United States Department of Agriculture
Forest Service

Draft Bio-Regional Assessment

TABLE OF CONTENTS

WHAT IS THE BIO-REGIONAL ASSESSMENT? 3
- Structure of the Bio-Regional Assessment 4
- How can you help? 5
- History and Context 6
- 2012 Planning Rule 6
- Leadership Intent and Ecological Restoration 7
- Best Available Scientific Information 7
- Science Synthesis 8
- Drivers and Stressors 8
- Collaboration 8
- Topic Papers and Public Input 9
- Identifying Themes 10
- 2004 Sierra Nevada Framework 10
- Sustainability 11

WHAT IS THE ASSESSMENT AREA? 12

WHAT ARE THE FINDINGS? 14
- WATER QUALITY AND QUANTITY 14
  - What are we trying to sustain at the bio-regional level? 14
  - Weaving it Together 14
  - Biodiversity of Aquatic and Riparian Ecosystems 14
  - Functioning Watersheds 17
  - Good Water Quality and Quantity 19
  - 2004 Sierra Nevada Framework 25
- FIRE RESILIENCE 27
  - What are we trying to sustain at the bio-regional level? 27
  - Weaving it Together 27
  - Ecosystem Resilience to Fire 28
  - Benefits People Obtain from Ecosystem Services 37
  - Resilient Communities in the Face of Fire 40
  - 2004 Sierra Nevada Framework 45
- SUSTAINABLE RECREATION 46
  - What are we trying to sustain at the bio-regional level? 46
  - Weaving it Together 46
  - Culture and Lifestyle 47
  - Connections to the Land 51
  - Economic Opportunities for Communities 53
  - 2004 Sierra Nevada Framework 55
- ECOLOGICAL INTEGRITY 56
  - What are we trying to sustain at the bio-regional level? 56
  - Weaving it Together 56

Biological Diversity 57
Ecosystem Resilience 67
Benefits to People from Functioning Ecosystems 72
2004 Sierra Nevada Framework 75
COMMUNITY RESILIENCE 76
What are we trying to sustain at the bio-regional level? 76
Weaving it Together 76
Opportunities that Support the Diversity of Cultures and Values 77
Connections to the Land 85
Social Interactions 87
Local Economic Opportunities from Forest Activities 88
Health, Safety, Education and Skills 93
2004 Sierra Nevada Framework 95
WHAT ARE THE CONCLUSIONS? 97
What did we learn? 97
WATER QUALITY AND QUANTITY 97
FIRE RESILIENCE 98
SUSTAINABLE RECREATION 99
ECOLOGICAL INTEGITY 100
COMMUNITY RESILIENCE 102
Where do we go from here? 103
REFERENCES 104
HELPFUL LINKS 123

WHAT IS THE BIO-REGIONAL ASSESSMENT?

The Bio-Regional Assessment:

paints a picture of conditions on a larger landscape;

ahead of forest-level assessments;

to help the public and land managers understand how

national forests

fit within our social, economic and ecological systems.

The Bio-Regional Assessment seeks to

use a transparent and collaborative approach,

offer context for forest assessments on cross-cutting themes.

supply trends for an expanded area,

weave together over-arching themes and pressures on the landscape,

promote an understanding of how systems work,

identify what is working well at a large landscape scale,

provide information to support the need for change, and

look beyond forest boundaries during the planning process.

Structure of the Bio-Regional Assessment

The Bio-Regional Assessment is organized as follows:

An opening section that answers the question "WHAT IS THE BIO-REGIONAL ASSESSMENT?" and provides context around the writing of it;

A description and map of the ASSESSMENT AREA;

FINDINGS for the key themes identified:

1. Water Quality and Quantity
2. Fire Resilience
3. Sustainable Recreation
4. Ecological Integrity
5. Community Resilience

CONCLUSIONS about the key themes and integration across them;

REFERENCES cited throughout the document;

HELPFUL LINKS.

The goal was an understandable, plainly written document. The writers tried to include an appropriate level of technical detail without jargon. Acronyms were spelled out or avoided when possible.

How can you help?

We welcome your feedback to help us improve the Draft Bio-Regional Assessment. An email address is being established for gathering your comments. Please check the Bio-Regional Assessment webpage for the mailbox address (http://www.fs.usda.gov/detail/r5/landmanagement/planning/?cid=STELPRDB5420599).

Feedback received by June 15, 2013 will be considered in finalizing the Bio-Regional Assessment.

When you are reviewing the document and submitting feedback, please consider:

- Clarity of the document

- Identification of overarching themes, including:
  - Appropriateness at the bio-regional scale
  - Broad level of interest
  - Sustainability
  - Linkages to the 15 topic papers
  - Influence of forest plans
  - Consistency with the Leadership Intent for Ecological Restoration and the 2012 Planning Rule

- Meeting the purpose of the document, including:
  - Use of a transparent and collaborative approach
  - Context for forest assessments on cross-cutting themes
  - Trends for an expanded area
  - Identification of over-arching themes and pressures on the landscape
  - Understanding of how systems work
  - What is working well at the large, landscape scale
  - Information to support the need for change
  - A view beyond forest boundaries during the planning process

Your feedback is welcome and highly valued. Thank you for providing your input.

History and Context

There has always been strong interest in the management of the national forests in the Sierra Nevada, but interest really became focused with the original forest plans developed in the 1980s through early 1990s. Those original forest plans took between 6 and 8 years to complete and were contentious. They mainly focused on social interests of the time, and new computer modeling that, in a mechanical way, found "optimal" solutions. As a result, there was controversy over balancing multiple uses. In the early 1990s, concerns emerged about trends in old forest habitats needed for species like the California spotted owl. This led to a major change in the newly adopted forest plans. This was the start of considering a bio-regional approach to planning around resources in the Sierra Nevada. This approach ultimately culminated in the Sierra Nevada Forest Plan Amendments to each individual forest plan.

Controversy is not always a bad thing. One positive benefit of continuing controversy surrounding management of Sierra Nevada forest resources is the emergence of local and larger-scale collaborative efforts. These span collaboration with local stakeholders on specific projects, to nationally selected 10-year projects under the Collaborative Forest Landscape Restoration Act, to the Sierra Cascades Dialog initiated in 2010. Each of these works to strengthen understanding of the social, economic, and environmental resources to consider, plan and act toward common goals.

The 2012 Planning Rule, with its substantial focus on collaboration and adaptive planning, is the next step in improving management of the national forests. There is an opportunity to blend and leverage the different strengths that come from collaboration at multiple scales. Adaptive planning is an opportunity to find a better balance between planning, doing, and learning that more effectively and efficiently uses taxpayer funds to manage for sustainability of the resources and opportunities provided by national forests. This process of developing a Bio-Regional Assessment, followed by Forest Assessments and Plan Revisions on the three "Early Adopter" national forests represents the evolution of improved management that will benefit not just the Sierra Nevada, but the nation as a whole.

2012 Planning Rule

The 2012 Planning Rule provides the structure for the national forests in California to create local land management plans. The Rule establishes an ongoing, three phase process: 1) assessment; 2) plan development or revision; and 3) monitoring.

The 2012 Planning Rule is intended to create understanding around landscape scale management. It takes an integrated and holistic approach that recognizes the interdependence of ecological processes with social and economic systems. This approach uses best available science to inform decisions along the way. Collaboration with stakeholders, and transparency of process, are key ways the 2012 Planning Rule guides creation of forest plans for the future.

The Bio-Regional Assessment provides context on themes that cross boundaries over this larger landscape. The forest plans that flow from it will guide sustainable integrated resource management on National Forest System lands. Forest plans will consider a full range of multiple uses on NFS lands where jobs are generated and economic opportunities are created. The Bio-Regional Assessment lets us start talking about issues that affect larger areas and more people, and lets the Forests use the information for forest-level assessments. The three "early adopter" forests under the 2012 Planning Rule which will tier off the Bio-Regional Assessment are the Sierra, the Sequoia and the Inyo National Forests.

Leadership Intent and Ecological Restoration

In the Pacific Southwest Region of the Forest Service, leadership intent around ecological restoration is to retain and restore ecological resilience of National Forest lands to achieve sustainable ecosystems that provide a broad range of services to humans and other organisms. Forest Plans guide decisions that will achieve that sustainability for both the resources and our stakeholders, today and in the future.

The Bio-Regional Assessment is a reflection of conditions on the ground. Wildfires don't care about forest or county boundaries. Organisms aren't concerned with state lines. Pollution drifts over the entire landscape, not a particular city. The hope is that considering the larger landscape will show the fluidity and interconnectedness of social, economic and ecological elements, and shine light on issues to work on in a larger way.

Best Available Scientific Information

The Bio-Regional Assessment is based on the best available scientific information (BASI) as required by the 2012 Planning Rule. The writers reviewed the available scientific information and determined which is the most accurate, reliable, and relevant information for the issue. The characteristics generally expected in a valid scientific process are:

Peer review: The information has been critically reviewed by other qualified scientific experts in that scientific discipline. The criticism of the peer reviewers has been addressed by the proponents. Publication in a refereed scientific journal usually indicates that the information has been appropriately peer-reviewed.

Methods: The information gathering methods are clearly stated and can be replicated. The methods are standardized in the pertinent scientific discipline or, if not, the methods have been appropriately peer-reviewed for reliability and validity.

Logical conclusions and reasonable inferences: Conclusions are based on reasonable assumptions, are supported by other studies, and are consistent with the general theory underlying the assumptions. Conclusions are logically and reasonably derived from the assumptions, and are supported by the data. Gaps in information and inconsistencies with other pertinent scientific information are explained.

Quantitative analysis: Data have been analyzed using appropriate statistical or quantitative methods.

Context: The information is in proper context. Assumptions, analytical techniques, data, and conclusions are appropriately framed with respect to the prevailing body of pertinent scientific knowledge. Information is the most pertinent to the conclusions being drawn and to the geographic context.

References: Assumptions, analytical techniques, and conclusions are well referenced with citations to relevant, credible literature and other pertinent existing information.

Typically BASI is developed using the scientific method, which includes clearly stated questions, well designed investigations and logically analyzed results, documented clearly and subjected to peer review. However, BASI may also be information from analyses of data from a local area, or studies to address a specific question in one area. The BASI could also result from expert opinion, panel consensus, or observations, as long as the responsible official has a reasonable basis for relying on that scientific

information as the best available .Additionally the Bio-Regional Assessment used local knowledge, such as tribal knowledge, when appropriate and applicable.

Science Synthesis

To support the scientific basis of the Bio-Regional Assessment, the Pacific Southwest Region of the Forest Service sponsored a Science Synthesis, researched and written by scientists at the Pacific Southwest Research Station. At the time of the writing of the Bio-Regional Assessment, the Science Synthesis was still in draft form. The Science Synthesis integrates peer-reviewed scientific information across disciplines to inform and lead to tangible options for land managers and stakeholders. The Research Station provided additional review opportunities after the draft was released, and will publish a final version in the near future. This document will be used during the NEPA phase of forest plan revision. Much of the information compiled in the draft Science Synthesis was relevant and useful to help frame the Bio-Regional Assessment.

Drivers and Stressors

Changing climate, human populations, floods, and fires are all potent forces that drive or stress natural ecosystems, communities of people, and services derived from wildlands. These are called "drivers and stressors". Drivers and stressors are used throughout the Bio-Regional Assessment to connect the dots. Drivers and stressors are repeating threads, and looking at them across boundaries helps describe the current condition and pick up on trends.

The 2012 Planning Rule describes drivers as: "natural disturbance regimes; predominant climatic regimes; broad-scale disturbance regimes such as wildfire, wind, flooding, insects, and disease and natural vegetation succession including: human-caused changes in successional pathways that may maintain vegetation in an uncharacteristic age or size-class condition; scarcity and abundance of successional states relative to the reference period." Stressors are defined by the 2012 Planning Rule as: "those that: directly and indirectly degrade or impair key ecosystem characteristics and ecological integrity."

Collaboration

There has been a major shift in how collaboration is approached in these early stages under the 2012 Planning Rule. The old way of doing business was to create forest plan documents, and then present them to the public for comment. Changes in society, higher expectations for engagement, and new regulations have all created the need to take a different approach. Success means new, different, creative ways of operating collaboratively.

There has been engagement with the public at numerous face-to-face workshops and technology has been used to interact virtually. The Sierra Cascades Dialog continues to be an important vehicle for engagement on forest planning. The meetings are designed and built *with* partners, not in a vacuum. The on-line community called *Our Forest Place*, a non-Forest Service site, is where members interact on blogs, and in discussion groups, and where they can find information about forest planning and current events. *The Living Assessment* is a wiki tool comprised of the fifteen topic chapters laid out in the 2012 Planning Rule:

Chapter 1	Ecological Integrity of Ecosystems
Chapter 2	Air, Soil, Water
Chapter 3	Drivers and Stressors
Chapter 4	Assessing Carbon
Chapter 5	At-risk Species
Chapter 6	Social, Cultural, Economic
Chapter 7	Benefits to People
Chapter 8	Multiple Uses
Chapter 9	Recreation
Chapter 10	Energy and Minerals
Chapter 11	Infrastructure
Chapter 12	Tribal
Chapter 13	Cultural
Chapter 14	Land
Chapter 15	Designated Areas

The topic papers found inside each of these chapter headings on *The Living Assessment* represent the best effort at describing current conditions and trends. By outreaching to stakeholders, there has been direct engagement in writing, not just reviewing these papers. Many interested constituents have added important and valuable input directly, creating a "living" body of work, in partnership with Forest Service scientists and specialists. This is a remarkable shift in the approach to public involvement. While not without bumps, it has proven extremely valuable in capturing the best information available, and has facilitated a higher level of conversation with our stakeholders. This has made a stronger Bio-Regional Assessment.

The Living Assessment will continue to be updated by Forest Service specialists and by members of the public after the Bio-Regional Assessment and Forest Assessments are finalized, and during the forest-level NEPA processes which follow. It is intended to inform the process along the way and help to develop the need for change.

Topic Papers and Public Input

The writers used a very deliberate process to move between the topic papers and the Bio-Regional Assessment. In January, the Regional Planning Team began working with interested stakeholders and providing their own contributions to the *Living Assessment*, also known as the WIKI. They monitored entries, gathered information, responded personally to questions and addressed concerns from contributors. They focused attention on areas where there was significantly more interest than others and provided additional exposure to those through workshops and podcasts. On April 8, a snapshot of the WIKI was taken, and the team began sifting through the information to synthesize what was most relevant under the five themes of the Bio-Regional Assessment. You will note places where the writers specifically cite to the topic papers. These will look like this: Chapter X, WIKI. The topic papers under the 15 chapters in the WIKI were the foundation and the precise location for specific information found in this document. In the process of writing the Bio-Regional Assessment, the team refined or developed additional information, this information has been or will be posted to the WIKI soon.

Identifying Themes

The Bio-Regional Assessment integrates social, economic and ecological systems. The Regional Planning Team relied heavily on the topic papers described above. The goal was to weave together the information from *The Living Assessment* to describe the interconnectedness of these systems, the condition they are currently in, and how they are trending.

The five themes identified are: Water Quality and Quantity; Fire Resilience; Sustainable Recreation; Ecological Integrity and Community Resilience.

These key themes were identified by asking the following questions:

- *Is it related to, and appropriately addressed at the bio-regional scale?*
- *Is there broad interest in it?*
- *Is sustainability in question?*
- *Does it have linkages woven through the topic papers?*
- *Is it something that forest plans influence?*
- *Is it relative to the Leadership Intent for Ecological Restoration and the 2012 Planning Rule?*

These questions led to emerging themes consistent with the Leadership Intent for Ecological Restoration and the 2012 Planning Rule, both of which focus on sustainability of key ecosystem services. In both, the integration of social, economic, and ecological sustainability are emphasized. In the Leadership Intent, specific areas of water and riparian areas, watershed restoration, fire and carbon resiliency, recreational opportunities and local economies, and ecosystem services in general are emphasized. The topics set out in the 2012 Planning Rule gave us a way to gather information on a more detailed set of topics. Within those 15 topics, there are repeating threads that connect water, fire, air, ecological integrity, recreation, and communities.

Our goal was to identify key themes consistent with the Leadership Intent for Ecological Restoration, find common threads among the fifteen topic areas, and focus on sustainability and integration of social, economic, and ecological integrity as directed by the 2012 Planning Rule.

2004 Sierra Nevada Framework

Information on the current bio-regional scale management direction is included at the end of each theme for understanding of the management practices that have resulted in the current conditions and probable trends. Trends were determined assuming that current management direction would persist into the future.

The next phases of the plan revision process include determinations of the need for change to existing management direction. The hope is that these short summaries of the existing management direction are helpful as they relate to the five themes of the Bio-Regional Assessment. As the forests progress through the next stages of the planning process, a more detailed look at management direction will take place to determine what may need to be changed in specific forest plans.

Sustainability

The 2012 Planning Rule directs that forest plans provide for social, economic, and ecological sustainability within Forest Service authority and consistent with the inherent capability of the plan area. Sustainability is the capability to meet the needs of the present generation, without compromising the ability of future generations to meet their needs. Ecological, economic, and social sustainability are further defined as follows:

Ecological sustainability: Capability of ecosystems to maintain ecosystem integrity.

Economic sustainability: Capability of society to produce and consume or otherwise benefit from goods and services including contributions to jobs and market and nonmarket benefits.

Social sustainability: Capability of society to support the network of relationships, traditions, culture, and activities that connect people to the land and to one another, and support vibrant communities.

According to the National Report on Sustainable Forests (USFS 2011a), through sustainable management, forests can contribute to the resilience of ecosystems, societies, and economies, while safeguarding biological diversity and providing a broad range of goods and services for present and future generations. Land management decisions need to account for influences and interactions among the three arenas of environment, society, and economy in order to achieve sustainability.

Outdated and weak sustainability envisioned the environmental, social and economic realms as intersecting, yet separate parts of a system. The updated model of strong sustainability, adopted by the Forest Service (USFS 2011a), reflects a more holistic and scientifically rigorous understanding of the role and need for a healthy environment to sustain human society and economies, in synch with intact ecosystems.

The 2012 Planning Rule recognizes that social, economic, and ecological systems are interdependent, without one being a priority over the other. As such, it requires the consideration of all three in all phases of the planning process. National forest management can influence social and economic conditions relevant to a planning area, but cannot ensure social and economic sustainability, because many factors are outside the control and authority of the decision maker. For that reason, the 2012 Planning Rule requires that forest plans contribute to social and economic sustainability within Forest Service authority, and the inherent capability of the plan area.

WHAT IS THE ASSESSMENT AREA?

The boundary of the Sierra Nevada bio-region is the full study area boundary used in the 1996 Sierra Nevada Ecosystem Project (SNEP) final report to Congress. Socioeconomic data for the counties that intersect this boundary was examined.

Findings from the Sierra Nevada Conservancy (SNC), a California state agency that recently developed a report on socioeconomic indicators in the Sierra Nevada were also used. The SNC's boundary for the Sierra Nevada was established by statute. The report either uses census block data that closely aligns with the boundary, or county-level data. The SNC boundary is similar to the SNEP boundary of the Sierra Nevada used in Forest Service's bio-regional assessment, however, it excludes the Tahoe Basin, a portion of Nevada, and a portion in the northwest along the boundary with Oregon.

Using census block data allows for a precise definition of the Sierra Nevada as defined by the SNC boundary, with the toe of the Sierra foothills forming the western boundary. Alternatively, using counties that intersect the SNEP boundary, results in the inclusion of certain Central Valley cities, such as Fresno and Bakersfield. The SNC report is more descriptive of local socioeconomic conditions in the Sierra Nevada. The SNC population base is much smaller than what is used in the Bio-Regional Assessment, and portrays a substantially different picture in terms of population growth, diversity, employment, and other socioeconomic measures.

Providing a broadened definition of the Sierra Nevada is vital to understanding the region and changes on the horizon. Many of the changes to the communities immediately outside the Sierra Nevada will influence national forest system management. These are communities the Forest Service is trying to better understand, reach and engage.

The following is a relief map showing mountain ranges in light brown, valleys in beige, and water in blue. Also shown on the base map are county lines, major highways, and key gateway cities such as Redding, Sacramento, Reno, Fresno, and Bakersfield. Additional major cities shown are San Francisco, Los Angeles, and Las Vegas. The Bio-Regional Assessment area is the boundary from the Sierra Nevada Ecosystem Project. It is shown in orange and includes the entire Sierra Nevada mountain range and California portion of the Cascades Range north to the Oregon border and east generally to the Nevada border. It includes the Sierra Nevada foothills on the west, the Modoc Plateau in the northeast and the eastern portion of the Sierra Nevada range that extends into Nevada around Reno and Lake Tahoe and south and east to the White Mountains. Overlaid on the map within the Bio-Region boundary are the national forests in green and national parks in medium brown. The national forests from north to south are: Modoc, Lassen, Plumas, Tahoe, Lake Tahoe Basin Management Unit, Eldorado, Stanislaus, Inyo, Sierra, and Sequoia. Also included in the northwest are small portions of the Klamath and Shasta-Trinity National Forests. The national parks shown from north to south are: Lassen Volcanic, Yosemite, Sequoia & Kings Canyon, and Death Valley.

