring program.

Scale of analysis: Regionwide.

What are the status and trends of air quality across Region 5?

Rationale for selecting monitoring question: The 2012 planning directives identify that monitoring questions should be developed for climate change and other stressors (FSH 1909.12.32.13). The directives recommend that the Strategy incorporate national monitoring programs such as air monitoring and climate change to address uncertainty and provide early warnings of ecosystem response. The Region has selected the question "*What are the status and trends of air quality across Region 5?"* to incorporate air monitoring in the Strategy.

Wilderness visibility

Rationale for selecting indicator: With the Clean Air Act of 1977, Congress established a national goal to remedy existing and prevent new human-caused visibility impairment to Class 1 wilderness areas, national parks, and national wildlife refuges. Region 5 has been monitoring wilderness visibility as a cooperator of the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program since the late 1980s. Region 5 conducts visibility monitoring in multiple wilderness areas throughout the Region.

Given the regulatory requirements for air quality and the Region's participation as a long-term cooperator in the IMPROVE program, wilderness visibility was selected as an indicator to address the monitoring question *"What are the status and trend of air quality across Region 5?*

Data collection: Data are available at the Federal Land Manager Environmental Database.

Data Application: The results of the IMPROVE network can help determine current wilderness visibility trends.

Effects to air quality are evaluated during environmental planning to determine potential wilderness plume blight from machinery. Local examples include machinery operating within forest boundaries related to mining, oil and gas extraction, utility construction, and other emissions. A land manager can review modifications within 100 kilometers of large stationary sources (powerplants, large mines) under the Prevention of Significant Deterioration regulation of the Clean Air Act. In these cases, the land manager can require the most efficient engines or the Best Available Retrofit Technology (BART) be used.

Alerts: When monitoring indicates wilderness areas are not meeting standards, states can regulate emission sources through a state implementation plan to reduce haze on a large scale as required under the Regional Haze Rule of the Clean Air Act.

Adaptive management: The Forest Service can enact measures to mitigate effects to air quality such as using machinery with better emissions control from new emission sources.

Scale of analysis: Regionwide and by individual wilderness area.

How have fire regimes varied over time across Region 5?

Rationale for selecting monitoring question: California has seen an increase in annual area burned by wildfires (Williams et al. 2019, Collins et al. 2019), causing a detrimental impact on life and property (Keeley and Syphard 2019). Uncertainty exists regarding the degree and extent of negative impacts of changing fire regimes on terrestrial and aquatic ecosystems due to the interaction of additional stressors (climate change, invasive species, insect outbreaks) with fire. A fire regime identifies the patterns of fire that occur over long periods of time, and the immediate effects of fire in the ecosystem in which it occurs.

Region 5 has identified a goal of decreasing the occurrence of uncharacteristically severe wildfires and their associated impacts through environmentally and ecologically sensitive vegetation treatments, fire management, and public education (USDA 2015). Monitoring fire regimes can inform the Region on the ecological changes that are seen throughout regional landscapes as well as provide insight in to what has been occurring on the forests. Altered fire regimes relate to many of the Strategy questions and associated indicators (ii, iii, iv, vi, vii, viii, ix) identified in the 2012 planning directives (FSH 1909.12.32.1).

Given how altered fire regimes have caused profound effects on life and property, and the uncertainty of how changing fire regimes will affect ecosystems processes, the Region has selected the monitoring question *“How have fire regimes varied over time across Region 5?”*

Data collected: Fire regimes will be measured through three indicators: fire size, fire severity, and fire return interval departure.

Fire size

Rationale for selecting indicator: The size, shape, and intensity of a disturbance influence future landscape dynamics (Sugihara et al. 2006).

Data collected: The CalFire California Fire and Resource Assessment Program (FRAP) Statewide Fire Perimeter Database tracks fire perimeters for all Forest Service wildfires 10 or more acres since 1950. Major vegetation types can be summarized from EVeg data, which can be found on the FSGeodata Clearinghouse.

Fire severity

Rationale for selecting indicator: Vegetation burn severity can provide insight into the degree of post-fire ecological change, including changes in post-fire stand structure (e.g., canopy cover or basal area loss).

Data collected: Data sources are Monitoring Trends in Burn Severity (MTBS) analysis completed one-year post fire on all fires greater than 1,000 acres, the Burned Area Reflectance Classification (BARC) satellite-derived data layer of post fire as input to the soil burn severity product produced by the Burned Area Emergency Response (BAER) teams, and the Rapid Assessment of Vegetation Condition after Wildfire (RAVG) products produced at the Remote Sensing Applications Center for wildfires 1,000 acres or more. The Forest Service Region 5 Remote Sensing Lab Vegetation Burn Severity uses one-year post-fire images using techniques similar to RAVG data. Acres of fire severity (unchanged, low, moderate, and high) will be totaled by major vegetation types.

Fire return interval departure

Rationale for selecting indicator: Fire return interval departure analysis quantifies the difference between current and presettlement fire frequencies, allowing managers to target areas at high risk of threshold-type responses to altered fire regimes and interactions with other factors.

Data collected: Fire return interval departure analysis calibrates fire frequency by vegetation types on national forests in California and adjacent land jurisdictions. Data will be summarized by fire return interval condition class to indicate the level of departure from historic reference to show current conditions.

Applying adaptive management informed by the fire regime

Data application: Data on fire regimes provide an integrated way to view the diverse spatial and temporal patterns of fire and impacts of fire at an ecosystem or landscape level. Understanding changing fire regimes will inform how to adapt fire-prone landscapes and how to develop strategies for restoration, depending upon regional or forest-level objectives. An action plan may be developed to identify how to mitigate the risk of large-scale high-severity wildfire with consideration of other stressors.

Alerts: Increasing trends of uncharacteristically large-scale, high-severity wildfire.

Adaptive management: Although historical conditions may not be attainable or sustainable in long-term management, comparisons between historical and current fire regimes can assist managers in prioritizing areas for ecological restoration and other management actions (Safford et al. 2014). Areas with large deviations (more frequent or less frequent) from historic return intervals may be at a higher risk to ecosystem degradation and type conversion, making them priorities for restoration. Other factors to consider along with the fire regime are climate, site history, fuel loading, vegetation structure, and topography.

Scale of analysis: Regionwide.

What are the trends in ecosystem services and economic contributions in Region 5 national forests and surrounding communities?

Rationale for selecting monitoring question: This question focuses on understanding the Region's contribution to economic and ecosystem services that benefit the Nation. The 2012 Planning Rule defines economic sustainability as "the capability of society to produce and consume or otherwise benefit from goods and services including contributions to jobs and market and nonmarket benefits" (36 CFR 219.19). Forest plans are required to have plan components to guide the planning area's contribution to social and economic sustainability (36 CFR 219.8(b)) and for integrated resource management to provide for ecosystem services and multiple uses in the planning area (36 CFR 219.10(a)).

Understanding the conditions and trends of communities affected by forest management provides insight in community resilience to changes in management activities. Specifically, communities that are more dependent on forest activities for local fiscal resources are potentially more susceptible to changes in forest management.

Data collection: Data sources are the U.S. Forest Service Ecosystem Management Coordination Program and the U.S. Census Bureau.

Data application: Monitoring information can be used to determine trends in jobs supported by the Forest Service or outreach effectiveness in communicating with lower income and minority groups during forest planning.

Alerts: Decreasing trend in jobs supported by the Forest Service or outreach effectiveness in communicating with lower income and minority groups during forest planning.

Adaptive management: Trends may indicate changes in job sectors or demographics in communities near forests throughout the Region.

Jobs supported

Rationale for selecting indicator: Forests provide economic contributions to communities through activities such as forest products, recreation visitation, grazing, mining, and by employing Forest Service staff. Monitoring changes in these contributions can provide insight as to how forest management may be supporting economic and social conditions in these communities.