Map of the Sierra Nevada Bio-Region in California

WHAT ARE THE FINDINGS?

WATER QUALITY AND QUANTITY

What are we trying to sustain at the bio-regional level?

1. **Biodiversity of aquatic and riparian ecosystems**
2. **Functioning watersheds**
3. **Good water quality and quantity**

Weaving it Together

A conversation about where water comes from and how important it is will be very important. There is a ways to go in how water is understood. For people, the benefits of water are about health and economics. Water has benefits far beyond our ability to live and prosper. It has cultural importance to the tribes. It is hugely connected to recreation opportunities – people love to see and be in water. For some, like ranchers, it is connected to their way of life.

Population growth will have a variety of impacts on water quantity and quality, and will need to be a major piece of the conversation. Climate change is one of the most impactful pieces of the puzzle, because its effects reduce quality and quantity. With more people, more water is needed, but there will be less. Research and monitoring show that there is good work being done managing for the water resource, but more can be done.

The landscape and the water have been used to such an extent that degraded conditions are now normal to people. They enjoy being in the forests to recreate and spiritually renew, but from an ecological integrity perspective, that landscape may be in a degraded condition.

The scale of the benefit runs from local, where water is drawn from wells and citizens are close to fantastic recreational opportunities, to major urban areas, some of the largest in the country, where water from headwaters on national forests is available for millions of people. The Forest Service has very little control over water development, but National Forest System lands provide the water for that development.

The Forest Service can manage for healthy streams, but partnering with other agencies across different scales of government, and with people directly is really the key to sustainability. The quantity and quality of water coming off our national forests provides tremendous benefits to people. Sustainability is possible, if the dialogue about the importance of water in our lives continues.

Biodiversity of Aquatic and Riparian Ecosystems

The ecological condition of aquatic and riparian ecosystems incorporates the physical and the biological components of ecosystems. Physical components are water, rock and soil. Biological components are living plants, animals and micro-organisms.

Aquatic ecosystems, particularly along rivers and streams with moving water, are naturally dynamic. Water moves. Levels rise and fall with rain and snowmelt. Water courses move side to side with short-term flooding, or very long-term shifts in direction. As part of this natural movement, erosion of stream banks is inherent in aquatic ecosystems. Higher levels of sediment, or more and larger areas of high sedimentation, can have negative impacts on aquatic ecological integrity. Sediment can reduce oxygen levels, cover gravel beds, reducing habitat quality and extent for aquatic insects that are the basis of aquatic food webs, and that are rearing grounds for other invertebrates, amphibians, and fish. A major proportion of these animals are threatened, endangered or vulnerable because of their limited distribution or constricted habitat from water development. Water development further modifies sediment levels and distributions because it changes seasonal fluctuations that would naturally flush out the sediment, transporting it to the valley.

Biodiversity of aquatic and riparian ecosystems in the bio-region is high. The aquatic and riparian habitats in the bio-region support 61 fish species and 37 amphibian species (California Department of Fish and Game 2011). Forty of these fish are native to the area, and 11 occur only in this area (Moyle et al. 1996). Riparian communities have more plant and animal species than any other California community type (Schoenherr 1992) and about one-fifth of terrestrial vertebrate species in the Sierra Nevada depend on riparian habitat (Kattleman and Embury 1996). Thirty-seven species of birds in the Sierra Nevada are critically dependent or strongly associated with montane meadows (Siegel and DeSante 1999). Many land-dwelling animals, such as the fisher, use riparian areas as their preferred travel corridors (Zielinski 2013). Other species that have poor temperature regulation are drawn to the cooler temperatures, or more humid microclimates, to nest or roost, such as the California spotted owl in the hotter, drier parts of its range in the foothill oak woodlands (Verner et al. 1992). About one quarter of wildlife species that depend upon riparian habitat are considered to be at risk of extinction today (Graber 1996, Kattlman and Embury 1996). A large number of the plant species of concern are found around seeps or springs or in fens or meadows (Chapter 5, WIKI, and USDA Sierra Nevada Forest Plan Amendment EIS 2001). Springs, fens, bogs, snowmelt ponds, alkaline and caldera lakes, vernal pools, marshes, and seeps are less common. The biodiversity of the aquatic ecosystem depends on water quality, connectivity, riparian vegetation, and overall watershed condition.

Water is of utmost importance to tribes; by its very nature, it is the life blood of the earth. Tribes need clean water, for direct consumption and for the resources needed for a viable culture. Aquatic ecosystems are important to tribes throughout the bio-region because they provide fish, clean water, food, material culture, and spiritual connections. In general, tribes are concerned with the overall health of watersheds.

Fire suppression, and other management that has limited manipulation of vegetation in riparian zones, have had a direct effect on the composition and structure of riparian vegetation (Van de Water and North 2011, Russell and McBride 2001). This effect results in cascading changes to the aquatic environment, nutrient cycling, and food webs. Fires naturally spread into riparian areas, although sometimes in different ways and frequency than into adjacent uplands (Collins and Skinner 2013). One of the most important ecological effects of these fires is to promote sprouting hardwood shrubs, trees, herbaceous flowering plants, and grasses that otherwise have a difficult time competing with densely canopied conifers that rapidly tower above them and shade them out (van Wagtendonk and Fites-Kaufman 2006). Conifer "encroachment" is one effect (Van de Water and North 2011, but there are also ecological effects of less foliage, less healthy foliage, and more insect infested stems (Lake 2013) and often flowering and fruiting that are stimulated by fire (Fites-Kaufman et al. 2006). Lack of fire creates less patchiness, less diversity of plants and structure, and fewer associated animals. Fire is inherently

variable. Fire spread and intensity is influenced and differs by whether it is burning during the day or at night, what time of day the winds go upslope and downslope, if temperatures are hotter or cooler, and when little patches of sun or moisture occur. When there is less fire, the amount of litter fall and nutrients into streams changes, as does the habitat for those amphibians or insects that spend part of their life in the water and part out. The litter fall into streams is an important part of the food web that drives what is available for aquatic insects, bottom feeders, and fish to feed on.

Increased conifer, and overall vegetation density and uniformity in the riparian area, result in higher intensity fires across large areas, sometimes across entire watersheds or basins. The ecological effects are compounded with roads, trails, and skid trails that have minimal effect, but with fire, can have a great effect. Soil is exposed, and sometimes becomes resistant to water infiltration. When high precipitation follows a fire, there is considerable soil erosion into streams and other water bodies.

According to the Sierra Nevada Ecosystem Project (SNEP) report, aquatic ecosystems are the most degraded of all ecosystems in the bio-region (Centers of Water and Wildland Resources 1996). Development of streams, rivers, lakes, and springs has had the most impact on the ecological integrity of aquatic ecosystems. This development includes dams, diversions, and development of springs for human or livestock water sources. The results are highly fragmented habitat, and highly contracted distributions of wide-ranging species, or species that migrate locally, such as salmon and steelhead. Water development has allowed the widespread establishment of non-native species (introduced fish) that have contributed to declines in native species (e.g. frogs; from eating them, and through competition for food sources and habitat). Non-native species have few natural controls and can aggressively increase in population. Most water development is beyond the scope and control of National Forest management, falling under water rights administered by the State of California, and regulation by the Federal Energy Regulatory Commission (FERC).

Ninety percent of historic salmon spawning and rearing habitat has been lost because of the physical barriers of dams (Chapter 1, WIKI). Other species are affected by change in the in-stream environment such as insects (caddis flies), riparian plants that grow on recent floodplains (cottonwood, willows); and frogs. Biodiversity may be significantly decreased (e.g. Stanford and Hauer 1992). Dams can be operated to provide desirable temperature regimes downstream by selective water withdrawal from varying reservoir depths (Stanford and Hauer 1992), but water allocation models are currently based on unchanging climate and will result in less water available for biodiversity with future reductions in water supply from climate change (Null and Viers, 2012). Recent large water developments have been limited, and are carefully evaluated with FERC and the National Environmental Protection Act (NEPA). The many small hydro projects that started in the 1980s are less closely managed, and have added significantly to fragmentation of the aquatic ecosystems, particularly on smaller, headwater streams.

Among other things, human population growth impacts can increase the spread of aquatic invasive species. Aquatic invasive species, such as quagga mussel and New Zealand mudsnails, have spread throughout California on boats, fishing equipment, and other water sports gear (California Department of Fish and Game 2008). In addition, the growing number of people using National Forest System lands may create more complex situations that affect invasive species management due to the diversity of recreation values. For example, some people fishing in national forests may value more “pristine” lakes, stream, or river fish communities, compared to others who want the opportunity to catch a fish, regardless of the species origin or ecological function (Moyle et al. 2011).

Thirty species of non-native fishes have been introduced or have invaded most waters of the range. These waters include extensive areas that were once fishless at high elevations. These non-native fish outcompete and feed on the native species in these lakes. Sierra Nevada fisheries have largely shifted from native fishes, especially salmon and other migratory fishes, to introduced fishes. Largely as a consequence of water development and non-native fish introduction, 20% of the species are formally listed as threatened and endangered, 10% are in danger of extinction in the near future, 20% are on a trajectory toward extinction if present trends continue, and 30% are in long-term decline, or have small isolated populations, but do not face extinction in the foreseeable future. The remaining 20% are at least of concern (Moyle et al. 2011).

Riparian vegetation is also affected by invasive species. Riparian zones are among those areas of the Sierra Nevada that are most impacted by non-native invasive species (Schwartz et al. 1996). Altered riparian systems may be especially vulnerable (Parks et al. 2005).

Riparian vegetation has almost disappeared in riparian areas where water flow has been nearly or completely eliminated due to water development (Kattelman and Embury 1996). Ninety-three percent of studied watersheds in the bio-region have clear gaps in the riparian corridor, largely from road and railroad crossings, timber harvest, private lot clearing, livestock grazing, and dam and diversion de-watering (Kondolf et al. 1996).

Other pollutants that affect aquatic ecosystems were discussed in Pope and Long (2013). Pesticide residues from Central Valley agricultural areas have been found in samples of air, snow, surface water, lake sediments, amphibians, and fish across the Sierra Nevada (Cory et al. 1970, McConnell et al. 1998, Fellers et al. 2004, Hageman et al. 2006, Pope and Long 2013). Pesticides have been implicated as potential contributors to the decline of native amphibians, namely frogs (Davidson 2004 and Fellers et al. 2004), although, no direct association has been found (Bradford et al. 2011). As with other pollutants, it may be a contributing stress, along with the non-native chitrid fungus, that is causing the decline (Davidson et al. 2007).

Functioning Watersheds

A watershed has five main functions (UF IFAS Extension 2007). These functions are hydrological and ecological in nature.

- Hydrological functions: collect rainfall water; store water in various amounts and for different periods; release water as runoff.
- Ecological Functions: provide conditions and sites for various biochemical reactions to take place; provide habitat to flora and fauna of various kinds.

A total of 774 sub-watersheds were assessed on the ten Sierra Nevada National Forests in 2010 with the USFS Watershed Condition Framework. The sub-watersheds ranged in size from 8,058 to 236,289 acres (including National Forest System [NFS] and non-NFS lands), with a mean of 23,025 acres. Of these sub-watersheds, 490 (63%) were classified as "functioning properly," 280 (36%) were classified as "functioning at risk," and 4 (0.5%) were classified as "impaired function." (Chapter 8, WIKI)

At the watershed scale, ecological function conditions are variable, but overall they are fair to good, particularly when compared with overall conditions in California. Seventy-eight percent were in an un-

degraded condition, according to a 2010 rapid watershed condition assessment by forest hydrologists, soil scientists, and aquatic biologists (Chapter 1, WIKI).

Sierra Nevada watersheds face significant threats including fire, poorly planned development, and unauthorized recreation (Sierra Nevada Conservancy 2011a). Additionally, hydrologic function can be adversely impacted by forest activities such as livestock grazing and development.

Effects of Fire

Uncharacteristically large and severe fires may also cause erosion and reorganization that can eliminate vulnerable aquatic population, degrade water quality, reduce capacity of downstream reservoirs, and increase the risk of flood (Long et al. 2013c). More information on fire and its effect on hydrologic function may be found under the Fire Resilience theme.

Effects of Development

The majority of National Forest System lands in the bio-region are not developed because of the vast amount of wilderness in the bio-region and other wildlands, however, conversion of forest land to developed uses, such as roads or camp grounds, often disrupts wetlands, and interferes with their ability to store, clean, and cool water, especially in flood or drought periods (Burns et al. 2005). California's population growth has been accompanied by increased land development, resulting in a loss of forests and rangelands (USFS Region 5 2013). These changes can alter the stability of the ecosystem by favoring certain species and marginalizing others (Havlick 2002). Infrastructure development can add pollutants to local watersheds, altering the localized supply of clean water to humans, and possibly destabilizing ecological processes that produce other ecological services important to human wellbeing (Zedler 2003, Zipperer 2002).

This development includes road infrastructure on forest lands. When roads and drainage features contribute flow directly to a natural water body, they become part of the drainage network and are connected hydrologically. These drainage systems may further increase connectivity if they deteriorate because of use, weather, or poor maintenance. Hydrologically disconnecting roads is an important practice for eliminating chronic water-quality impacts (USFS 2011b). As budgets tighten, and maintenance and closure efforts are constrained, water quality issues with roads could increase. (See discussion of best management practices and the effect on water quality below.)

Connectivity in watersheds and aquatic habitat has been impacted by water development projects. These projects are numerous in the watersheds in the bio-region and therefore many watershed flow cycles and function have been disrupted. Most of this development occurred more than a decade ago. The trend is toward maintaining existing dams and infrastructure, rather than expanding the network. Additionally, Federal Energy Regulatory Commission (FERC) relicensing results in a review of the ecosystem conditions and watershed function and in operational changes that benefit watershed function, such as more ecosystem-friendly flow patterns or more cold water being released. The hydropower licensing process provides an important opportunity to restore wetlands, rivers, and watersheds through intensive and long-term collaboration with project licensees, federal and state agencies and non-government organizations. Some opportunities for watershed restoration include restoring essential river flows where projects have diverted water for generations, protecting fish and wildlife habitat and listed species, providing fish passage, and restoring degraded habitats.

Unauthorized or Unmanaged Recreation

Unmanaged recreation can adversely impact natural resources. Manipulation of streams for water recreation, among other uses, has degraded watersheds. Population growth has led to increased competition for water among the different uses. In addition, the growing number of people using National Forest System lands may create more complex situations that affect invasive species management due to the diversity of recreation values. For example, some people fishing in national forests may value more "pristine" lakes, stream, or river fish communities, compared to others who want the opportunity to "catch a fish" regardless of the species origin or ecological function (Winter et al. 2013a, p. 11).

Livestock Grazing

Livestock grazing occurs around riparian areas, particularly meadows, and has for over a hundred years. The effects of grazing depend on the intensity and level. Livestock can compact soil, remove vegetation, and deposit waste in or near water, which results in reduced infiltration, increased runoff and erosion, and higher concentration of sediment, nutrients, and bacteria in surface waters.

Grazing with high stocking rates and long seasons of use generally decreases infiltration, increases overland runoff, and increases surface erosion (Kauffman and Krueger 1984, Trimble and Mendel 1995, Jones 2000). Less intense grazing has much less significant effects (Trimble and Mendel 1995). Early livestock grazing was very intense, with high stocking and little consideration of impacts to aquatic and riparian ecosystems. This resulted in extensive impacts to meadow condition (Loheide and Lundquist 2009) and reduced water levels, reduced plant cover, shifts in species composition, and overall degradation of ecological condition. More recently, grazing has been managed, and stocking levels have been lower. Permanent, ecological condition plots were installed in 1999, and have been looked at each year to track trends. Overall, monitoring of meadows in active grazing allotments shows that conditions are improving over time (Weixelman 2013).

While livestock grazing has probably contributed to channel incision in Sierra Nevada meadows, the effects of grazing are difficult to separate from those of other land uses, such as road building, railroads, ditches, and climatic variability (Ratliff 1985). One recent study on channel incision in Sierra Nevada meadows showed 54% of meadows to be incised, while 46% were not (Fryoff-Hung and Viers 2012).

According to the Sierra Nevada Ecosystem Project (SNEP) report (Centers for Water and Wildland Resources 1996), manipulation of streams for water supply, irrigation, transportation, hydropower, waste disposal, mining, flood control, timber harvest, recreation, and other uses has degraded the watersheds. This has made aquatic and riparian systems the most altered and impaired habitats of the Sierra Nevada. As the human population of California has grown, so has the demand for water, leading to greater diversion and de-watering within Sierra Nevada riparian systems (Elmore et al. 2003). The synergistic impacts of the declining water table depth, due to expected increasing human demand, coupled with more climate variability, from climate change, will likely facilitate further degradation of watersheds and threaten ecological sustainability (Elmore et al. 2003).

Good Water Quality and Quantity

Forested watersheds in the bio-region provide an abundant supply of clean water that supports a broad range of downstream uses (California Department of Forestry and Fire Protection 2010). Water supplied

from forests provides water for municipal and agricultural supplies (USFS 2011). This water also provides a variety of recreation, tourism and travel opportunities. It provides habitat for fish and wildlife. Water from most streams on the western slope is used to produce hydropower. It also supports vegetation and provides flood protection (Chapter 8, WIKI) and tribal needs (Chapter 12, WIKI). These result in economic, recreational and cultural benefits (Postel and Carpenter 1997). Water is a very valuable commodity in California.

Water is a basic requirement for people's quality of life, and there is a strong relationship between forest land and clean water. Water originating from the Sierra Nevada supplies roughly 60 % of California's fresh water (Sierra Business Council 2007). For approximately 23 million Californians, or about 60% of the population, their drinking water begins its journey in the Sierra Nevada.

Water is critical to California's agricultural industry, which supplies most of the nation's fruits and vegetables. Sierra Nevada supplies drive the Central Valley's extensive agricultural economy (Sierra Business Council 2007). The Central Valley, which receives most of its water, both groundwater and surface water, from the bio-region, is one of the world's most productive agricultural regions. More than 230 crops are grown there. On less than 1% of the total farmland in the United States, the Central Valley produces 8% of the nation's agricultural output by value: 17 billion USD in 2002 (Reilly 2008). Virtually all non-tropical crops are grown in the Central Valley, which is the primary source for a number of food products throughout the United States, including tomatoes, almonds, grapes, cotton, apricots, and asparagus (Pollan 2011). The top four counties in agricultural sales in the U.S. are in the Central Valley (2007 Data). They are Fresno County (#1 with $3.731 billion in sales), Tulare County (#2 with $3.335 billion), Kern County (#3 with $3.204 billion), and Merced County (#4 with $2.330 billion) (Parker 2011). Thirty-four million-acre feet (MAF) of water (14 MAF from the bio-region)is used primarily in the Central Valley for agricultural purposes (Chapter 8, WIKI).

Water plays a major role in providing a diverse set of recreation opportunities on forests in the bio-region. The Sierra Nevada ecosystem is the setting for a large recreation and tourism industry, and for new homes built for the influx of people who enjoy living here. Each national forest has a defined set of "recreation settings," representing geographic areas for particular recreation opportunities, and to which forest visitors have grown emotionally attached over time. Many forests in the bio-region have recreation settings related to rivers and lakes. According to 2005-2009 National Visitor Use Monitoring (NVUM) data, approximately 10% of visitors to forests in the bio-region fish, 5% do motorized water activities, and 3% do non-motorized water activities. Water bodies also support a variety of other recreation activities, like viewing natural features, hiking, and camping.

Ecosystems near water (riparian), and in water (aquatic), account for more than 50% of the animals, plants, and other living things of concern (Chapter 5, WIKI). More detail on this may be found under the Biodiversity of Aquatic and Riparian Ecosystems section under this Water theme.

Hydropower is currently the primary source of renewable energy generation in the bio-region. The bio-region, including the Sacramento River, the San Joaquin River and the Tulare Lake Basin hydrologic regions produce approximately 1,800 megawatts annually, although this is dependent on precipitation (Fromeworth, 2004, p 578).

All known living organisms need water to survive, and vegetation needs more water than animals. Vegetation is up to 90% water by weight compared to animals, which are about 75% water. Vegetation

replenishes water needs by pulling moisture up through root systems. Like all living things, vegetation uses water for cell growth and overall health, but also for several specific functions. Vegetation plays an active role in regulating water, energy, and carbon dioxide fluxes, which makes it a key regulatory force in the earth's hydrological cycle. Through the plant-soil system, carbon dioxide uptake and water evaporation are inherently connected.

In addition, regulating the timing of water flow provides benefits to people located in floodplains, inside and outside the bio-region. Manmade infrastructure, like dams, reservoirs and levee systems, regulate water supply and help lower the risk of extreme floods. They also provide for a constant supply of water when there is less late season flow. The managed release of snowmelt throughout the spring and summer helps control winter flooding in the valleys, and provides irrigation for crops and water to keep recreation and other businesses and industries thriving through the summer (Sierra Nevada Conservancy 2011a).

Tribes throughout California have rights to access water for adequate supplies for direct consumption, agricultural purposes, or protecting existing resources. Tribes may have senior water rights and some water sources may be defined as Sacred Sites (USFS 2012a). Infrastructure development or improvements to recreational sites needing additional water, electricity, sewage, and roads, may impact traditional landscapes. "Native American cultural resources are often concentrated along perennial streams due to availability of water and culturally important plants, travel corridors, and other patterns that facilitated development(Jackson 1988)" (Hunsaker et al. 2013). It is essential to consult with tribes before permitting, licensing, or taking action that may affect tribal water quality, quantity or cultural site condition. Although there are regulations in place in the bio-region to prevent infringement on tribal water rights and to protect cultural properties and sacred sites, complete implementation of these regulations has not always occurred.

Clean water is highly valuable to the people and ecosystems of the Sierra Nevada and all of California. In terms of natural resources, water is the most valuable commodity in the bio-region, followed by timber, livestock and other agricultural products. Based on estimates of direct resource values as one input (not the total revenue produced by resource dependent activities), the Sierra Nevada ecosystem produces approximately $2.2 billion in commodities and services annually. Water accounts for more than 60% of that total value. Given population increases in the state resulting in more people benefiting from these commodities and services, as well as the conflicting uses for water resulting in rising costs for this resource, the trend in this value is increasing and will continue to increase into the future. Most of the water value accrues to water rights holders and beneficiaries outside of the bio-region. About 6% of the total consumption of this water supply happens within the bio-region (Stewart 1996).

Water is a vital resource and critical to the social, ecological and economic sustainability of the bio-region. Forests in the bio-region are the primary source of water used throughout California. Socially and ecologically, water is fundamental because all life depends on it (Hunsaker et al. 2013). The benefits of water, a key forest ecosystem service, accrue to people throughout many economic sectors and across a broad landscape.

Growing Need for Water

The population of California is expected to grow 37% between 2010 and 2050. This will require additional water in order to meet the needs of more people (California Department of Finance California

Department of Forestry and Fire Protection 2010). Recent population growth has led to increased competition for water among various uses throughout the state, and in the bio-region. For those counties in California partially or entirely within the bio-region, total population is expected to increase by 69% between 2010 and 2050 (California Department of Finance 2012). Growth is expected to be greatest in the South Sierra sub-region counties of Fresno, Kern, and Tulare. Within the Sierra Nevada, these competing interests include in-stream flows for aquatic species, water recreation, hydropower, domestic uses, and national forest and special use permit site uses. This expected population growth will only increase the competition for these various water uses in the state and the bio-region.

Many uses for the water from the bio-region compete. The resulting conflicts mean that there isn't enough water for all user groups. Going forward, climate change is expected to reduce the supply, and may increase the competition for water use. Development and population growth will put even more demand on the available water.

The competition for the availability of limited water supplies has led to continuing political activity in the state related to water. As time goes on and water will be needed by even more people, numbers of this political conversation will continue with increasing intensity. Pressures from expansion of California's agricultural and urban areas are being resisted by groups interested in preserving biodiversity and environmental quality in the Sierra Nevada, and who view the continuous and rising export of water to other regions as undesirable in the long run (Mittelbach and Wambem 2003).

Water Quantity

Annual water yield from National Forests in the bio-region is estimated at 14 million acre feet per year (Rector and MacDonald 1986; Brown and Froemke 2009). The Forest Service "Forests to Faucets" project highlights that this water from National Forest System lands is critical for communities and the state economy. Many of the major municipal water systems rely heavily on surface water supplies that originate on the forest lands of the bio-region. This surface water is also important to irrigated agriculture and recreational and uses. These key economic sectors rely on dependable and consistent water supplies USFS 2011d).

As an example of the use of bio-region water supplies and the need for water quantity, water from the Sierra Nevada supplies San Francisco and Los Angeles. For instance, according to the Los Angeles Department of Water and Power (LADWP) 2010 Urban Water Management Plan, the Los Angeles Aqueduct, which originates in the Sierra Nevada, is one of the major imported water sources to the City of Los Angeles, averaging 36% of total water supplies in recent years, and delivering 39% of the total runoff in the eastern Sierra Nevada in an average year.

The amount and distribution of rainfall is the main factor determining the amount of water supplied by a watershed. Rainfall patterns, in turn, depend mainly on climate and topography, and not on management of the ecosystems directly (Egoh et.al. 2008, USFS 1976). However, forest decisions about vegetation, fuel, range, and road management can influence the timing of water supply from storm flows and snowmelt. In addition, vegetation and fuel management may influence water quantity through changes in the amount of evapotranspiration from vegetation on forests lands (FAO 2008, Rector and MacDonald 1986, Ziemer 1986). Forest Service mandates to manage for a wide range of resource values make it difficult to apply the scale of management practices needed that would actually increase the flows of a watershed (USFS 2000).

Climate predictions for California include increased warming, less snowpack, and earlier spring snowmelt. These changes would influence the amount of water supply that can originate from forest lands and from reduced precipitation, as well as the amount and types of vegetation that would influence the timing of this water supply. Climate change is also expected to increase the severity and area of fires, which would directly impact the timing of water supply. All of these factors would change how water is budgeted and the ecological integrity of stream ecosystems (Viers and Rheinheimer 2011).

Additionally:

> Watersheds in the northern Sierra Nevada may be most vulnerable to decreased mean annual flow, south-central watersheds to changes in runoff timing, and the central portion to longer periods of low flow. Although the Kern River may be the most resilient watershed, the anticipated shifts in the hydrologic cycle will impact spring and summer water-based recreation and tourism and, more importantly, the California communities that depend heavily on Sierra Nevada water supplies (Jardine and Long 2013).

Climate change, development, and population growth are expected to strain this supply, and increase competition between the various uses. Future uncertainty in water supply leads to difficulty in planning and decreases in the profitability of key economic sectors in the bio-region such as agriculture and recreation. Management of the supply will impact social and economic sustainability, since communities and local economies rely on this water.

Water Quality

Forest ecosystems provide stabilization of soils and filtering that reduce sedimentation and pollutants, and regulate water quality (de Groot et al. 2002). Forests often produce high-quality water. For example, water quality of the Sacramento River and its tributaries, which drain primarily National Forest System lands, have generally good quality and support their beneficial uses (Domagalski et al. 2000). Sediment and nutrient loads from forested watersheds in the Sierra Nevada, including large areas within national forests, were found to be substantially lower than loads from downstream agricultural areas and significantly lower than average pollutant loads nationwide (Kratzer and Shelton 1998). (Chapter 8, WIKI).

Long- term studies have shown this to be generally true in undisturbed ecosystems, and for some classes of land use. Other forms of land use have been found to degrade water quality to varying degrees and at different scales. The most significant forest scale water quality problems are sediment, nutrients, temperature, and hazardous chemicals (Dissmeyer et al. 2000, USFS 2000).

Threats to forest scale water quality affect the sustainability of these ecosystem services and the resulting economic benefits. These threats to water quality are climate change, fire, development, and increasing use of forest land, all of which have the potential to alter existing landscapes affecting both forest vegetation and soil that protect water quality. The resulting reduced filtration of precipitation and runoff, and the potential for increased sedimentation, can reduce the benefits associated with recreational and cultural experiences on the forest and can negatively impact the functioning of the localized ecosystem.

Climate Change

Climate changes are also expected to change the pattern, frequency, and intensity of disturbances. The result will be increased wildfires, doubling the area burned annually by the middle of the 21st century. Pulses of soil erosion and flooding caused by higher rainfall intensity will increase, but the pattern will be highly variable. This will also affect how forest roads are built and maintained, along with other infrastructure (USDA OCE 2012).

Effects of Fire

Fires have varying effects depending on the extent, soil erodibility, and rain events after the fire. Extensive, high severity fires can also reduce infiltration of water, and reduce runoff from development of water repellant soils (Neary et al. 2005). Fuels and vegetation management and fire can all contribute to erosion and sediment transport to aquatic ecosystems. Even when best management practices are used, impacts to roads, trails, and skid trails are felt immediately following large, high severity fires.

Timber Harvest

Timber harvest can also contribute to erosion and sediment transport to aquatic ecosystems. "Water quality characteristics most affected by timber harvesting are: (1) sediment (2) dissolved nutrients . . . and (3) water temperature. Undisturbed forests are generally low in dissolved or suspended matter and sediment loads and dissolved nutrients generally increase with the level of disturbance to the forest. Timber harvesting adjacent to stream channels increases sediment flows into streams (Backiel and Gorte, Report to Congress on Clearcutting). Logging and related activities such as road building, skidding, slash burning, and others have the potential to produce erosion that can deliver sediment and nutrients to streams (Foster Wheeler, 69).

Development and Increasing Use of Forest Land

Grazing, roads, and recreation can all lower water quality. Road and trail construction, use, and maintenance can all contribute to erosion and sediment transport to aquatic ecosystems. These influences are mainly removal or reduction of soil cover or soil disruption, destroying roots that bind soil, removing woody debris that slows runoff and erosion, and reducing infiltration. Sedimentation and barriers from road and trail crossings have also contributed to degraded conditions. Restoration activities have had widespread, although not readily quantifiable, effects.

Water quality issues are often associated with ranching activities. Ranching activities can also provide important contributions to water quality (Sierra Nevada Conservancy 2011a). Ranching is also a major part of the cultural heritage in the Sierra Nevada and helps preserve the open space and rural character of communities that residents and visitors in the Sierra Nevada value so much (Sierra Nevada Conservancy 2011a).

On the national forests in California, best management practices (BMPs) are used to protect water quality and habitat for more than 30 years. These best management practices are designed to protect, restore, or mitigate water quality issues and are used to limit the potential impacts from these management activities. BMPs on National Forest System lands have been effective in preventing potential or adverse impacts to water quality more than 95% of the time (USFS 2009). BMPs for roads have been effective 85% of the time, and 81% of the time for livestock grazing. Only 2% of the evaluations indicated significant adverse effects to water quality.

Roads provide important services to society; however, their presence can also negatively influence the hydrology, geomorphology, and ecosystem processes on National Forest System lands. There are numerous articles in the peer reviewed literature describing the impacts of roads on the landscape (Chapter 11, WIKI). Fragmented habitats, polluted waters, failed culverts, and eroded road beds are just a few of many road-related impacts that undermine the natural capacity of our forests to provide clean water and valuable wildlife habitat (Chapter 11, WIKI). Excessive road densities directly affect water quality and aquatic values, and have been tied to reductions in pool frequency within a channel, increased sedimentation, and warmer water temperatures (Chapter 11, WIKI).

Geologic sources of mercury in the Sierra Nevada are limited to relatively small areas; however, historic gold mining introduced large quantities of mercury into streams of the Northern Sierra Nevada in the nineteenth century. The American, Feather, North and Middle Yuba, South Yuba and Bear are all currently listed as impaired owing to excessive mercury concentrations (Chapter 8, WIKI).

The national forests in California have generally provided a high level of water quality protection for the Sierra Nevada headwaters (Ode 2007, Domagalski et al. 2000, Kratzer and Shelton 1998, Ahearn et al. 2005).

The most direct beneficiaries of good water quality on forest land are the recreational and cultural users who enjoy benefits on the forests, and before any manmade treatment processes are available. These recreational and cultural services provided by the forests yield great benefit, both to the individuals enjoying these experiences and the local economies benefitting from visitor spending in the local economy.

Users who benefit the most from high water quality on forest land are recreational visitors who swim and boat in lakes and rivers, and traditional gatherers who fish and collect plants. The number of water bodies currently considered to be impaired by the State's water quality regulatory agency is a small fraction of the hundreds of water bodies on National Forest System lands and therefore, conditions are favorable for providing these benefits (Chapter 8, WIKI). Maintaining the future sustainability of these benefits is at risk if water is of poor quality. Other direct beneficiaries are local residents who get their drinking water from wells. Therefore, if there are threats to well water quality, these can be reduced with water treatment, but it is usually expensive and comes with technology limitations thus reducing the benefits to people.

2004 Sierra Nevada Framework

The strategy for aquatic management in the 2004 Sierra Nevada Framework, which amended all the forest plans in the bio-region, is to maintain and improve water quality and satisfy all federal and state water quality requirements. Water and riparian areas are such key resources that there is extensive direction provided.

Some highlights of the key direction from the 2004 Framework are:

- a description of desired conditions for aquatic, riparian, and meadow habitats;
- a set of land allocations, specifically riparian conservation areas and critical aquatic refuges, that delineate aquatic, riparian, and meadow habitats, which are to be managed consistently with the applicable riparian conservation objectives and associated standards and guidelines; and

- an adaptive management program that includes monitoring and research specifically aimed at assessing effects of management activities on the willow flycatcher and Yosemite toad.

The aquatic strategy also includes stream-type dependent flexible width riparian areas, protection for in-stream flows, controls on sedimentation and loss of soil productivity, direction to restore and maintain hydrologically functional meadows, conservation assessments of aquatic or riparian-related threatened and endangered species, and incorporation of established recovery plans, standards to move the level of coarse large woody debris toward the range of natural variability, controls on livestock grazing in meadows and riparian areas, and standards for road construction and stream crossings.

All ground disturbing projects must implement state-approved Best Management Practices (BMP's) specifically designed to protect water quality and comply with Clean Water Act and state water quality standards.

For waters designated as "Water Quality Limited" (Clean Water Act Section 303(d)), managers must participate in the development and implementation of Total Maximum Daily Loads (TMDLs) and TMDL Implementation Plans.

Post-wildfire management activities in riparian conservation areas and critical aquatic refuges should emphasize enhancing native vegetation cover, stabilizing channels by non-structural means, minimizing adverse effects from the existing road network, and carrying out activities identified in landscape analyses. Post-wildfire operations will minimize the exposure of bare soil.

The aquatic strategy recommends restoration practices in: areas with compaction in excess of soil quality standards, areas with lowered water tables, and areas that are either actively down cutting or that have historic gullies. The 2004 Framework provided flexibility for developing management strategies for road building, recreational use, grazing, and timber harvests, and other forest activities that may be contributing to the observed degradation.

Flood Plains and Wetlands, Executive Orders 11988 and 11990, require federal agencies to avoid, to the extent possible, short- and long-term effects resulting from the occupancy and modification of flood plains, and the modification or destruction of wetlands. Standards and guidelines are provided for soil, water, wetlands, and riparian areas to minimize effects to flood plains and wetlands. They incorporate the Best Management Practices of the Soil and Water Conservation Handbook. The standards and guidelines apply to all floodplains and wetlands where less restrictive management might otherwise occur.

FIRE RESILIENCE

What are we trying to sustain at the bio-regional level?

1. **Ecosystem resilience to fire**
2. **Benefits people obtain from ecosystem services**
3. **Communities in the face of fire**

Weaving it Together

In our current condition, fire is a double edged sword. It has always been one of the most fundamental processes that shape the landscape, and it will remain so. It is widespread and it is here to stay. For a time, the focus was on suppression. Now there is a deficit which has created denser and more continuous forests. There are more large and severe fires in the wildland urban interface. This is good and bad. Fire is needed, but it creates issues.

The Science Synthesis points out that a lot of institutional and political realities really constrain how Forest Service managers feel they can make fire decisions. Incorporating fire back onto the landscape is difficult because of the politics around lighting the fire. Changing the pace and scale of burning is very difficult, which is why the conversation is important. There needs to be political and social engagement to reach understanding about the benefits of burning. There is disagreement about how to solve the problem and how to pay for it. The infrastructure to treat acres mechanically is declining, which puts more pressure on to treat acres with fire. At the present, our pace and scale of burning are not keeping up with the need.

Re-introducing fire onto the landscape provides cultural benefits for Native Americans, and could involve them in restoration efforts, directly managing land as part of their culture. Burning also benefits the plant products that are an important part of their culture. There is strong desire from some tribes to be involved in stewardship contracting to work on restoration. The tribes have strong needs to continue practicing traditional methods.

Fire has always shaped the structure and composition of vegetation and animals across the landscape. This landscape was much more diverse, patchy and varied in the past. Now it is much more uniform and dense, and more vulnerable to insects, drought, high severity fire, mortality of trees, and habitat loss. For watersheds and streams, fire exposes roads and skid trails, which create sediment issues. People don't want to see that kind of condition on the land.

There are costs from fire; some are quantifiable, and some are not. There are enormous financial costs to the agency. Communities pay heavily in terms of disruption of life, and interruption of ecosystem services. All these costs are incurred at the local level and on a much larger scale as well. People come from long distances to enjoy the forests, and fire and smoke can have a negative effect on their experience. There is no question that fire affects the scenic attractiveness and integrity of the landscapes.

Human beings are responsible for a large proportion of fires. With development and access, fires are more likely to start along a road or a campfire. Population growth in the wildland urban interface means there are more people impacting the landscape, and more risk of human caused fire. The additional result is more people need the services, the very services that are impacted by fire.

Growth in the wildland urban interface has had a profound effect on organizing for fires. Funds are concentrated on the land inside the urban interface, and not on increasing the resilience of the wildlands themselves. The agency has been focused on suppression, rather than reintroduction of fire or fire management, and there are far fewer people devoted to fire management than have been in the past.

The challenge is building capacity for the future, at the personal, community and wider bio-regional level. Community involvement, collaboration and education build that capacity. Bringing together the social, environmental and economic pieces builds strength and capability when the large fires come, and understanding of how managed fire can benefit people at all scales. It's about opportunity, taking the time and energy to organize, educate and become stewards of the land.

Ecosystem Resilience to Fire

Fire is one of the most pressing and recurring issues in the bio-region and western United States. There are two related wildland fire issues in the bio-region, and in much of the drier portions of the west. First, there is a trend of larger, high intensity fires, with greater amounts of high severity effects that threaten ecosystems, homes and economies than in past decades. These fires are increasingly outside the range of variation of the historic fire regimes for most ecosystems. Second, there is a significant absence of low and moderate severity fire, in these strongly fire adapted forests of the Sierra Nevada. These two issues are related because suppression of fire has led to significantly less fire than once occurred naturally on a frequent basis (Van de Water and Safford 2011), and as a result, vegetation is denser, more continuous, and more explosive than ever before (Chapter 3, WIKI; Collins and Skinner 2013; Safford 2013b). This, coupled with more people and homes in and near the forest, makes it more difficult to control large, severe wildlfires during the hottest, driest and windiest times, and to conduct fuels treatments to reduce the severity of fires and restore fire to the environment at a pace and scale that will be meaningful.

In much of the wildland of the western United States and in other Mediterranean climates around the globe, fire has played a central role in shaping ecosystems. There are numerous ecological implications that come with changing the type and amount of fire including changes in species and habitat, reduced resilience to stressors, and disruption of carbon cycling. For humans, the implications include threatening fires in the wildland urban interface, reduced air quality, increasing risk to life and property, and disruptions to local economies such as recreation, power generation, and wood utilization. Fire has occurred regularly and continues to occur every year in the Sierra Nevada bio-region. What is important is what kind of fire and where it occurs.

There is a trend of increasing fire severity over the past 10 years or more (Miller et al. 2009). However, the total acreage burning annually is well below historic levels (Stephens et al. 2007; Miller et al. 2009; North et al, 2012).

Over the last century or longer, with good intent but unforeseen consequences, most fires were rigorously suppressed. For at least half a century, this suppression was successful (McKelvey et al. 1996, Husari and McKelvey 1996, Husari et al. 2006), but over the last several decades, increased vegetation

density and uniformity, increase of less fire tolerant trees (North et al. 2009), increased human development on the fringes and intermixed with wildlands (FRAP 2010), and most recently climate changes (Safford and Meyer 2012) have vastly changed the patterns of fire and ecological, social, and economic consequences of fire (Husari et al. 2006, Collins and Skinner 2013, Science Synthesis Chapter). Predicted trends are for longer fire seasons, drier and hotter fire conditions, coupled with persistent trends of over-dense and uniform vegetation, all leading to increased trends in extensive high severity fires during the peak fire season (Westerling2006; Westerling and Bryant 2008; Westerling et al 2011).

Today, there is an imbalance of the types and extent of fire. On one hand, there is an ecological "fire deficit" of low and mixed severity fire. On the other hand, there is more high severity fire in large patches in low and mid-elevation ecosystems. Severity is defined by the degree or magnitude of effect on different elements. High severity to the wildland urban interface (WUI) would mean that houses are burned and property is destroyed. In forests, the more trees that are killed, the higher the severity. In chaparral, severity is defined based on how much of above ground foliage and stems are consumed by fire. Extensive weeks or months of heavy smoke is unpleasant, can drive away income from recreation business, and result in negative health effects. High severity effects to ecological integrity are more subtle. Fire is fundamental in shaping the diversity of habitats, species, and vulnerability to natural events such as drought, or insects and pathogens. Generally, if fire and the severity or effects are within the natural range of variability, it supports or drives ecological integrity. But there are uncertainties defining aspects of the natural range of variability of fire, such as the size and frequency of patches of fire of different severities, and the role in critical habitats such as riparian areas. Despite these uncertainties, fire is one of the foremost drivers of ecological integrity of most ecosystems in the bio-region and is important to understand.