Data collection: The Ecosystem Management Coordination Program has developed annual At a Glance reports that summarize the number of jobs supported and income contribution the Forest Service provides to local economies.

Data application: Results should be examined to determine if there are recognizable changes (downward trends) in values suggesting a potential change in forest contributions to communities. Information can be presented by annual jobs and annual jobs by program type

(recreation by local or non-local visitors, minerals and energy, forest products, livestock grazing, Forest Service resource management investments, and payments to counties).

Alerts: Sustained downward trends in these values would suggest that changes in local conditions may be related to forest management.

Adaptive management: Economic data are driven by many factors that are beyond forest management control. Consider evaluating data for long-term trends and as a basis for conversations with local community stakeholders and county governments to better understand the factors driving changes. Contacting key local stakeholders to review trends will help build relationships and ensure a common understanding and interpretation of the results, and identify if any forest management actions may be leading to these changes.

Scale of analysis: Regionwide.

Environmental justice

Rationale for selecting indicator: In 1994, Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" was signed requiring that each Federal agency make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations (Quality 1997). Environmental justice communities may require different outreach strategies; therefore, it is important to understand where these communities occur near national forests.

Data collection: The U.S. Census Bureau publishes the American Community Survey, which includes 5-year estimates of minority and low income communities.

Data application: Monitor forest contributions to community income.

Alerts: Low-income communities are increasing near national forests.

Adaptive management: If there is a shift in environmental justice communities near national forests (either an increase or decreases), forests should revisit communication and outreach plans. Ideas for outreach can be found in a technical report (RMRS-GTR-396) that provides social vulnerability assessments (Armatas et al. 2019). This report provides a manual for engaging the public, including an approach for implementation using various practices.

Scale of analysis: Regionwide.

Forest carbon stocks and flux

Rationale for selecting indicator: Forested ecosystems provide carbon storage as an ecosystem service. Forests contribute to climate change mitigation by absorbing carbon dioxide and storing it in the trees and soil. The 2012 planning directives (FSH 1909.12.4) identify that carbon stocks should be assessed to understand how “The plan area plays a role in sequestering and storing carbon” [§12.4.1.a]; “Disturbances, projects, and activities influenced carbon stocks in the past and may affect them in the future” [§12.4.1.b]; and “Where the carbon is stored, how the storage is changing, and how the storage might be influenced by management” [§12.4.1.c].

Data collection: Previously published reports provide baseline estimates of carbon resources: (1) USDA Office of Sustainability and Climate report for the Pacific Southwest Region (2015), and (2) the California Department Board of Forestry and Fire Protection AB1504 California Forest Ecosystem and Harvested Wood Product Carbon Inventory Reports (2017), which summarize carbon stocks and flux by forest and by region.

Data application: These reports can serve as baseline estimates for future comparisons to determine trends in carbon resources.

Alerts: Trends indicate regionwide or forest-level decreases in pools and increases in fluxes in carbon resources over time.

Adaptive management: Undesirable values in carbon resources should be evaluated to consider how carbon stocks are affected by factors such as timber harvesting, natural disturbances, climate variability, increasing atmospheric carbon dioxide concentrations, and nitrogen deposition (Birdsey et al. 2019).

Forest mitigation strategies for climate change and managing carbon stocks are to ensure forests are in a healthy condition through proper management, increasing carbon sequestration by planting trees or other forest management techniques that increase biomass, and increasing the use of wood products and substitute wood for materials that require energy-intensive production. The California Board of Forestry and Fire Protection AB1504 carbon inventory reports provide information on mitigation opportunities, such as mitigating disturbance effects on flux trends on National Forest System lands.

Scale of analysis: Regionwide.

Forest products – cut volume

Rationale for selecting indicator: Timber is an ecosystem service National Forest System lands provide. Cut volume is a quantifiable measure calculating the use of a specific forest product.