Fire has often been described as a "disturbance". However, in Fire in California Ecosystems, Sugihara et al. (2006b) deleted that word from the entire text and extensively described how integral fire is as an ecosystem process in the bio-region. It has occurred regularly for hundreds of thousands of years (Skinner and Chang 1996). It is a process that does not operate in a vacuum, but is closely tied to many other ecosystem processes and human uses, including vegetation, wildlife habitat, soils, hydrology, carbon cycling, insect populations, air quality and even climate. It is characterized in terms of a "regime" that encompasses how often and regularly it occurs, how hot it burns, how much it influences living and non-living parts of the ecosystem, and how it occurs across the landscape (Sugihara et al. 2006a). As vegetation and weather change, fire regime characteristics change. For example, at the highest elevations, with predominately rocky soils and short growing seasons and subalpine and alpine ecosystems, the fire regime is characterized by small fires, with irregular frequency (depending on lightening patterns), and varied severity (van Wagtendonk and Fites-Kaufman 2006). At lower elevations, in the ponderosa pine or mixed conifer dominated forests, fire seasons were longer, fires were more frequent, larger and dominated by low and moderate severity effects. The regularity, intensity, and severity vary with density of the vegetation and dryness or temperature of the growing season. Forests that receive more rain and snow, such as the west slopes of the northern Sierras have different patterns than the drier ones east of the crest or on west slopes in the southern Sierras. Fundamentally, fire shaped vegetation variation, including what kinds of plants and trees, how dense they were and how they were arranged in the landscape. As Barbour et al. 1993 stated:

> In California, vegetation is the meeting place of fire and ecosystems. The plants are the fuel and fire is the driver of vegetation change. Fire and vegetation are often so interactive that they can scarcely be considered separately from each other.

Prior to extensive fire suppression in the mid-1900s, fires were frequent, larger, and mostly low or mixed severity (van Wagtendonk and Fites-Kaufman 2006; Safford 2013b). Recurrent fire kept tree and other plant density lower or patchier, so that when dry summer or windy fall conditions occurred, fire swept through with fewer effects (i.e. less large tree kill) than what is seen now. It invigorated browse for wildlife (Shaffer and Laudenslayer 2006). It kept levels of insects in acorns low for better deer and bear browse (Lake and Long 2013). It recycled nutrients, fertilizing soils. It created diverse riparian plant communities (Webster and Halpern 2010), dominated by deciduous shrubs and trees that are important for many songbirds, insects, and litter inputs into the stream food webs. Native Americans lived with fire and through traditional ecological management, utilized it for many life-sustaining purposes, such as: enhancing straight growing shrub stems with no insects to make better baskets; improving game forage or plant vigor for food sources; reducing habitat for disease- spreading ticks; and clearing around living areas or travel routes (Anderson 2006; Lake 2013).

Very large patches of high severity fire can change ecological function of old forest ecosystems, killing most or all large, old trees across large areas, and breaking connectivity (Franklin and Fites-Kaufman 1996) of canopied forests for cover and travel of wide-ranging species such as the fisher (Zielinski 2013; Keanne 2013). Other species, such as the black-backed woodpecker are drawn to these freshly burned sites with their high prevalence of snags. Other birds increase or are drawn here by the vigorous growth of shrubs or hardwood trees, stimulated to sprout by fire (PRBO 2012). Songbirds and the black-backed woodpecker use other habitats and it is likely that previous, highly variable, fine-scale patchiness from varying fire was equally used. The California spotted owl has a more variable and complex response. Some level of predominately low and moderate severity fire may not change reproduction or occupancy of owls, and can increase rodent populations that provide food. It is uncertain how much and what kind of fire has specific effects but large areas of high severity fire remove nesting habitat for long periods until forests can grow and mature.

For plants, there are varied effects but repeated (re-introduced) fire tends to enhance plant diversity in the mixed conifer (Webster and Halpren 2010). A large number of plants are adapted, often enhanced, and sometimes dependent upon fire for successful survival and reproduction (van Wagtendonk and Fites-Kaufman 2006, Webster and Halpern 2010)). Fire can enhance survival and persistence for sprouting species, particularly when they compete with conifers, such as aspen. Others may actually be less common or have lower flowering now because of a lack of fire (Fites-Kaufman et al. 2006). Many plants in the bio-region have underground tubers or rhizomes that store food and energy that are buried deep below the ground, allowing them to survive high fire temperatures.

In order to look at conditions and trends in fire resiliency across the bio-region, two different approaches were applied: fire return interval departure, and fire resiliency index across watersheds. For both, the purpose was to define resilience in terms of sustaining ecological integrity, the primary intent of the new planning rule.

First, available Fire Return Interval Departure" (FRID) maps were used (Van de Water and Safford 2011). The FRID approach compares reconstructed, historic average years between fires with current fire return intervals. This serves to provide an overall view of ecological "fire deficit", where many fire cycles have been missed with associated ecological consequences. Some of these fire deficits were already discussed and more are described in the ecological integrity section that follows. The map displays the departure in terms of the percent of fire cycles that were missed (difference in average now compared to average historic) or where fires are more frequent. In general, there are large fire deficits in the lower elevation

forests and few changes in subalpine or higher reaches of the upper montane forests. Other areas, namely desert and sagebrush steppe where cheatgrass invasions are extensive, have a trend of increasing fires over what occurred historically.

For the second approach, a fire resiliency index was calculated for large areas reflecting differences in current potentials for high, moderate or low severity (to vegetation) fires. This index is described in more detail in Chapter 3 on the WIKI. Severity to fire in the forests was assessed with potential fire type developed with LANDFIRE data (Rollins 2009). There were two categories applied: crown or surface.

Photograph that shows a "surface fire" burning in the understory of a forest with flames below the crowns of the large trees

Two photos showing crown fires

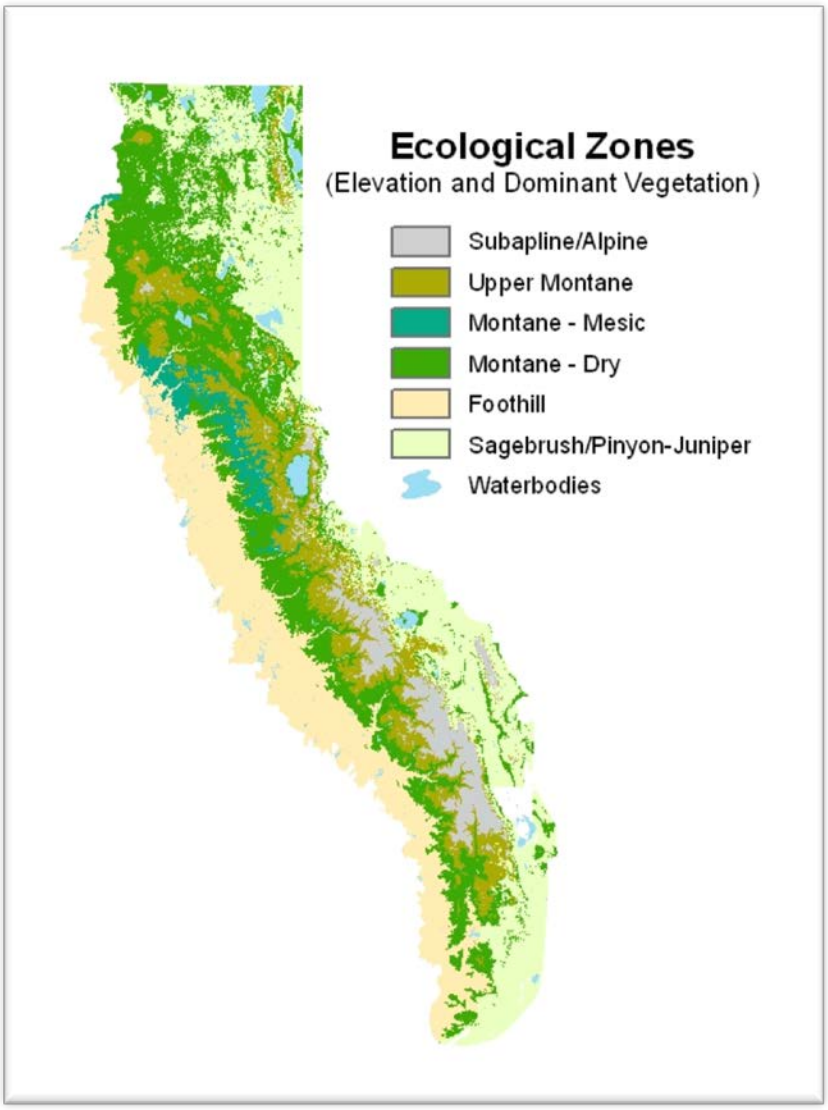
In contrast, these two photos show "crown fires". In the photo on the left, flames extend up into the crowns of some of the clumps of large trees, but are on the surface in other places. This is called "passive

crown fire". In the photo on the right, massive flames, hundreds of feet tall, extend above the crowns of all the trees in the forest. This is called "active crown fire".

The type of fire depends upon the weather conditions that are input into the model and the detail of information available for the live and dead vegetation. At the bio-regional scale, potential fire behavior provides a useful gauge of overall fire effects to vegetation or communities (CALFIRE 2010). For non-forested types, the Departure from Fire Return Interval Index was used (Van de Water and Safford 2011).

Fire effects to ecological integrity are far less important at the individual forest stand, animal or plant location or meadow. Ecological integrity is most influenced by fire effects at landscape scales, across areas where large fires occur and fire regimes are characteristic. More importantly, current and more uniform, dense landscape vegetation makes development of large intense fires more likely. Once a fire gets started in the drier part of the summer or fall, it often covers thousands of acres in days or hundreds of acres in short bursts in the crowns of trees. These fire runs are often very difficult to "attack" directly in a safe or effective manner, and therefore, the consequences must be evaluated in larger areas. Readily available, large watershed basin boundaries were used to delineate large landscapes. For a first approximation of ecological resilience, four different levels based largely on the likely degree of effect on wildlife habitat, for example spotted owls, and old forest, and to some degree on natural range of variability were used (NRV). NRV only was not used because at this time, conditions are far removed from them in terms of fire regime, and even a modest shift toward that level of resiliency would benefit ecological integrity and is more feasible in a short period of time. The planning rule specifically provides for using ecological integrity based on measures other than NRV where this is the case.

These were not meant to represent desired conditions but rather broad, relative differences in fire effects. The levels were developed for broad landscapes (Chapter 1, WIKI) defined by dominant vegetation and climate.

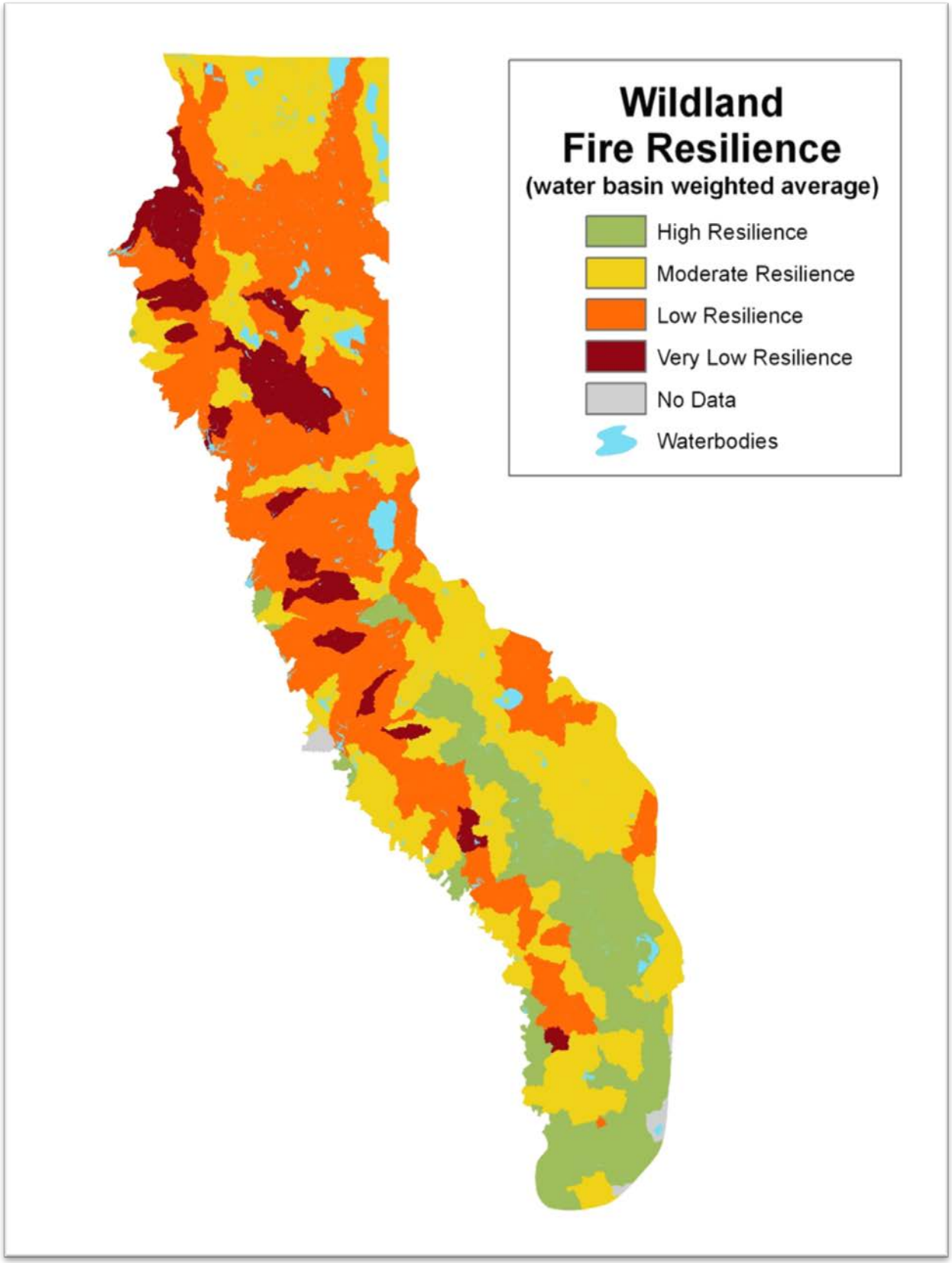


Map of the bio-region displaying ecological zones

In this map of the bio-region, the six ecological zones representing major elevation and precipitation zones are shown. There are six ecological zones, including: foothill, montane-dry, montane-mesic, upper montane, subalpine/alpine, and sagebrush/pinyon juniper. Descriptions of the locations of these and major vegetation types are: On the lower western slopes, the foothill zone occurs as a band, extending from the north all the way to the south, bordering all national forests and overlapping with only small portions. Oak woodland, chaparral, and grassland are the primary wildland vegetation. Directly adjacent, extending to the east in a parallel band upslope is the montane zone, encompassing mixed conifer, yellow pine, and mixed hardwood forests on the west side and east side. Across the north, on the Plumas National Forest, it is continuous to the east side except for several higher elevation "islands" of red fir. In the south, the montane band is narrow, especially on the Sierra and Sequoia National Forests. To the east, and at the highest elevations, the upper montane and subalpine/alpine zones are shown. These form a wide belt across the top of the mountain range in the south but narrow progressively north through the Tahoe National Forest, where it becomes discontinuous islands. Red fir, Jeffrey pine, and lodgepole pine forests, meadows, and chaparral comprise the upper montane vegetation. Along the eastern portion of

the bio-region, there are large expanses of sagebrush and the pinyon/ juniper zone. Over half of the northern third of the bio-region, from Lake Tahoe north to the California border, is occupied by the sagebrush, pinyon/juniper and eastside montane zones. To the east and south of Lake Tahoe, the sagebrush and pinyon/juniper zones occur mainly to the east in Nevada, and then in a wider band on the Inyo National Forest to the southern edges of the bio-region. In the southeastern corner, a small area of desert occurs, and subalpine forests of bristlecone pine.

Within these landscapes, forested areas (pine, mixed-conifer, red fir) were rated by broad levels of fire types. For other types, where the potential fire models are less useful for ecological effects (chaparral), the FRID data were used. Resilience was also rated differently around communities and infrastructure, or the wildland urban interface (WUI), based on fire behavior standards for firefighting based on an interagency fire assessment group including state and federal partners. This is described more in Chapter 3 on the WIKI, and the results in the following section on social and economic sustainability. This was in a relatively narrow bandand is largely masked in the wildland fire resiliency ratings at the bio-regional scale. The wildland fire resilience ratings are very important to fire resilience in the WUI, since the intensity and speed that fires that start in wildlands and move into the WUI is dependent on the conditions in the wildlands. In the map below, the wildland fire resilience ratings are shown. For WUI resilience, a different rating system for wildlands was used than the FRID, based on fire suppression.



Wildland fire resilience map

In the map above, fire resilience is low to very low across most of the bio-region. The exception is at the highest elevations in the subalpine and alpine zones and limited areas of the foothill zone. Large patches of very low fire resilience are found in the montane zone, in the mixed conifer and pine dominated areas. These patches are larger and more prevalent in the central and especially the northern Sierra Nevada

Fire resilience affects the integrity of many species, particularly those that are limited in distribution or impacted by large, severe fires. Nearly half of the Critical Aquatic Refuges (CARS), 2/3 of the goshawk and fisher locations, and more than 80% of the spotted owl and pine marten sites are in landscapes with a low to very low fire resilience. This means that during a typical fire season, in the drier, hotter portions, fires are likely to be large with a high proportion of large patches of high severity fire, which threatens the forest conditions upon which these resources depend.

Invasive, non-native plants are a considerable threat to ecological integrity (Chapter 3, WIKI). The interaction of invasive plants and changes in fire regime are addressed where particularly notable, the drier low elevation eastside and westside foothill areas. In these areas, cheatgrass invades in many burned areas and once established, precludes native plant community recovery and causes serious changes to the natural fire regime (Klinger et al. 2006, Brooks and Minich 2006, Riegel et al. 2006, Skinner and Taylor 2006, van Wagtendonk and Fites-Kaufman 2006). Fires became more frequent than in the past and changed from native chaparral, sagebrush or desert, to non-native grasslands. These are very difficult to restore. Controlling invasive plants is usually very difficult as well, since they spread readily by numerous vectors.

Restoration to lessen fire threat to wildland urban interfaces, reduce large, high severity fires, or reintroduce low to moderate severity fire means addressing far more acres than are currently managed (Collins and Skinner 2013: Science Synthesis Chapter 4.1). North et al. (2012) estimated that current treatment rates, including wildfires of all severities, is at a rate less than 20% of what burned historically. However, this historical comparison was at a time with fundamentally different social and environmental conditions. Fires that burned for months created smoky conditions that would be considered acutely unhealthy today. Wildfires burned through homesteads and even communities with little ability to do anything about it other than clean up and rebuild. More importantly, fires burned differently when the vegetation and therefore fuel conditions were shaped by centuries of frequent fire. While this historic condition cannot be recreated everywhere, it helps to inform that both pace and scale need to be increased to affect change fire resilience at the landscape scale. It also strongly suggests the need to consider the consequences of altering the amounts of fire in the system.

The removal of Native American management from the landscape has and continues to influence Sierra Nevada forests. According to Anderson and Moratto (1996), resource management by Native Americans in the Sierra Nevada bio-region was long term and widespread, producing ecological and evolutionary consequences in the biota (Blackburn and Anderson 1993). Therefore, many ecosystems in the Sierra are not self-maintaining islands that require only protection to remain in a "pristine" state. There is an ecological vacuum, or disequilibrium, in the Sierra Nevada resulting from the departure of human management of these ecosystems. This disequilibrium shows up in a decline in biotic diversity, in species being endangered and eliminated, in humans encroaching into fire-type plant communities, and in greatly increased risk of large, high intensity, undesired fires.

The number of fires in the bio-region that have been of higher severity than expected in recent years is increasing and this trend is expected to continue. Recent research demonstrates an increased

proportion of high-severity fire in yellow pine and mixed-conifer forests in the Sierra Nevada from 1984 to 2010 (Miller et al. 2009, Miller and Safford 2012). These studies demonstrate that fire sizes and annual area burned have also gone up during that period. Notable increases in fire activity are predicted for California. These are driven by projected increases in temperature, and decreases in snow pack. To a lesser extent, they are driven by increased fuel production from CO_2 "fertilization" (Collins and Skinner 2013, Flannigan et al. 2000, Lenihan et al. 2003, Lenihan et al. 2008, Westerling et al. 2011). In addition, as human development continues in the bio-region, the need to protect lives and property continues to increase (CalFire 2010).

Current conditions have led to more funding needed to manage fuels and suppress fire. Forest Service spending from 2006 through 2012 in the bio-region has increased mostly as a result of increases for wildland fire management (USFS 2012b). Fire suppression costs are also skyrocketing. At the national level, these increases are seriously jeopardizing the agency's ability to fund its natural resource mission (USFS 2008).

According to Winter et al. (2013a), institutional, political, and social constraints influence management decisions and need to be accounted for and examined in models, tools, and applications, especially with managing wildland fires for resource management objectives. District rangers and forest supervisors have cited the lack of agency support in their decisions regarding managed wildfires, as well as air quality regulations, as reasons to continue full fire suppression. Rangers also referred to public concern, including the impacts of lingering smoke, risks of damage to habitats, and risks of fire escapes to communities as reasons influencing their decisions. Some fire managers in the Sierra Nevada. Yosemite and Sequoia & Kings Canyon National Parks have long managed wildfires to restore fire to the ecosystem. More recently, the Sequoia, Stanislaus, and Eldorado National Forests have begun to strategically manage wildfires for resource benefits.

Education about the ecological role of fire may result in people being more accepting of fire, and the smoke and the risks that come with it. Many people's concern for fire and smoke may stem from a belief that wildfire only has negative outcomes, when, with proper management, fire also has extremely beneficial outcomes. It may also take time and experience with successful outcomes for people to become comfortable with managing to increase the amount of fire on the landscape.

Any major reduction in fire suppression and fuel loading, as well as restoring the role fire plays on the landscape, is heavily dependent on increased local, regional, and national political support (Winter et al. 2013a). In addition, increased prescribed burning will disproportionately affect residents and tourism-related businesses in order to provide benefits for the greater public good and reduce negative impacts to future generations (Winter et al. 2013a).

Benefits People Obtain from Ecosystem Services

Ecosystem services are the valuable outputs of healthy ecosystems. These services are critical to the wellbeing of people. The bio-region provides an array of ecosystem services enjoyed directly by individuals and communities, such as wood products, energy, and recreational opportunities. There are also many vital services that provide benefits less apparent in daily life but important for the support they offer the ecosystems, such as water filtration, carbon sequestration and biodiversity. Uncharacteristic fire disrupts ecosystems and threatens the sustainability of these benefits through interruptions and lower quality of ecosystem services provided by the forests.

Landscapes that provide key ecosystem services are found throughout the bio-region (Chapter 7, WIKI). The continued enjoyment of the benefits from these services is vulnerable to the threat of uncharacteristic fire across these landscapes. Disturbances to ecological integrity also threaten the benefits to people from ecosystem services in the bio-region More details on these threats are included under the Ecological Integrity theme. Wildland fires are becoming larger, more frequent and of greater severity. These fires threaten the health of resources in the forests that support ecosystem services and any resulting interruption or loss of these services has a cost to us all. As a result, the agency's commitment to restoration based-management includes, "a commitment to a renewed focus on the sustainable delivery of ecosystem services" (USFS 2013 p .1).

The value of ecosystem services that are easiest to characterize are the commodities that come directly from the natural resources originating on forest lands, examples of these are water, timber, grazing and energy. The term "value" is used here to represent something more inclusive than a monetary or dollar value, but rather to capture the idea that benefits, even when they are not directly relatable to dollars spent or received, are still able to contribute to improving the quality of our lives. Examples of such value associated with non-monetary benefits are provided by cultural heritage, sense of place, aesthetics and biodiversity (Chapter 7, WIKI).

The 1996 Sierra Nevada Ecosystem Project (SNEP) estimated that the bio-region produces approximately $2.2 billion worth of ecosystem commodities and services annually (Stewart, 1996). In today's dollars, this amount would be around $3.2 billion and does not include many of the non-monetary benefits described above. Clearly our forests provide us with tremendous value that contributes greatly to our quality of life. In this estimate from SNEP, the value from water supply alone accounts for more than 60% of this total and the benefits of this water are enjoyed across all of California, thus showing the vast numbers of people who rely on these benefits on a daily basis and who would feel the cost associated with any interruption or loss of this service (Chapter 7, WIKI).

Other important ecosystem services in the bio-region are timber and grazing, both of which provide value to people through production of fiber and food as well as through job opportunities in rural forest communities. The current and potential use of renewable energy generated from hydropower, biomass, geothermal and solar and wind facilities on forest lands is another important commodity of forest lands. This energy potential has increasing value as the state looks to diversify its energy portfolio and also reduce carbon emissions from energy generation (NREL 2005).

The bio-region also provides the setting for a large recreation and tourism industry. The national forests in the bio-region provide immense value through a diversity of forested, river and lake-based recreation settings; a vast spectrum of public and private recreation opportunities for the summer and winter; and a variety of popular modes of recreation access (motorized, mechanized, non-motorized and equestrian) (Chapter 9, WIKI). These activities draw people from around the world and provide enjoyment and benefit local economies.

Cultural heritage and sense of place are also important in providing benefits to a wide selection of people. The Sierra Nevada bio-region has a rich history and culture that has always been deeply connected to the land and its natural resources starting with Native American settlement in the region 10,000 years ago and through the gold rush, which brought tens of thousands of people into the Sierra Nevada area. This mining activity also led to significant timber harvesting, ranching, and farming and was followed by a growing number of exurban migrants who wanted a refuge from urban life and were attracted to the

natural beauty and cultural history of the area. All of these uses have defined cultures in the bio-region as well as the provided identity to individuals and communities (Chapter 6, WIKI).

Other key ecosystem services provided by forests in the bio-region are carbon sequestration and biodiversity. Sequestering carbon is an important attribute of forest ecosystems and provides a great benefit globally by reducing atmospheric greenhouse gases. Biodiversity provides value to people as it allows for protection of the species necessary to provide the services of recreation, agriculture, fisheries and forest products. It also provides benefits through non-use as the value placed on an ethical obligation to protect other species from extinction, religious and cultural values associated with cherishing the earth and its inhabitants, and the desire to leave for future generations that which we are able to enjoy (EPA 1999).

Major unplanned events like wildfire are expected to continue to occur every year and have the potential to interrupt and reduce the benefits of these ecosystem services. Scientific findings point to more impact from fire on the recreation visitor experience than anticipated by managers (Winter et al. 2013), Sometimes, health and safety issues are of sufficient concern to cause people to change their travel plans. Studies have found long term effects of large wildfires on wilderness visitation. They have also reported variable effects of forest fires on recreation and tourism associated with fire intensity and recreation use activity. Other studies suggest minimal impact of fires on the overall experience of recreationists and tourists (Chapter 9, WIKI). It is important to note that decreasing visitation not only reduces the benefits to the visitors, but also the benefits to the local economies that cater to these visitors (Chapter 6, WIKI).

To get a sense of the extent to which fire threatens the many important services that are provided by our forests in the bio-region, important landscapes that provide these services were examined for their risk for uncharacteristic fire that would be detrimental to these services. It is clear that a high percentage of these important landscapes are under a threat from uncharacteristic fire (Chapter 7, WIKI).

Specifically:

- 99% of the important timber-producing land in the bio-region is at risk for uncharacteristic fire;
- 90% of the important carbon sequestration land in the bio-region is at risk for uncharacteristic fire ;
- 74% of the land with the most valuable assets for protecting water quality is at risk for uncharacteristic fire;
- 87% of the land with the most valuable assets for supporting water supply is at risk for uncharacteristic fire;
- 89% of the Forest Service recreation facilities in the bio-region are at risk for uncharacteristic fire;
- 91% of the locations in the bio-region that provide habitat for important ethno-botanical species for cultural heritage uses are at risk for uncharacteristic fire;
- 62% of the land important to providing terrestrial biodiversity in the bio-region is at risk for uncharacteristic fire;

- 86% of the land important to providing aquatic biodiversity in the bio-region is at risk for uncharacteristic fire;
- 83% of the land with high potential for solar energy, 46% of the land with high potential for wind energy and 97% with high potential for geothermal energy are at risk for uncharacteristic fire; and
- 45% of existing hydroelectric facilities and 23% of the acres in existing transmission corridors are in areas at risk for uncharacteristic fire.

The fact that such a large extent of the bio-region's landscape which is important in providing these services is at risk suggests that under current conditions, future trends will be for increased loss and interruptions in the benefits that these services provide (Chapter 7, WIKI). Contributing to this potential trend in declining benefits to people is the fact that the cost of fire management (fuel reduction and fire preparedness), and fire suppression, have made up larger and larger portions of forest budgets in the bio-region. With limited financial resources available for management, this increase in fire spending reduces the ability of forests in the bio-region to take care of other management needs that also threaten the sustainability of these services (Chapter 3 and 6, WIKI). These other threats are discussed in more detail under the Ecological Integrity theme.

Resilient Communities in the Face of Fire

Wildland fires have a variety of impacts on individuals, families, neighborhoods, social groups, and communities (McCool 2007). These fires can lead to death, increased personal stress, problems with health from smoke, psychological and emotional impacts, increased community tension and conflict, destruction of property, interruption to businesses, and decreased opportunities for recreation (California Department of Forestry and Fire Protection 2010; Chapter 3, WIKI). The costs associated with these impacts to communities are above and beyond any Forest Service fire suppression costs and have been estimated to be far larger in magnitude including both monetary losses (e.g. destroyed property and disruption to local businesses) and non-monetary losses (e.g. changes to social conditions and overall quality of life in the affected communities) (Zybach et al. 2009). Forest Service strategies can directly influence the magnitude of these impacts by determining how fires can best be managed and how communities can best prepare for, recover from, and understand wildland fires (Chapter 3, WIKI).

Resilient communities are able to cope with, adapt to; persist and develop in the face of change; and innovate and transform into new, more desirable configurations in response to disturbances such as wildland fires (Folke 2006). However, rural communities in the United States tend to be more vulnerable to these types of disturbances than are urban communities, and the people residing in the wildland urban interface (WUI) are particularly vulnerable to fire (Charnley 2013, p.5). Given recent trends in the development in the WUI of the bio-region, the impact of fire on communities is an important management concern. Key issues in developing and maintaining resilient communities include these recent WUI development trends in the bio-region as well as the effects of smoke, the need for collaboration, the role of tribes in fire management and the important role for rural communities in forest restoration efforts. Each of these issues is discussed below.

Development in the Wildland Urban Interface

Population growth and more demand for housing are resulting in increased development in the wildland urban interface (WUI) across the state. Within the bio-region, over 90% of homes in the Sierra Nevada and Sierra Nevada Foothills regions were located in the WUI in 2000, and the WUI captured virtually all of the net-growth in housing units from 2000-2010 (Hammer et al. 2007). This recent growth and settlement in the Sierra Nevada is influenced by amenity migration into the WUI and settlement of seasonal and year-round residents drawn here by its unique features (Loeffler and Steinicke 2007). Amenity migration in the Sierra Nevada has also been characterized by people moving to higher elevations further expanding this WUI into previously undeveloped areas (Loeffler and Steinicke 2006). Also, California's senior population, which is the largest in California's history, is expected to continue to grow and settle in foothill and rural counties (Roberts et al. 2009). More population in these areas means a greater risk to communities and greater potential for impacts from fire.

The condition of fuels in forests also contributes to increased potential for community impacts from fire. The Sierra Nevada has been subject to fire suppression for over a century, resulting in ecological and human safety problems (Heckmann et al. 2008). After over 100 years of putting out fires (suppression) in the bio-region, vegetation and fuels have become denser and more continuous. As a result, fires have become more difficult to suppress. As a result of this combination of forest fuels condition along with increased development in the WUI, California has experienced significant increases in the frequency and intensity of wildfires with the potential to impact communities (Rahn 2009). In terms of this impact to community safety, a concentration of California's highest priority landscapes, defined as having high wildfire threat, together with human infrastructure assets, is located within the bio-region (California Department of Forestry and Fire Protection 2010).

Smoke and Communities

Smoke from wildfires is particularly contentious for communities, fed by trends of more people, more homes, and more recreational uses in the bio-region. Wildfires result in lower air quality and can impact human health as intense, large, and long-lasting wildfires are likely to result in air quality that exceeds set standards (Bytnerowicz et.al. 2013). While fire and associated smoke have always had a consistent presence in the bio-region, and are key ecosystem components, the levels and patterns of smoke, and the resulting effects on people have changed. Prior to the 19th century, when fires were burning extensively across much of the lower and mid-elevation areas annually, smoke emissions were substantial (Stephens et al. 2007). "A long history of fire suppressions has encouraged residents and visitors to the Sierra Nevada to expect exceptional visibility and smoke-free conditions during the summer and fall. This may not be a realistic expectation for the area, especially under a changing climate projected to increase the likelihood of large, severe wildfires (e.g. Westerling et al 2006)" (Bytnerowicz et al. 2013). Unmanaged wildfires cause the highest levels of smoke. Extensive absence of fire has resulted in even greater smoke emissions when uncontrolled wildfires burn because of high, accumulated fuel levels, burning when temperatures are hottest, and combustion is greatest (Chapter 3, WIKI).

Managed fires, and prescribed fires, where smoke is managed, produce emissions, although these emissions are at generally lower levels than wildfires, and may reduce overall emissions in the long-run. A study of the western states found that large-scale prescribed fire could reduce long-term carbon emissions in the western U.S. by about 20% (Wiedinmyer and Hurteau 2010). The discussion around this tradeoff can be contentious and difficult for local air quality boards to grapple with. In the bio-region, this situation occurs in the southern Sierra Nevada in the San Joaquin air basin. The San Joaquin Valley Unified Air Pollution Control Board, Sequoia National Forest, and Sequoia-Kings Canyon

National Park dealt with it through a great deal of communication with one another. Joint meetings were held to discuss the benefits of reduced emissions from unmanaged wildfires and ecosystem health, and the short-term impacts. One outcome was that remote, 24-hour live video cameras were installed to provide real-time condition tracking by the Air Pollution Control Board. This effort has enabled the Sequoia National Forest to restore managed fire to substantial areas on the Kern Plateau.

Importance of Collaboration

With the migration of more urban and suburban Californians to the bio-region, more people are exposing themselves and their families to the danger of wildfire. Many newer residents in fire risk areas are unfamiliar with the safety problems associated with building in certain locations (Sierra Business Council 1997). People tend to underestimate the risk of living in high fire risk areas and landowners are not typically liable for failure to take risk reduction actions on private property (Winter et al. 2013a and Yoder and Blatner 2004). However, community involvement in wildfire planning is extensive in California (California Department of Forestry and Fire Protection 2010). Examples of this community involvement include:

- Fire Safe Councils (FSCs) where The Forest Service plays an active role supporting and engaging with the FSCs in their activities, and provides funding. FSCs help Californians mobilize to protect their homes, communities, and surrounding lands from wildfire.
- Fire Learning Networks foster collaboration across organizations and administrative boundaries to develop landscape-scale restoration plans for fire-prone ecosystems.
- Conservation learning networks promote education by spreading best practices and identifying barriers and solutions.
- Community Wildfire Protection Plans not only help communities address fire risk locally, but also help people create social networks, enhance learning, and build community capacity.

The Forest Service can play a role in all of these types of activities, providing data and expertise, and helping stakeholders form networks. Collaboration between managers, researchers, and tribal practitioners can be the vehicle for evaluating cultural resources that support community health and livelihoods. Tribal communities within the Sierra Nevada present distinctive opportunities for mutually beneficial partnerships to restore ecologically and culturally significant resources, and to promote resilience (Charnley et al. 2013, p.19).

Tribal Concerns and Fire Management

Modern towns and cities now exist in the places where tribal communities once stood. Traditional tribal practices not only protected those communities, but provided for the communities at large. Traditional practices such as burning were passed on because tribes knew that small fires prevented large catastrophic ones. Fires that started in the late summer were known to trigger salmon runs. This was an effect of inversion layers of smoke settling in on river canyons and cooling the water through shading the sun's rays. The cooler water would be felt by the salmon downstream and would initiate their move up-stream. Eventually, in some places, this became ceremony and continued for thousands of years. Today's practice of suppressing fires has had an impact on these ceremonial traditions, and may have impacts on salmon species and subsistence and commercial fisheries as well.

Sacred sites can be classified as those places yet to be formed. Sacred sites are not static, but change and can still come to be. Due to disturbances such as fire, tribes may establish new locations for sacred sites or ceremonial areas and these must be taken into consideration during management (Chapter 12, WIKI).

Wilderness designations are controversial with the general public as well as with tribes (Chapter 12, WIKI). The intent of maintaining these areas in their "pristine" condition can be felt by tribes as not considering traditional ecological knowledge and associated tribal practices. Tribes have historically managed the landscapes through the introduction of fire at appropriate times of the year and in specific locations. There are several plants that have cultural significance to tribes, and special ecological value in providing habitat or playing key ecological roles dependent on fire and smoke. A prime example in the Sierra Nevada is California black oak, which is an important food source for Native Americans, and is recognized as a key species to manage for wildlife habitat (North 2012). Fire can be targeted at specific locations to enhance willows in riparian areas, acorns, and feeding locations for wild game, as well as to reduce insect infestations that damage traditional food sources or species gathered for traditional purposes (Chapter 12, WIKI).

Forest Restoration and the Role of Rural Communities

Rural communities in the wildland urban interface (WUI) are likely to be economically connected with key forest sectors such as timber, mining, grazing and recreation. Wildfire in these areas can damage the resources on which these forest sectors are dependent and disrupt the livelihood for many of the residents in these communities. Within the bio-region, some communities specialize in natural resource sectors such as agriculture, forestry and mining. These communities are concentrated in the northern portion of the bio-region. In the central and southern areas, there is more of a community focus on the travel and tourism sectors. In all cases, fire that disrupts these activities in the forests can have a dramatic effect on local economies (Chapter 6, WIKI).

Current policy for national forest management calls for approaches that accomplish ecological restoration goals, while simultaneously producing forest products that can benefit local communities (USDA 2010, USFS 2007). Sound restoration work to retain and restore ecological resilience in the face of wildfire is being conducted throughout the bio-region; however, important indicators suggest that impacts from disturbances are outpacing the benefits of this work. Specifically, wildland fires in the bio-region are becoming larger, more frequent and of greater severity and these fires threaten the health of resources in the forests that support human wellbeing (e.g. wood, fiber and water as well as biodiversity, scenic landscapes and wildlife habitat). To counter this trend and ensure the sustainability of the benefits these resources provide, forest management will need to significantly increase the pace and scale of restoration in order to remove the conditions driving these increases in fire (USFS 2013).

Ecological restoration as a policy in the bio-region can contribute to reducing current trends in fire and contribute to improving the sustainability of the benefits of forests while simultaneously contributing to the sustainability of local community wellbeing. Specifically, restoration projects that support the local wood product economy also provide support to local residents in rural areas who rely on the forest for their livelihoods. Not only is restoration a potential benefit to these communities, but healthy local communities are also a benefit to the success of Forest Service restoration goals. Given the desire to increase the pace and scale of restoration, maintaining a robust local workforce and infrastructure is necessary to support the logistics and economics of restoration (Charnley and Long 2013; Charnley et al., in press).

The revenue that can be generated through stable local markets for timber and non-timber biomass from restoration activities can help offset the costs of Forest Service restoration goals. In addition, the further the haul distance from the harvest site to the processing facility, the higher the transportation costs and less economical the timber sale. Therefore, maintaining local wood processing infrastructure in the bio-region is an important strategy for maintaining favorable economics for accomplishing ecological restoration goals while sustaining jobs in the local wood products industry (Chapter 8, WIKI).

However, changes in the timber economy have resulted in drastic reductions in the local timber infrastructure and labor that supports this industry. Timber harvest in the bio-region has been declining since the early 1990s. The declines are a result of protection of old growth forests, protection of threatened and endangered species, restrictions on harvesting in unroaded areas, and timber sale appeals and litigation. At the same time, state regulations resulted in similar decreases in timber harvests from state and private lands (Morgan et.al. 2004 and 2012). The volume of timber harvested from Sierra Nevada national forests was 1.29 billion board feet in 1988, and 183.8 million board feet in 2010, 86% lower than it was in 1988 (Charnley and Long 2013).

This reduction has contributed to the number of sawmill closures that have occurred in California between 1988 and 2006 (Morgan et.al. 2012). Between the late 1980s and 2000, California milling capacity dropped by almost 60% and closures since 2000 have continued this trend (Charnley and Long 2013, Morgan et al. 2004). As of 2006, there remained 12 sawmills, 2 medium-density fiberboard and particleboard mills, and no veneer mills in counties within the Sierra Nevada synthesis area. Current and expected economic conditions are difficult for these facilities and continued decline in the number of mills in the bio-region would not be surprising (Morgan et al. 2012, Charnley and Long 2013).

A long-term view of the California wood products industry seems to indicate that infrastructure is capable of providing an effective linkage between the supply of available logs and societal demands for wood products. While the number of operating manufacturing facilities has sharply declined in the face of significant declines in home construction, improved economic conditions are likely to, at least, stabilize, if not increase their number. Future timber harvests throughout the bioregion are dependent on multiple factors such as the demand for wood products, which fluctuates in response to both regional and international economic conditions, the pace of new home construction and future decisions on restoration (Chapter 8, WIKI).

Non-timber biomass is also generated during forest management and this biomass can be used to generate energy. Biomass energy is promising. It is renewable and like timber, the revenue from this biomass can help offset restoration costs and contribute to the economies of local communities. California has more biomass power plants than any other state. This capacity has been growing (Mayhead and Tittmann 2012; Morgan et.al. 2004). Even so, biomass currently only accounts for around 2% of the state's electricity generation. There are also economic challenges facing biomass power plants that hinder development of any new facilities. These challenges include existing contracts that make these plants unprofitable, and that restrict the ability of new plants to attract investment capital, given the uncertainty of biomass supply (Mayhead and Tittmann 2012). There are challenges to the development of biomass energy that limit its growth potential in the bio-region.