Data collection: National Forest System Cut and Sold reports provide data on total volumes and values of all convertible forest products sold and harvested on National Forest System lands and national grasslands.

Data application: Compare accomplishment reports to set targets by the region and by forest.

Alerts: Downward trends in cut volume targets by region and by forest.

Adaptive management: Identify fluctuations in cut volumes and the reasons for variability in meeting targets such as when product is sold, when implementation occurs, and the capacity of mills to accomplish timber work.

Scale of analysis: Regionwide.

What is the status of the ecological restoration goals identified in the Region 5 Leadership Intent document (2015)?

Rationale for selecting monitoring question: The Region 5 leadership intent document identifies ecological restoration as a central driver of wildland and forest stewardship across all program areas and activities (USDA 2015). The document identifies the following activities, among others, to be promoted: forest thinning and prescribed fire to decrease fuel loading and increase forest heterogeneity, meadow and riparian restoration to improve watershed function, environmentally and ecologically sensitive fire management practices, invasive species eradication, and wildlife and fish habitat improvement.

The Pacific Southwest Region's goal is to implement the pace and scale of restoration necessary to reverse current trends by accomplishing specific goals within the next 15 to 20 years. The Strategy has identified two goals to monitor:

1. *Forest resilience*: Increase forest resilience through treatments (including prescribed fire and thinning) and wildfire, resulting in resource benefits to approximately 9 million acres on National Forest System lands.
2. *Meadow resilience*: Restore at least 50 percent of accessible degraded forest meadows to improve habitat function, ability to hold water longer into the summer, and deliver clean water when most needed.

Given that ecological restoration benefits many of the Region's program areas, the urgency to increase pace and scale to enhance forest resilience, and the targets set forth by the Region, the monitoring question *"What is the status of ecological restoration goals identified in Region 5 Leadership Intent (2015)?"* was selected as a high-priority monitoring question.

Data collection: The Strategy will monitor accomplishments specific to forest and meadow resilience.

Data application: Accomplishment reporting establishes accountability, provides for quality decisions, and provides reporting to outside stakeholders and the public. Forest accomplishments will be rolled up to the regional level and will be evaluated to determine if the Region is on a trajectory to accomplish targets by 2035. Accomplishments will be summarized by the Region.

Alerts: Trends indicate that the pace and scale of restoration are not on a trajectory to accomplish goals.

Adaptive management: Goals may be modified as new science, technologies, ideas, or collaborations identify efficiencies to increase the pace and scale of restoration to develop resilient forests and wildlands. Shifting priorities may also occur when large-scale mortality events require the Region to focus on public safety, life, and property, rather than restoration.

Forest resilience:

Rationale for selecting indicator: Healthy, thriving ecosystems are less vulnerable to extreme wildfires that can devastate watersheds, destroy wildlife habitat, and risk lives. Healthy ecosystems can adapt to climate change, invasive species, and insect infestations. Fire suppression has created thick, dense forests that are susceptible to large-scale high-disturbance events. Landscapes are now vulnerable to devastating, extreme wildfires.

Restoring ecosystems will require 2 to 3 million acres of thinning and prescribed burning treatments. The Region is working with partners to restore healthy, resilient, fire-adapted ecosystems.

Data collection: Data sources are FRAP (total acres of wildfire by objective within each management zone), and FACTS for fuels treatments (acres of prescribed fire, mechanical and hand thinning).

Data application: Results can inform if forests and the Region are meeting annual targets and developing resilient landscapes.

Alerts: Acres of treatments are not meeting annual restoration targets.

Adaptive management: Evaluate trends to determine if activities are meeting desired outcomes in areas prioritized for restoration. Make adjustments as needed to enhance resource benefits such as more fuels treatments in strategic places, considering constraints such as weather (drought preventing prescribed fires), regulatory requirements (air or water board concerns), or insufficient budgets.