Without stability in these local wood products industries, and without more stable markets for timber and biomass flowing from restoration, the ability of the Forest Service to achieve its restoration goals on this landscape will be limited. Fewer acres can be treated as the opportunity to offset costs of restoration

is lost. Supporting the development of these industries aids restoration, but also promotes development and creates jobs (Chapter 8, WIKI).

2004 Sierra Nevada Framework

Goals for fire and fuels management are intended to reduce threats to communities and wildlife habitat from large, severe wildfires and re-introducing fire into fire-adapted ecosystems. They include:

- Managing hazardous fuels in and around communities;
- Strategically placing treatment areas across landscapes to interrupt potential fire spread; fuel treatments such as thinning and brush removal are designed to reduce the amount of burnable material over 25-30% of the land base;
- removing sufficient material in treatment areas to cause a fire to burn at lower intensities and slower rates of spread compared to untreated areas, and
- Considering cost-efficiency in designing treatments to maximize the number of acres that can be treated under a limited budget.

Fire and fuels management is integrated with the strategy for conserving old forest ecosystems. Direction is included to guide managers in placing and designing effective area treatments while incorporating needs for retaining key habitat elements for sensitive species. The direction was designed to protect old forest species and to perpetuate old forest ecosystems, while addressing the need to intervene in the forest to reduce the fuel loads feeding catastrophic fires.

The basic strategy also includes other management objectives such as reducing stand density for forest health, restoring and maintaining ecosystem structure and composition, and restoring ecosystems after severe wildfires and other large catastrophic disturbance events.

Site-specific fuels treatment prescriptions are designed to modify fire intensity and spread in treated areas. Managers consider: topographic position; slope steepness; predominant wind direction; and the amount and arrangement of surface, ladder, and crown fuels in developing fuels treatment prescriptions for each treatment area. Fuels treatments are intended to reduce surface, ladder, and crown fuels. Crown fuels are modified to reduce the potential for spread of crown fire. Consideration should be given to the frequency of entries to the site that will be needed to achieve desired reductions in fuels condition class. Expanded use of mechanical treatments can be used to set the stage for prescribed fire as a follow-up treatment, or to deal with those specific situations when there are concerns about smoke or available burn days.

The integrated strategy emphasizes ecosystem restoration following catastrophic disturbance events, allows for salvage of dead and dying trees for both economic value and fuels reduction purposes, and incorporates fuels and vegetation management standards and guidelines. Over a period of time it is expected that land managers can gradually restore fire to the ecosystem in its more natural form.

Appropriate tribal governments and tribal communities will be consulted regarding fire protection and fuels management activities that potentially affect ranches, reservations, and other occupied areas. Fire protection plans will be developed for such areas in consultation with appropriate tribal or intertribal organizations. The direction is to coordinate with tribes and appropriate tribal organizations regarding

training, outreach, and other items of mutual interest in order to support tribal and national forest fire programs.

The standards and guidelines call for mitigation of impacts from fuels and vegetation management to protect spotted owl and Northern goshawk nest sites, and fisher and marten dens.

The Forest Service must meet all regulations put forth by the air districts. Smoke from both wildland and prescribed fires affect the air quality in in the Sierra Nevada bio-region. These effects are short term; meaning that smoke from fires can be severe but limited to when fires are burning. Smoke often impacts more than a single basin when present and can be transported great distances from its source. California's Code of Regulations, Title 17 Subchapter 2 Smoke Management Guidelines for Agricultural and Prescribed Burning sets forth smoke management requirements. The requirements set forth by the state are then implemented by air districts. Coordination between the Forest Service and air districts are required for prescribed burning permission. Local air districts have established regulations to minimize smoke impacts from prescribed fires (5CARB).

SUSTAINABLE RECREATION

What are we trying to sustain at the bio-regional level?

1. **Culture and lifestyles**
2. **Connections to the land**
3. **Economic opportunities for communities**

Weaving it Together

The great outdoors is a huge part of the culture and lifestyle in the Sierra Nevada. Forests provide many opportunities for connecting to the land and to each other. The benefits go far beyond the bio-region. People visit from all over the country and the world. The bio-region enjoys a large, diverse community of visitors and is known for its scenic beauty and wide variety of opportunities to be with nature.

There are many unknowns about the effects of all of that usage. For example, it is very difficult to quantify the effects of the dispersed recreation on the landscape. Often, dispersed recreation activities occur near water and vegetation is trampled or cut, soils are compacted and wildlife habitat is affected. Generally, the effects of use at each individual location are small, but the cumulative impact to ecological integrity is unknown.

There are more people living in the area and using the national forests, and demand for recreational opportunities is going up. The scenic character has been degraded, both from fire suppression and more tree density. Dense stands are less resilient to large, high severity fire and to insects and pathogen outbreaks. The scenic character is more susceptible to dramatic changes in a short period of time, with long recovery periods. People like the way dense forests look, but that view may be disconnected from the natural condition of the landscape.

Local economies depend on recreation for jobs and tax revenue to support community services. As Forest Service budgets go down, it is harder to maintain existing recreation opportunities and develop new ones. Creating partnerships within the local communities offers ways to fund recreation activities, thereby keeping the flow of visitors and income coming in. This cycle of visitors and income contributes to sustainable communities.

Culture and Lifestyle

Recreation as Part of the Sierra Nevada's Identity

Outdoor recreation has had a long history in the Sierra Nevada and is a distinct part of the culture and lifestyle in the region (Sierra Nevada Conservancy 2011a). According to 2005-2009 National Visitor Use Monitoring (NVUM) data, almost 19 million people visited the national forests in the bio-region during this period. Round 2 (2005-2009) NVUM data was used, because data collection for Round 3 (2010-2014) has not been completed for all forests in the bio-region. NVUM data are collected using a random sampling method that yields statistically valid results at the forest level. As a rule, NVUM results are unbiased; however, results for any single year or season may under- or over-represent some groups of visitors. Unusual weather patterns, major fire closures, or unanticipated pulses or lapses in visitation are not, and maybe can't be, incorporated into the sampling framework.

The Sequoia, Inyo, and Sierra National Forests account for 45% of all recreation visitor days on National Forest System lands in the Sierra Nevada. Together with the adjacent national parks, this portion of the Sierra Nevada probably has one of the highest recreation activity levels in the world (USFS 2012c). In general, being outdoors is an important part of the California lifestyle, and national forests are part of an expansive network of local, state, and federal parks, forests, trails, and open space systems in the state (Roberts et al. 2009). Eighty-four percent of Californians polled in the most recent Comprehensive Outdoor Recreation Plan (CORP) statewide survey said outdoor recreation was an "important" or "very important" contributor to their quality of life (Roberts et al. 2009).

Recreating in Sierra Nevada national forests is highly valued by communities both inside and outside the bio-region. Based on 2005-2009 NVUM data, about 24% of visitors to a forest in the bio-region travelled 201-500 miles, and an additional 23% traveled over 500 miles. The largest percentage of visitors to national forests in the bio-region (7.2%) came from Washoe County in Nevada, which includes the Reno metropolitan area, as well as the northeast portion of Lake Tahoe. Los Angeles County provided the second highest percentage of visitors to the bio-region (5.6%). Together, the nine counties in the San Francisco Bay Area contributed a large proportion of visitors (17.3%). A relatively large percentage of visitors also come from Fresno County, Sacramento County, and the central Sierra counties. Eight percent of visitors come from states other than California or Nevada. Two percent of total national forest visitation in the bio-region is from foreign visitors, and most of those come from Europe.

Sierra Nevada national forests provide scenic routes, river corridors, wildlands, developed destinations, lakes recreation, backcountry, high country, and other recreation settings. This diversity of settings provides a backdrop for a vast range of recreation opportunities, including non-motorized, motorized, developed, and dispersed recreation on land, water, and in the air. According to 2005-2009 NVUM data, the most popular activity in the bio-region is viewing natural features, followed by downhill skiing, hiking/walking, relaxing, and viewing wildlife.

Across the country, participation in nature-based outdoor recreation has been on the rise (Cordell 2012). Nature-based outdoor recreation is defined as "outdoor activities in natural settings or otherwise involving in some direct way elements of nature—terrain, plans, wildlife, water bodies, and even celestial bodies," and can include visiting sites, viewing and photographing nature, backcountry activities, motorized activities, hunting and fishing, non-motorized boating and diving, and snow skiing and other winter activities (Cordell 2012). However, the specific mix of outdoor activities and their popularity with the public has changed over time (Cordell 2012), and these demands influence forest lands and management decisions. Between 2000 and 2009, there was considerable growth in viewing and photographing nature, as well as moderate growth in visiting recreation and historic sites and non-motorized boating. Participation in different types of recreation activities varied by: gender, ethnicity and race, annual family income, place of residence, and residence status (Cordell 2012).

In California, Roberts et al. (2009) describe five recreation trends: Californians seek relaxation, socialization and natural values from their outdoor recreation pursuits; they pursue a wide range of outdoor activities; they want more amenities when they engage in outdoor recreation; they differ in their outdoor recreation styles and participation patterns; and outdoor recreation and nature-based tourism are important elements of California's tourism portfolio. Being with friends and family is one of the main motivators for pursuing outdoor recreation. Roberts et al. (2009) also note the growing importance of volunteerism in recreation, which enhances both people's lives and landscapes. Evidence suggests this form of outdoor recreation activity is on the rise. Themed days and special events increase the visibility of volunteering on public lands.

Recreation and tourism greatly contributed to growth and development in the bio-region, bringing new economic opportunities to many communities that were formerly timber dependent (Charnley 2013, p.16). As people moved from urban areas to Sierra Nevada forests for their amenities and improved quality of life, they brought new values and differences in recreation engagement, compared to residents who have had a longer history in the area (Winter et al. 2013b, p.12). While more recent growth has occurred in the Central Sierra, largely due to urban expansion from the Sacramento metropolitan area, "protecting scenery, outdoor recreation opportunities, and environmental quality will likely continue to encourage amenity migration" (Winter et al. 2013b). Positive outcomes of amenity migration are reliant on local adaptive capacity to manage change in both social and physical attributes of community (Winter et al. 2013b, p.5).

With the wide range of recreation styles and interests, it is no surprise that recreation user conflicts exist throughout the bio-region. A stable public land base, a declining private natural land base, and increasing numbers of outdoor recreation enthusiasts are expected to result in increased conflicts and declines in the quality and number of per-person recreation opportunities, especially on public lands near large and growing population centers (USFS 2012f). In addition, stressors like climate change may exacerbate competition among uses. For example, climate change is expected to impact water flow and timing in the Sierra Nevada, which is anticipated to affect water-based recreation activities and tourism (Winter et al. 2013a, p.6). In California, activities like off-highway vehicle recreation, mountain biking, boating and adventure recreation have increased dramatically in recent years. At the same time, population growth, urbanization and alternative energy production compete for suitable lands (California Department of Forestry and Fire Protection 2010). The California Department of Parks and Recreation (2002) recognizes the importance of good trail design, construction, and maintenance in accommodating higher numbers and multiple uses, while also recognizing that because of the state's

finite resources, increased sharing of resources will be necessary, inevitably creating some friction among diverse user groups.

The range of recreation opportunities, as well as other services and benefits provided by National Forest System lands, supports the diversity of values that people hold. However, these ecosystem services have limits, impact each other, and require tradeoffs. The Forest Service will continue to manage national forests for multiple uses and benefits, working directly with communities to find balance across the various uses. Ecological constraints, external drivers and stressors, policies and laws, and agency resource limitations will be factored in as well. The ability to work across agencies and governments to address recreation demand can influence the effectiveness of management across all jurisdictions, particularly in light of future uncertainties and change.

National Forests as a Playground for All

According to Roberts et al. (2009), "No demographic trend is of greater importance to national forest managers and leaders than the immense growth of cultural diversity. California is home to more than one-third of the entire U.S. Asian American population and about 30% of all U.S. Latinos and Native Hawaiians or Pacific Islanders." Increases in culturally diverse populations will likely be reflected in recreation in the Sierra Nevada forests (Chavez and Olson 2011).

While population growth in California has slowed over the last two decades and has had unprecedented migration of residents to other states, international migration to the state has remained strong (Johnson 2011). Public open spaces offer a place for many immigrants to recreate and relax, help maintain cultural traditions, and connect with other immigrants for mutual support and information sharing (Roberts et al. 2009). A number of studies have revealed the cultural variations evident within recreation studies linked to Latino and Asian populations, including recreation patterns and preferences for development, underrepresentation in some forest areas, and communication and information needs on and off site (Winter et al. 2013b, p.11). Forty-three percent of Californians speak a language other than English, and 20% speak English less than "very well" (Headwaters Economics 2012a). Socializing and spending time with family plays a major role in how and why California's Latino population recreate on federal lands. Studies have shown that Latino outdoor recreationists: enjoy all-day, extended-family social outings; are interested in an outdoor experience with a strong social recreation component; and identify having a good family experience as one of the most important features of a satisfying outdoor recreation excursion (Roberts et al. 2009). The Latino emphasis on family and family values is maintained across generations and does not seem to diminish with increased time in the U.S. (Roberts et al. 2009).

According to Roberts et al. (2009), "more than 45 years of research continues to show that people from culturally diverse backgrounds are not using the national forests and other public lands in numbers representative of the populations within the market areas. Not all people feel comfortable and safe, have access, maintain strong and positive ties, or have knowledge about these natural areas and what to do on them." According to 2005-2009 National Visitor Use Monitoring (NVUM) data, 84% of visitors to national forests in the bio-region were white, and 8% of visitors were Hispanic or Latino (of any race). While the local Sierra Nevada population is less racially and ethnically diverse than the rest of the state (Sierra Nevada Conservancy 2011b), many visitors to the bio-region's national forests are not local. In the counties that contribute to the bio-region, which include Central Valley cities outside of the bio-region such as Fresno and Bakersfield, just over 70% of the population is white and 32% is Hispanic or Latino.

In California, just over 60% of the population is white and 37% is Hispanic or Latino (Headwaters Economics 2012a).

According to Winter et al. (2013b, p.7), demographic changes may be addressed by adjusting how the Forest Service works with and offers opportunities to the public. "Services offered through existing communication and information approaches and more direct opportunities, such as those represented in recreation and tourism might be a poor fit to these populations that are increasing in the region and surrounding areas. Planning for the Sierra Nevada may consider these cultural shifts and how they may be met through adjustments in local and regional services. Sensitivity to cultural differences in relationships to government, the land, and land management will aid effective management in this diverse region." Through programs like the Central California Consortium, the Forest Service continues to look for ways to engage with youth and underserved communities on natural resource issues, and to encourage them to use public lands.

Native American Culture and Rights

The agency is required by law to administer the National Forest System for outdoor recreation, among other uses including range, timber, water, wildlife and fish. Untold numbers of Native American sacred sites and traditional places are located on these same lands, and tribal practices are tied to these resources. Economic and recreational drivers are important in land management decision-making, but sacred site concerns are equally important. "American Indians are part of the Old and the New West. They have historic, contemporary and symbolic links with the landscapes-of the West, including the landscapes in and near the major recreation, park and tourism resources of the West. Tensions are growing among American Indians and those using and managing the outdoor recreation resources of the West" (McAvoy 2002).

Infrastructure development or improvements to recreational sites will require additional water, electricity, sewage, and roads. This may impact traditional landscapes and will trigger the need for consultation. Increasing user visits or directing recreational or user traffic towards sacred sites or traditional cultural properties may have an adverse effect on the location, as well as the religious, ceremonial or cultural activity of the tribes. Conflicts may occur with the designation of areas as recreation fee sites; however, consultation should occur with tribal governments and traditional practitioners and any potential conflicts should be resolved before a prospectus is issued. Federal land management agencies are prohibited from charging a standard amenity or expanded amenity fee for "any person who has a right of access for hunting or fishing privileges under a specific provision of law or treaty" (FLREA, 16 USC 6802(d) (1)). Hunting and fishing rights include the right of gathering wild plants and forest products.

Despite their longevity in the region and status as sovereign nations, California Native Americans, their history, and their cultures are still not appropriately or accurately recognized by the American people and the federal government. Currently, there is a lack of understanding by visitors and managers toward Native American values and traditions, as well as a lack of understanding of treaty rights that give Native Americans unique use rights on National Forest System lands (McAvoy et al. 2004). Agency cultural training is currently being developed by the Washington Office of Tribal Relations specifically for the purposes of carrying out the recommendations within the Sacred Sites Report to the Secretary of Agriculture. Staff in the Washington Office is also working with Regional Tribal Relations Program Managers to develop broader training on tribal issues and needs.

Connections to the Land

Most people have come to know their national forests and grasslands through the unparalleled diversity of outdoor recreation opportunities (USFS 2010a). Outdoor recreation, including trail sports, biking, camping, snow sports, water sports, fishing, hunting, wildlife watching, motorcycle riding, and off-roading, provide the opportunity to unplug from our busy lives, recharge our souls and live healthier lifestyles (Outdoor Industry Association et al. 2012). Connection to the natural environment plays an important role in contributing to community attachment and wellbeing, especially in communities where public lands dominate the landscape (Brehm et al. 2004). Positive and meaningful outdoor recreation experiences offer people a chance to develop connections to natural spaces and a foundation for stewardship that further protects the physical environment and contributes to community resilience (Winter et al. 2013a, p.2).

The places that people go to when they recreate on national forest lands have important social meaning that relate to or depend on scenery (Mattson and Mosier 2012). People form varied and complex relationships with specific places that often hold emotional, symbolic, and spiritual meanings (Kruger et al. 2008). As described in Winter et al. (2013b, p.9), people whose connections to place are intertwined with their sense of self are likely to hold much stronger place attachments and may consider discussions of place as equal to self-determination and personal identity. Therefore, management actions may cause concern when they are viewed as a threat or a personal attack. Group identities may also be attached to a particular place, where meanings and management preferences for areas are intertwined with social identity. Native Americans have a deep sense of place meaning and attachment to areas in national forests that have been traditionally used by their people, and gathering and recreation activities continue to tie them to these special places (McAvoy et al. 2004).

Though differences vary across regions and cultures, people who visit national forests tend to have a mutually shared expectation regarding the scenery, also known as "sense of place" (USFS 1995). A combination of physical, biological, and cultural images gives an area its positive scenic identity and contributes to sense of place. Scenic integrity is the degree to which these images are visibly disturbed (Mattson and Mosier 2012). The Native American community feels a close association with cultural and historic landscapes, and activities that alter or degrade scenic integrity may affect potential cultural or historic landscapes or traditional cultural properties.

Based upon Existing Visual Conditions surveys (from forest plan Environmental Impact Statements, 1988-1992), over 80% of recreation settings were estimated to have a high scenic integrity level, meaning no disturbance or unnoticed disturbance. This provides some sense of scenery conditions across forests in the bio-region and their ability to contribute to the important relationships that individuals and communities have with the places they visit, as well as to what newcomers are drawn to as their "place." People may have connections to particular places for entirely different reasons, unrelated to scenic integrity. Visually, scenery may appear largely undisturbed; however, the sustainability of scenic attributes over the long term is dependent on ecological integrity (Mattson and Mosier 2012). Overall, the foothill, montane, and to a lesser degree upper montane landscapes are outside the natural range of variability in most locations, according to an assessment conducted by Safford and others (Chapter 1, WIKI). Vegetation is more uniform and dense, there are more young trees than old, and fires occur in larger high severity patches (Chapters 1 and 3, WIKI). Dense stands are less resilient to large, high severity fire, and insect and pathogen outbreaks (Chapter 3, WIKI), making these landscapes more susceptible to dramatic changes in a short period of time with long recovery periods. These conditions

are also at odds with research findings concerning forest landscape aesthetics, which found that the scenic attributes that people prefer generally include large trees, herbaceous smooth groundcover, open mid-story canopy with high visual penetration, and vistas with distant views and high topographic relief (Chapter 9, WIKI). As population growth and urbanization continue, particularly along the Sierra Nevada foothills, demand for energy and communications infrastructure is expected to increase, potentially resulting in a loss of scenery in the bio-region and impacts to recreation experiences and sense of place (Chapter 9, WIKI).

Visitor satisfaction from the National Visitor Use Monitoring Survey can also provide some sense of people's ability to connect to the land through the quality of their experiences. The majority of visitors to the bio-region's national forests were satisfied with the elements most important to them for undeveloped areas, day-use sites, and overnight-use sights.

However, increasing demand for recreation opportunities in the Sierra Nevada and conflict among different user groups may impact people's ability to have high quality experiences on National Forest System lands. Reducing or limiting access to recreation on public lands by closing roads, campgrounds, RV parking, and trails can impact surrounding communities (Hurniston 2010). Changing recreation demands, due to demographic shifts, can also impact visitor satisfaction. Cultural diversity will continue to increase in California, particularly within Latino and Asian populations, and this trend will impact outdoor recreation planning and management (Winter et al. 2013b, p.11).

Wildfire and forest pests threaten large acreages of landscapes in the Sierra Nevada that have recreation value (California Department of Forestry and Fire Protection 2010). According to Winter et al. (2013a, p.10), scientific findings seem to point to more impact from fire on the recreation visitor experience than anticipated by managers. Studies have found long-term effects of large wildfires on wilderness visitation. They have also reported variable effects of forest fires on recreation and tourism associated with fire intensity and recreation use activity. Other studies suggest minimal impact of fires on the overall experience of recreationists and tourists. However, in some cases, health and safety issues are of sufficient concern to cause changes in travel plans.

Visitor satisfaction data provide useful information about people who are already using the forest. It does not, however, provide insight into those people who do not use the national forests and their level of connectedness with nature. Current forest management may be creating barriers to use and enjoyment (e.g. language and lack of information) by the growing population of ethnic minorities in California and the country as a whole (Roberts et al. 2009). Americans, especially those who live in urban areas, are becoming more disconnected from the outdoors, weakening the commitment to stewardship of our shared natural legacy (Council on Environmental Quality et al. 2011). Children today spend less than half as much time outside as their parents did, and are "plugged in" to electronic devices for more than seven hours a day (Council on Environmental Quality et al. 2011). An emotional affinity toward nature is linked to the willingness of people to protect the environment, and positive emotional experiences with nature play an important role in developing that affinity, especially if they share those experiences with significant others (Müller et al. 2009). In addition, a positive connection to nature develops earlier in life and remains a stable trait throughout adulthood (Berk 2006). Comparing Round 1 (2005-2009) and Round 2 (2010-2014) National Visitor Use Monitoring (NVUM) data for seven of the ten bio-regional forests, shows that visitation by people 19 years of age and under has decreased from 20.3% to 17.7% (Round 2 data is not yet available for the Sierra, El Dorado, and Stanislaus National Forests).

Economic Opportunities for Communities

California has historically provided recreational opportunities to many, many people, and the intensity of this use is expected to go up. This is a result of population increases in the state, as well as recent softening of the national economy and the volatility of gasoline prices, causing Californians to vacation closer to home. A 2009 study shows that adventure and high risk activities, like mountain biking, rock climbing, and wilderness backpacking, will be increasingly important uses of recreational areas in California. The same holds true for motorized trail biking and other motorized recreation which offer high risk adventure that will continue to be of interest to visitors (State of California Resources Agency 2009).

Visits to the bio-region for all types of recreating experience, including site-seeing, camping, hiking, hunting, fishing, motorized activities and adventure sports, play a key role in stimulating local employment in the bio-region by providing opportunities and goods and services for these recreation activities. Communities benefit economically from these visitors who spend money in hotels, restaurants, ski resorts, and gift shops. As a result, this travel and tourism sustains local economies for communities near these abundant recreational areas. This is especially true in the southern portion of the bio-region where the Sequoia, Inyo, and Sierra National Forests account for 45% of all recreation visitor days on National Forest System lands in the Sierra Nevada. Together with the nearby national parks, this portion of the Sierra Nevada probably has one of the highest recreation activity levels in the world (USFS 2012c).

Jobs in travel and tourism make up a high percentage of all employment in many communities throughout the bio-region and particularly in the central and southern areas (Chapter 6, WIKI). A study estimating the percentage of total county employment and earnings generated by visitor spending found that visitation is especially important to economies in Mariposa (accounting for 52% of all county employment and 33.4% of all county earnings), Mono (48.6% of employment and 32.2% of earnings), Inyo (23.5% of employment and 11.5% of earnings), and Sierra (22.7% of employment and 13.0% of earnings) (Dean Runyan and Associates 2012). It is important to note that while recreational jobs provide an important source of earnings in some communities in the bio-region, they are typically lower paying jobs than other traditional forest based activities such as timber, mining and agriculture. The 2011 average annual wage for travel and tourism industries was $17,892. This is much lower than the bio-region average of $42,776 (U.S. Department of Labor 2012). Nonetheless, communities are dependent on the quantity and quality of the national forest recreational opportunities and the other public lands in the bio-region. More details on the importance of forest activities to the economies of local communities are found under the Community Resilience theme.

In addition to the economic contribution of this spending to supporting jobs in these communities, counties in the bio-region also receive revenue from sales tax from visitor spending, and this money supports critical county services. This includes the taxes collected on all of the spending on goods and services while travelers are visiting an area, and it shows that visitors generate a large percentage of these important local government revenues in Mariposa (61.4% of all sales tax revenue collected in the county), Mono (57.9%), Alpine (33.3%), Sierra (29.9%), Plumas (24.9%) and Inyo (20.8%) (Dean Runyan and Associates 2012). While national forests do contribute to travel and tourism in the bio-region, and therefore, can influence revenue, there are other recreational opportunities in the bio-region that also drive this tourism, such as the National Parks, and therefore all of this revenue cannot *only* be attributed to visitors to the national forests.

Demand is going up for the Forest Service and other land management agencies to provide more and higher quality recreational opportunities in the bio-region. At the same time, Forest Service budgets are decreasing and fewer resources are available to maintain existing recreational facilities or to develop new ones. Any decrease in the quality of the recreational experience in the bio-region, or an inability to meet the needs of visitors will likely result in them going elsewhere to recreate (Chapter 9, WIKI). Local communities in the bio-region are dependent on the visitation that results from recreational activities, as these activities support the local economy and also pay into the tax revenues needed to support public services such as fire protection, education and roads. Therefore, a declining Forest Service budget to maintain the quality of existing facilities and to create the new opportunities that visitors to the bio-region are looking for threatens the sustainability and quality of life in local communities (Chapter 6, WIKI).

Declining federal budgets have the potential to result in a declining quality of condition for existing facilities, resulting in a lower quality of experience. In 2006, the Forest Service undertook the Recreation Facility Analysis (RFA), to identify national forest recreation-site priorities and establish annual programs of work to reduce a mounting deferred maintenance backlog. At the time, that backlog stood at $49,000,000 for national forests in the bio-region. During this same period, a small infusion of funding through the American Recovery and Reinvestment Act of 2009, and fees collected from the Land and Water Conservation Fund Act were used to do some recreation site improvement. These largely focused on addressing visitor-satisfaction comments from the National Visitor Use Monitoring (NVUM) surveys. Although these improvements improved conditions on specific sites, there was not enough funding to substantially reduce the backlog. Some forests in the bio-region used partnerships to get this work done; these efforts haven't been enough to make a very big dent in the backlog (Chapter 9, WIKI).

Communities who depend on visitor income to support their economy are therefore also dependent on the Forest Service maintaining a high quality of recreational experience so that people continue to visit. There are new and different opportunities for communities to partner with the agency to fund and maintain facilities and create new recreational experiences. These include community-based stewardships, volunteerism and special uses. Such partnerships can help to provide the types of recreational opportunities desired where current Forest Service budgets alone would not be enough to develop the opportunities the public wants (Chapter 9, WIKI).

Community-based stewardship and public land volunteerism is on the rise nationally. New organizations and communication tools are helping to increase involvement from new and different groups. Volunteers are crucial as they get work done on national forest trails, which the agency lacks the resources to accomplish. The 2012 Volunteers and Partners Accomplishment Report for the Pacific Southwest Region showed 467,448 accumulated volunteer hours overall, with approximately 70% of the hours within the recreation management functional area. At $21.79 per hour, the appraised value for recreation management was $7,167,051, a significant contribution to the sustainability of recreation and tourism in the bio-region. This creates a situation where the Forest Service can find high-quality volunteer experiences for visitors to national forests and achieve recreation management goals that may not be possible given budget limitations (Chapter 9, WIKI).

Special uses are another way that that the Forest Service may be able to meet increased demand for existing and new recreational opportunities. The majority of the special use facilities in the bio-region are privately owned. The condition of these sites varies depending on type, location, and the ability of the entity operator to maintain the site. Typical federal facilities include campgrounds that are maintained

through special use permits with private operators. These facilities vary considerably in their condition depending on their age, type, location and the level of revenue generated which can be reinvested (Chapter 9, WIKI).

There are about 900 possible types of special uses in the national forests, and about 100 are related to recreation. A majority of the commercial recreation special uses represent public and private partnerships. These recreation opportunities are made possible largely through private investment in facilities and infrastructure where appropriated dollars would be insufficient. However, because these opportunities are provided by commercial service providers, their supply and delivery is subject to the variation and demand of the market and the economy. The Forest Service helps these providers be successful by requiring sound business plans and assurance of financial and technical ability when the permit is issued, and then periodically as needed (Chapter 9, WIKI).

Special uses are important resources within the bio-region because they provide recreation opportunities and access to the National Forests to a variety of people. They also support communities because they generate jobs. These are significant contributions: federal revenues to the treasury derived from special uses in the region approach $20 million annually. Some of the uses within the bio-region serve large numbers of visitors. For example, ski areas see anywhere from 60,000 to 1.1 million visitors each year. Others, such as organizational camps, provide environmental learning and physical activities for young people that are critical to establishing healthy lifestyles and habits. Uncertainty associated with the economy, as well as environmental concerns surrounding the impacts of special use activities limit the ability to forecast to what extent expansion of special uses will alleviate issues associated with Forest Service budget limitations (Chapter 9, WIKI).

2004 Sierra Nevada Framework

Recreation management was not one of the key problem areas addressed in the 2004 Framework. However, the decision reaffirms that providing recreation opportunities is one of the Forest Service's major missions in California, along with providing sustainable, healthy ecosystems.

The introduction to the 2004 Framework addressed wilderness and Wild and Scenic Rivers. The 2004 Framework stated that wilderness is a unique and vital resource. It retains its primeval character and influence, without permanent improvements or human habitation. Natural conditions are protected and preserved. Fire is restored as a natural process through managing wildfires for resource management objectives. The area generally appears to have been affected primarily by the forces of nature, with the imprint of humanity's work substantially unnoticeable. The Sierra Nevada offers outstanding opportunities for solitude, or a primitive and unconfined type of recreation. Human influence does not impede or interfere with natural succession in the ecosystems.

The outstandingly remarkable values for which Wild and Scenic Rivers have been established, are candidates for designation, or are under study, are protected and preserved for the benefit and enjoyment of present and future generations. Free-flowing conditions of wild and scenic rivers, candidate or study rivers, are preserved. Human influence may be evident, but does not interfere with, or impede the natural succession of river ecosystems.

The standards and guidelines call for mitigation of impacts from recreation to protect spotted owl and Northern goshawk nest sites, and fisher and marten dens.

Lands are classified into two types of sensitivity to air quality to protect human health and natural resources. Class I lands have more stringent requirements for air quality. Class I lands are on wilderness or national park lands over 5,000 acres in size. The other classification is for areas with air pollution levels exceeding regulatory guidelines.

Each forest in the Sierra Nevada has completed a motorized travel management decision to implement the provisions of the 2005 Travel Management Rule (36 CFR Part 212, Subpart B). These decisions prohibited motor vehicle travel off designated National Forest Transportation System (NFTS) roads and motorized trails by the public except as allowed by permit or other authorization (excluding snowmobile use). They added unauthorized routes to the NFTS after careful study of which unauthorized routes made sense to adopt; made changes to existing NFTS roads including season of use and vehicle class changes; and road openings and closures were identified.

Since the 2004 Framework did not address recreation as one of the key problems, the decision had little direction related to this theme and current direction exists in the forest plans. Original forest plans include direction for recreation future conditions, management prescriptions and standard and guidelines. Estimates of recreation levels are included and monitoring and evaluation requirements are spelled out.

These plans used the Recreation Opportunity Spectrum (ROS) to characterize recreation management; and visual quality is measured using visual quality objectives (VQO's). They addressed a full spectrum of recreation from wilderness and wild and scenic rivers, to dispersed, non-motorized, dispersed motorized and developed sites. The management prescriptions included direction on where certain recreational uses were emphasized, and direction on where other uses are not allowed.

These original forest plans have not always been amended to be consistent with new information and current policy direction. One example is that the Forest Service now measures visual quality with the Scenery Management System (SMS) rather than the Visual Quality Objectives (VQO) system.

ECOLOGICAL INTEGRITY

What are we trying to sustain at the bio-regional level?

1. **Biological diversity**
2. **Ecosystem resilience**
3. **Benefits to people**

Weaving it Together

The Sierra Nevada bio-region contains a rich diversity of ecosystems. Fifty percent of California's plant species occur here, and 60% of California's animal species live here. While it varies across ecosystems in the Sierra Nevada, many landscapes, plants, animals, and fire patterns have been drastically altered by human management over the last 150 years.

In fire-prone ecosystems like those in the Sierra Nevada, forest resilience to intense fires is very important. These fires release huge amounts of carbon rapidly into the air. In a large portion of the bio-

region, increases in tree biomass are significantly more than the amount removed by decomposition, fire, or thinning. This leads to more likelihood of high intensity crown fires. Prescribed fire and mechanical thinning can greatly offset emissions from these types of fires.

Uniformity in forest structure, along with the absence of low to moderate intensity fire, has resulted in a vast reduction in forest complexity. This complexity is important for specific habitats that support a variety of species. Habitat connectivity is essential for the movement of species throughout the landscape and should be considered at the bio-region scale. Trends in fire across the bio-region affect connectivity for wide ranging species of concern.

Sierra Nevada ecosystems produce approximately $2.2 billion worth in commodities and services annually. Management of ecosystems has not kept pace with changes in climate, fire, and sustaining the needs of people. Disruption of ecological integrity and ecosystem functions threatens sustainability of the benefits that healthy ecosystems provide, such as wood products, energy, recreation, clean air, and clean water. The removal of Native Americans from the landscape has influenced and continues to influence ecological integrity in the Sierra Nevada. Resource management by Native Americans was long-term and widespread, producing ecological and evolutionary consequences on the landscape. Water is the most valuable commodity in the bio-region, though locally, other resource sectors involve many more employees and have greater visibility in the local economies.

Ecological integrity is closely tied to the scenery of the Sierra Nevada. People develop emotional and symbolic connections to the scenery and they come to expect quality recreation experiences. There will be continued losses in scenery will continue if pace is not able to be kept with restoration needs. More people in the area are expected to increase pressure on utility lines, impoundments, and alternative-energy infrastructure. This could affect ecological integrity and the scenery within the bio-region.

Restoration of ecological integrity can benefit communities by providing young people with educational and skill-building opportunities through work and training programs. It also provides opportunities for bringing stakeholders together, establishing trust, and creating long-term partnerships. With increasing diversity in California, it will be important to find effective ways to engage a wide and diverse audience in landscape-scale restoration efforts. Only through ecological resilience can forest and water ecosystems support plants and animals, and the services that benefit people such as water, recreation, fire resilience, and carbon regulation.

Biological Diversity

The suite and distribution of living things makes up biological diversity. Ecological integrity measures sustainability of biodiversity, non-living components, like air, soil and water, and the linkages or processes, like carbon cycling or fire, which tie ecosystems together. Characterizing biological diversity and ecological integrity is like painting a landscape; every artist paints the landscape differently. "Broad brush" or coarse-filter view of habitat or major processes, such as fire, or "fine-filter" view of individual species or habitat elements such as large trees or snags, can be applied. Both are done here, with an emphasis on those that are important across large areas or are common across the bio-region.

Thousands of plant, animal, and fungi species live in the bio-region. They are not all known. It is difficult to inventory, monitor and manage for individual species. Some species have gone extinct in the bio-region -- the grizzly bear for one -- and others are at risk of extinction. The Endangered Species Act determines management of these species. For the thousands of other species, managing the ecosystems

they occur in is important. Coarse filter measures of ecological integrity and biological diversity are key ways to do this. Natural range of variability, ecological processes such as fire, vegetation succession, and carbon cycling, and landscape connectivity are coarse-filter measures.

Natural Range of Variability

Under the 2012 Planning Rule, "natural range of variability" is a key means for gauging ecological integrity. Ecosystem sustainability is more likely if ecosystems are within the bounds of natural variation, rather than targeting fixed conditions from some point in the past (Wiens et al. 2012). Safford et al. (2013a) compiled comprehensive, scientific literature reviews on natural range of variability. Summaries are shown below, incorporating selected other scientific references including inventory and monitoring reports.

The foothill ecological zone occurs at the lowest elevations and is comprised of chaparral, blue oak savannahs, live oak woodlands and forests, narrow riparian stringers along rivers and streams, seeps, and scattered gray pine or occasional patches of knobcone pine (Barbour et al. 2007). Overall, the vegetation and fire patterns in this zone are outside of the range of variability (Estes 2013, Merriam 2013, and Sawyer 2013). The foothill zone is among the most altered, and fragmented from urbanization and agriculture, and lies mostly below the western boundaries of national forests (Sierra Conservancy 2011). Vegetation is mostly out of the natural range of variability as a result of persistent non-native species, urbanization, water development, changed fire regime, and agricultural uses.

Ponderosa pine, black oak, mixed conifer, riparian forests, chaparral and meadows comprise the vegetation mosaic in the west-side montane zone (Fites-Kaufman et al. 2007). Composition, structure, and fire regimes here have changed considerably since pre-settlement times, and are largely outside the natural range of variability (Safford 2013b, Merriam 2013). Pines and oaks have decreased substantially and shade tolerant species, such as cedar and fir, have increased. Forest density is higher, canopy cover of trees more uniformly higher, small and medium tree density is higher and large tree density is lower. Within stand variation in tree size and density has decreased. Climate has been wetter, with fewer droughts in the late 19th and 20th centuries than in earlier periods (Safford 2013b). This means that pre-settlement forest conditions may not reflect what will be resilient forests in the near future, given projected drying and warming climate. Fires are less frequent, but there is evidence that they are larger, or more severe than they were pre-settlement.

Changes in fire have contributed to contractions of interspersed chaparral patches (Estes 2013a), and black oak patches and trees (Merriam 2013). Overall resilience of the forests to drought and fire has changed considerably (Safford 2013b). Increases in chaparral and hardwood vegetation will most likely occur at lower reaches of the zone. The forest zone gets pushed up, compared to where it could grow (Sugihara, personal communication 2013). The Giant Sequoia National Monument, and the Tahoe, Stanislaus, Sierra and Sequoia National Forests are particularly vulnerable to climate change, because wetter areas they depend on are expected to shrink (York et al. 2013 and Giant Sequoia National Monument Plan).

Red fir forests, Jeffrey pine woodlands, lodgepole pine forests, meadows, alder patches, herbaceous patches and chaparral create a diverse mosaic in the upper montane ecological zone (Fites-Kaufman et al. 2007). Red fir forests are both within and without the natural range of variability (Meyer 2013a) and are among the most vulnerable to climate change (NPS 2013, TACCIMO 2013). Structure has shifted with

homogenization at stand and landscape scales, increases in small and medium trees, and decreases in large trees. Fire return intervals have lengthened, but total area burned has increased since 1984. Recent increases in mortality associated with moisture stress, insects and pathogens suggest that they may move outside the natural range of variability soon. Meadows and riparian communities are both within and outside of the natural range of variability (NRV), and very little scientific information on NRV for meadows exists (Gross and Coppoletta 2013). Early extensive grazing prior to 1930 was intense and concentrated in meadows. This, along with other land uses, caused a large number of incised stream channels, reducing small flood events and wetland species. Species composition has also shifted outside of NRV where non-native invasive species have been introduced, such as dandelion. Current livestock grazing levels are considerably lower, and overall biomass of most meadows is within NRV. Meadows are vulnerable to climate change (Hopkinson et al. 2013). There is limited scientific information on NRV of chaparral in upper montane landscapes (Estes 2013a and Meyer 2013). Changes in fire regime from suppression and land use have decreased shrub patches, but composition is thought to be within the NRV.

Subalpine forests are largely within the natural range of variability (Meyer 2013). There have been some shifts in structure toward higher density stands and a decrease in large diameter pines due to climate warming and logging in the 19th century. Fire return intervals have lengthened, but total area burned has increased in some types since 1984. Overall fire regimes are within NRV at this time. However, with climatic change anticipated, fire regimes are likely to increase in frequency, size of the areas burned and in severity. Increased mortality of western white pine from white pine blister rust has occurred, but otherwise mountain pine beetle outbreaks have likely not changed. There has been an upward migration of some species into alpine zones, and growth beyond the NRV, such as with bristlecone pine, is probably from increased temperatures. Subalpine forests are considered vulnerable to climate change (Eschtruth et al. 2013; TACCIMO 2013) and are projected to decrease by up to 85% or more by the end of the century.

Eastside yellow pine and mixed conifer forests are in similar condition to westside montane pine and mixed conifer forests (Safford 2013). Structure and fire regimes are outside of NRV, with denser trees, more uniform forests, and larger, higher intensity fires. While frequent fires were once common in the dry, flatter, lightening prone landscapes east of the Sierra Nevada and southern Cascades, they were not usually so uniformly intense. Plant composition has changed, but most species are still present.

Pinyon-Juniper woodlands and sagebrush are prevalent across the eastern portion of the bio-region, dominating where it is driest (Slayton 2013a, b). Some aspects of these types are in the natural range of variability and others are far outside of it. Research on some aspects is extensive, for instance with pinyon-juniper invasion and cheatgrass, but there are still many unknowns. Current patch structure and composition are within NRV, but landscape patterns are not. Fire regimes are partially outside of NRV, with less frequent fires in some areas, and more frequent fires where cheatgrass has invaded. Desert species are encroaching from the south. With climate change, fire will increase. Pinyon-juniper has always migrated with climate change, but fire suppression and grazing have accelerated the process, and the distribution has expanded recently.