Scale of analysis: Regionwide.

Meadow resilience: acres of meadow restoration by project type and normalized differential vegetation index anomalies

Rationale for selecting indicator: Meadow resilience was identified as a specific goal to address the monitoring question *"What is the status of ecological restoration goals identified in the Region 5 Leadership Intent (2015)?"*

Data collection: Data source is the Watershed Improvement Tracking system (acres of meadow restoration treatments). The normalized differential vegetation index anomaly data is being developed by the Remote Sensing Lab and can be a future data source when available. The Sierra Meadow Partnership in collaboration with the University of California, Davis, monitors and tracks restoration in meadows across land ownership.

Data application: The normalized differential vegetation index anomaly detection indicator will identify meadows that may be experiencing degradation.

Alerts: Restored meadows are experiencing degradation.

Adaptive management: Confirm that meadows are degraded, and if so, conduct further analysis to determine the following: (1) if degradation is occurring across a wide range of meadows that have been restored, (2) if specific types of restoration are trending toward degradation, or (3) if other factors are influencing the degradation that may be occurring at local or regional scales. Analysis should inform changes to management activities to improve management actions.

Scale of analysis: Regionwide.

Appendix B. Future indicators for consideration

Ecological conditions for ecosystems and at-risk species, climate change and stressors:

- Bats
- Sage grouse
- Giant sequoia
- Air quality (lichens)
- Gold-spotted oak borer
- Polyphagous shot hole
- All biotic agents affecting tree mortality
- Expand pests to include southern California
- Tree mortality: replace total number of trees affected with the area affected
- Long-term soil research

Visitor use and satisfaction:

- Closing facilities and facility accessibility.

Ecosystem services and economic contributions from national forests, as well as the economic conditions in communities located near national forests:

- Grazing (animal month units)
- Mining

Appendix C. Status of Region 5 Forest LMP Monitoring Programs

Table 2. Region 5 forest monitoring program status relative to transitioning to the 2012 Planning Rule. The table includes links to the most recent monitoring program documents

Forest	Plan Monitoring Program (MP) Status	Monitoring Program Completion or Revision Date	Monitoring Program HyperLink
Angeles	MP transition complete	2016	Updated Appendix C Monitoring Requirements
Cleveland	MP transition complete	2016	Updated Appendix C Monitoring Requirements
Eldorado	MP pre-2012 rule	1988	Chapter 5 LMP
Inyo	MP Complete 2012 FP Revision Complete	2019	Chapter 4 of LMP
Klamath	MP pre-2012 rule	2010	Chapter 5 of LMP
Lassen	MP pre-2012 rule	1992	Chapter 5 of LMP
Los Padres	MP pre-2012 rule – tried to transition in 2016 but based on comments made the decision not to transition	2005	Appendix C of LMP
LTBMU	MP transition underway	2016	Appendix A of LMP
Mendocino	MP pre-2012 rule	1995	Chapter 5 of LMP
Modoc	MP pre-2012 rule	1991	Chapter 5 of LMP
Plumas	MP pre-2012 rule	1988	Chapter 5 of LMP
San Bernardino	MP transition complete	2016	Updated Appendix C Monitoring Requirements
Sequoia	MP Pending 2012 FP Revision underway	Anticipated 2020	Chapter 4 of Draft LMP
Shasta Trinity	MP pre-2012 rule	1995	Chapter 5 of LMP
Sierra	MP Pending 2012 FP Revision underway	Anticipated 2020	Chapter 4 of Draft LMP
Six Rivers	MP pre-2012 rule	1995	Chapter 5 of the LMP
Stanislaus	MP pre-2012 rule	1991	Chapter 5 of the LMP
Tahoe	MP pre-2012 rule	1990	Chapter 6 of the LMP
Giant Sequoia National Monument	MP pre-2012 rule	2012	Page 108 of Part 3 Management Plan

MP = monitoring plan; LMP = land management plan

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