Vegetation Dynamics and Carbon

Just like people, families and communities, forests and grasslands grow and change over time. In ecological terms, this is called “vegetation dynamics” or “succession”. One important piece of vegetation

dynamics is how carbon balances or flows through ecosystems (Chapter 4, WIKI). This is called "carbon cycling". Extracting oil to use in cars and industry, and then that oil being emitted back into to the atmosphere and eventually affecting global weather is an example of carbon cycling.

With natural ecosystems, plants and fires play important carbon cycling roles. Plants use carbon dioxide from the air in photosynthesis to build sugar and grow. When they die and break down or burn, they release carbon dioxide back into to the air. More important in fire-prone ecosystems than holding onto carbon, is the resiliency of forests to intense fires. These intense fires release vast amounts of carbon rapidly into the air.

A large portion of the bio-region, the montane pine and mixed conifer forests, are relatively productive in terms of vegetation growth, but because they are dry, decomposition is slow. In other words, dead plant material continues to accumulate over time in the absence of fire (Stephens et al. 2012). Re-measurement of permanent Forest Inventory Analysis (FIA) plots show consistent increase in tree biomass that exceeds removal from decomposition, fire, or thinning by a significant margin (Chapter 3, WIKI; USFS 2012d; Fried personal communication). This results in increasing fuels for fire and the likelihood of high intensity crown fires (Stephens et al. 2012) and the likelihood of widespread insect outbreak (Sierra Nevada Conservancy 2012a) beyond natural range of variability levels (Chapter 3, WIKI).

Fire has played an important role as an ecosystem process in "regulating" forest structure and density (Collins and Skinner 2013). Previously, the focus was on sequestration of carbon from younger, fast growing trees. Newer studies show old forests and large trees continue to sequester carbon and store more carbon than younger stands (North 2013). The concept of carbon carrying capacity (Keith et al. 2009) emphasizes carbon stability, and is particularly relevant in dry, fire prone forests, such as in the bio-region. Historical forests may have been less dense, but they stored more carbon in the higher numbers of large trees (North 2013).

Offsetting reduced future wildfire carbon emissions from mechanical and fire treatments has been debated in the relative tradeoffs (North 2013). These are based largely on uncertainties with smoke emissions (Bytnerowicz et al. 2013) and carbon cycling estimates (Springsteen et al. 2011). Recent research in areas treated for fuel reduction with prescribed fire, thinning, or biomass show that there is a significant offset in potential emissions from high intensity wildfires (Springsteen et al. 2011). These offsets last at least 8 years (Vaillant et al. 2013). This confirms findings from more localized areas (Hurteau and North 2010) and other areas (Boerner et al. 2008, Hurteau et al. 2011). With less intensive treatment, the recovery is faster (Vaillant et al. 2013).

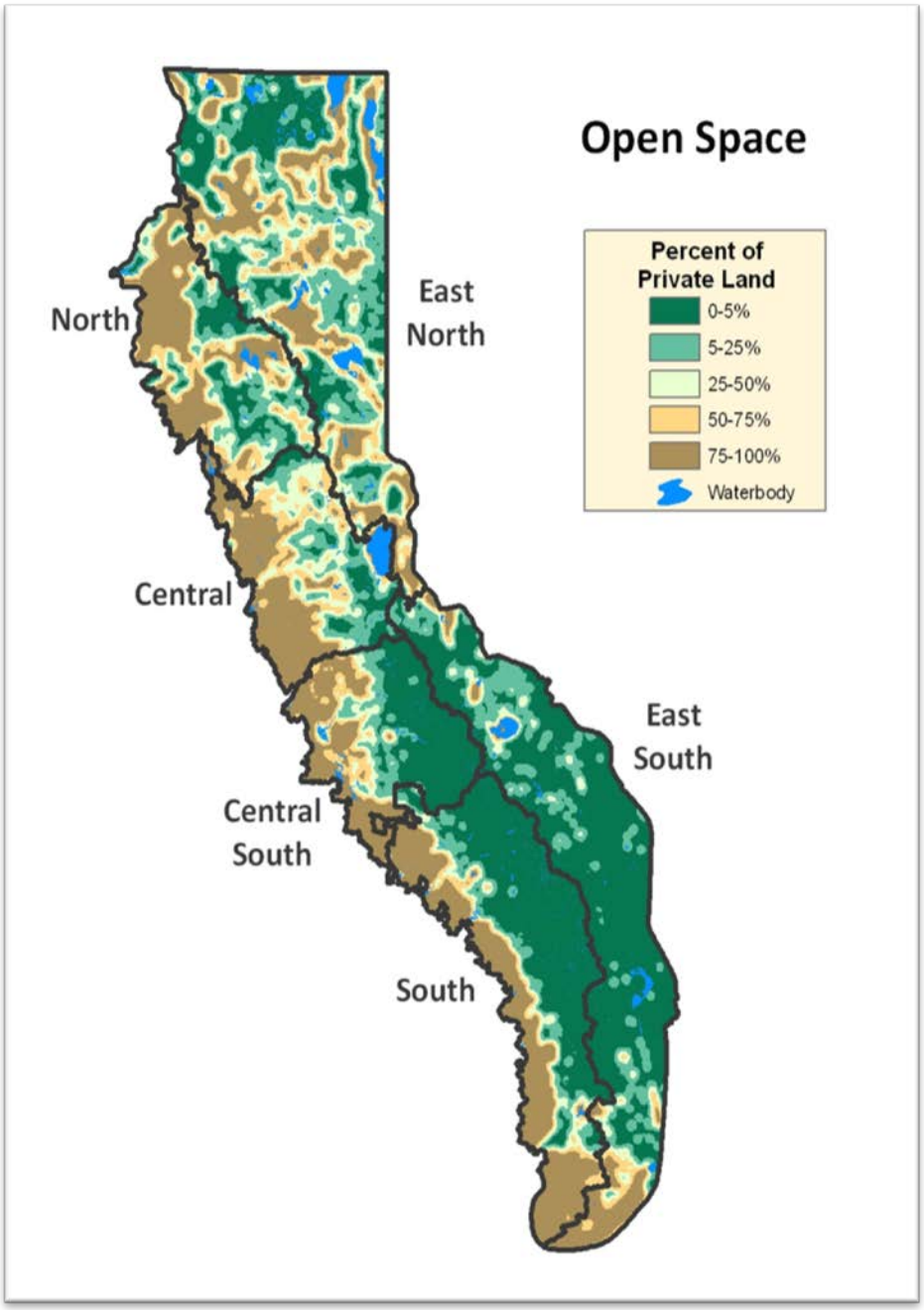
Rate of vegetation change and carbon dynamics are important considerations with restoration. Rate of vegetation response can yield positive and negative ecological integrity outcomes. Vaillant et al. (2013) found that understory shrub cover recovered within 5 to 8 years of both burning and thinning in monitoring plots. This is important habitat for many birds and small mammals. In turn, these smaller animals are important prey, which are often species of concern, including owls and goshawks. But tree seedlings also rapidly recover and the cycle of increased forest density goes on. Thinning may not sufficiently reduce surface or ground fuels to change fire intensity to desired levels, (Vaillant et al. 2013) and prescribed fire as follow up treatment may be needed.

The Importance of Connectivity

Connectedness of un-urbanized land (open space), species habitat, and ecological processes are important to biodiversity and ecological integrity (Lindenmayer and Fisher 2006). Connectivity is particularly important to consider at the bio-regional scale (Chapter 1, WIKI). Movement across all lands and different forest administrative units is difficult to consider one small area at a time.

Density and distribution of open space provides a broad picture of areas serving as habitat and movement corridors for individual species. Land where the focus is on resource management and conservation including county, state, and federal governments, land trusts, and conservation easements on private land are more likely to provide "open space" and connectivity for species and habitats, particularly species at risk. Urban areas do not.

On the following map, "open space" was assessed by creating a picture of the density of urbanized areas and private land where management was uncertain into the future. On this map, these areas are depicted as broad zones w with different concentrations, or percent of area, of open spaces and other lands. Broad categories of <5%, 5 to 25%, 25 to 50%, 50 to 75%, and more than 75% private land were mapped. The assessment area is subdivided into six different geographic areas that depict differences in climate and dominant vegetation. On the western half, to the west of the mountain crest, are four geographic areas. The northern geographic area includes the southern Cascade Mountains and areas to the west, encompassing the western one-third of the Lassen National Forest and Plumas National Forests, and Lassen National Park. The central geographic area includes the western half of the Tahoe National Forest and the entire Eldorado National Forest and adjacent private lands. The Stanislaus National Forest, Yosemite National Park and foothill areas to the east make up the central south geographic area. The south geographic area is comprised of the Sierra and Sequoia National Forests, Sequoia & Kings Canyon National Park, and private foothill lands to the west. To the east of the crest, there are two geographic areas. South of Lake Tahoe is the southeastern geographic area, encompassing the Inyo National Forest, the westernmost portion of the Toiyabe National Forest, and intervening Bureau of Land Management lands, and private lands. The entire Modoc plateau including the Modoc National Forest, and extensive Bureau of Land Management and private lands, the eastern two-thirds of the Lassen National Forest, and the eastern half of the Plumas and Tahoe National Forests comprise the northeastern geographic area.



Open spaces in the bio-region

The foothills are the most urbanized and have the least potential for open space, most with ›75% private land. Beyond the foothills, open space is more continuous in the southern and central portions, with ‹5% private land, than the northern portions of the bio-region. To the west of Lake Tahoe and north, there are alternating large areas with ›75% private with other areas of ‹25% private land. Large areas on the Eldorado and Tahoe National forests have extensive "checkerboard" lands, with 50% private land, a legacy from railroad land grants. Not all private land is urbanized, and many areas provide for habitat and movement of at least some species.

Some of the foothill private lands are used for ranching, above the foothills for forest management. These private lands can provide benefits of "working" landscapes with connectivity for a wide variety of species, if not all. Recent reintroduction of fisher onto the private timber lands of Sierra Pacific Industry is an example where focused attention on biodiversity and commercial timber objectives can provide for connectivity. Previously, fisher was absent from its former range in the northern Sierra Nevada and southern Cascades, but in the reintroduction area they are expanding and successfully breeding. Time will tell the final outcome.

Intermixed, private land and the roads that go with and between them have impacted species, such as deer, that move seasonally across the same large areas every year. Roads provide important services to society; however, their presence can also negatively influence the movement of species, hydrology, geomorphology, and ecosystem processes on National Forest System lands. There are numerous articles in the peer reviewed literature describing the impacts of roads on the landscape (Chapter 11, WIKI). A significant number of deer are killed along roads, (Romin et al. 1996) and others limited in movement or foraging habitat by fences, houses, or pets. Areas that have a lower proportion of open space have greater and sometimes severe connectivity issues for migrating species like deer.

The ability for species to move throughout a landscape is important for overall population viability and integrity. When local populations become isolated, they also become genetically isolated. They then tend to lose the genetic variability that lets them respond successfully to changes such as a new disease, a change in habitat, or climate change. Connectivity depends on habitat needs and life history of each individual species. It is not practical to look at connectivity for all species, and so for this assessment, the focus was on three aspects of connectivity related to habitat types or groups of species of concern: sagebrush (sage grouse), old forest (California spotted owl, and fisher), early seral vegetation (songbirds and some woodpeckers). In particular, the role of fire patterns in affecting connectivity of these habitats and the species associated with them.

Sage grouse lives in sagebrush habitat, with riparian areas in proximity. Locations in California are restricted to several in the southeast, on the Inyo National Forest and adjacent BLM lands, and in the far northeast, on the Modoc Plateau (Chapter 1, WIKI). Expansion of the non-native, invasive cheatgrass is reducing and fragmenting habitat. Although fire is a natural component of the sagebrush ecosystem, more recently, it can also result in more rapid invasion of cheatgrass.

Forests with large, older trees have been greatly reduced and fragmented since the 1800s from mining, logging, and more recently large, high intensity fires (Chapter 1 and 3, WIKI; Franklin and Fites-Kaufman 1996). A number of species prefer large, and especially live old or dead trees for nesting, denning, resting, or roosting. California spotted owls, goshawks, fisher, and pine marten are notable animals that have been the focus of concern and management for decades in the bio-region (Keane 2013; Zielinski 2013; Chapter 1, WIKI).

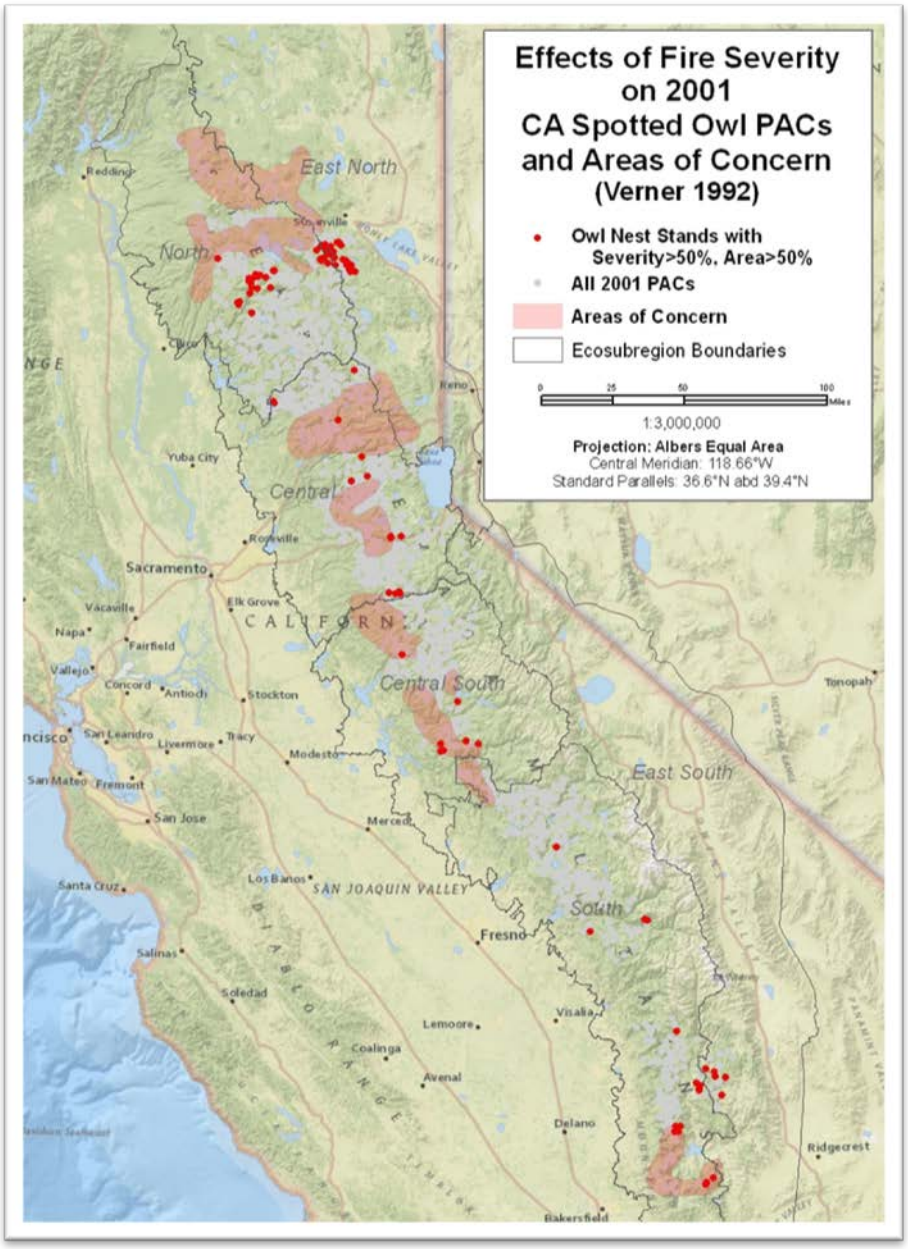
Overall forest cover is generally intact across much of the bio-region (Franklin and Fites-Kaufman 1996), but typically more uniform in density and size (North 2012; Chapter 1, WIKI). There are far fewer blocks of forest with old forest and very limited and shrinking forests with fine-scale mosaics of openings that support sun-loving plants and the animals that live or eat there.

The distribution of fisher has contracted to half of what it was, limited to the southern Sierra Nevada (Zielinski 2013). It is not known why they do not re-establish to the north. Large, high intensity fires

threaten to set back large areas of older or mature forest to early seral, fragmenting habitat in one year. Similarly, California spotted owl and goshawk are threatened by large, high severity fires.

Gradual, but steady population declines of California spotted owl over the past 20 years have been observed (Keane 2013). Although the distribution of the spotted owl is still intact, there have been concerns raised since 1992 about areas where there are low numbers of owls, high fragmentation from past, large, high intensity fires, or mixed ownership with less certainty of owl habitat management. These were called "areas of concern" in a comprehensive scientific report in 1992 (Verner et al. 1992). Both spotted owl and goshawk nest sites have widely varying levels of suitable habitat. Some areas have numerous nest sites with limited quality habitat, and other concentrated areas have had tens of nest sites impacted by extensive, high intensity fires. Although some low to moderate severity fire has little to no effect or is beneficial, fires that are high severity across much of the nest stands can impede breeding and survival.

The following map shows the areas of concern as polygons shaded light red and the owl nest sites with red dots that have had more than 50% of an area (half mile radius) round the nest site burned with more than 50% loss of overstory tree cover. The legend includes the abbreviation "PAC". This stands for "protected activity centers", which are stands of approximately 300 acres delineated around the most actively used nest trees, where the best nesting habitat occurs. There are seven areas of concern, widely spaced throughout the assessment area. There are three large areas of concern, encompassing 100s of thousands of acres in broad swaths (east to west) on the Eldorado, Tahoe, Plumas and Lassen National Forest vicinities where large portions (>50%) of private land occur. In central portion of the bio-region, on the Stanislaus and Sierra National forests, there are areas of concern that are smaller, but still in excess of 50,000 acres, running along the lower western slopes of the forests and adjacent private lands where there were large, high severity fires (i.e. Stanislaus Fire Complex from 1987) that disrupted habitat, and large areas of wildland urban intermix. In the southern Sierra Nevada on the Sequoia National Forest, large high fires and extensive logging created areas of concern in the tens of thousands of acres. There are over 30 owl sites that have been impacted by high severity fire in the last 15 years on the Plumas and Lassen National Forests as shown on the map. These are clustered just below the largest area of concern in the assessment area. All of the other national forests have had at least 2 and many 3 or more owl sites impacted similarly. Most of these other burned owl sites occur within or directly adjacent to the areas of concern.



Map of fire severity effects and areas of concerns

There has been a disproportionately high concentration of owl nest sites impacted by high severity fire in the north in the past decade, primarily from several large fires that burned under very hot, dry and often windy conditions in steep terrain. Some birds respond favorably to these fires; however, many distributed, smaller large severity patches would provide better connectivity across the bio-region, than several large, high severity patches in limited areas. A few high severity fires do not contribute as much to connectivity for early seral species, and are detrimental to connectivity for late seral forest species.

Fragmentation or breaks in connectivity from large, high severity fire, urbanization, and invasive plants all affect the ability of species to shift in response to climate change. Shifts in some animals have already

been documented, for example mice in Yosemite National Park (Yang et al. 2011). Upward or northward migration of species may be constrained by developed land, particularly in the foothills and northern part of the bio-region. As the Chief of the Forest Service described in a January 2010 speech, in order to restore and maintain ecological integrity, the work needs to happen at a scale that takes an "all-lands approach," bringing together landowners and stakeholders across boundaries to decide on common goals for the landscapes they share.

Amenity migration, which has been a driver in attracting people to the Sierra Nevada, can result in shifting ownership values on private lands from economic generation and family tradition to amenity and investment values (Ferranto et al. 2011). In the fast-growing foothills and high elevation meadows that adjoin urbanizing areas in the Sierra Nevada, agricultural and ranching lands have had pressure to convert to other uses, including residential development (Sierra Nevada Conservancy 2011a). Amenity migration in the Sierra Nevada has also led to an expansion of human settlements into higher elevations, which may affect ecosystems in ways not seen before (Loeffler and Steinicke 2006). According to the 1996 SNEP Report "by 2040, almost 20% of Sierra Nevada private forests and rangelands could be affected by projected development" (Patterson 2013, p.3). Increasing populations and urbanization near the forests in the bio-region is expected to lead to increased pressure for urban infrastructure such as utility lines, impoundments, alternative energy infrastructure , like wind energy, which could affect ecological integrity and associated scenery that provide the backdrop for recreation activities.

People are a major conduit for seed movement, and the number of non-native weeds found in California has increased with population growth (California Department of Forestry and Fire Protection 2010). National forest recreation can impact the spread of invasive species, for example, through the movement of firewood and through recreation activities and equipment, resulting in economic and public health impacts (Winter et al. 2013a, p.10).

Fine-filter: Species and Key Habitat Elements

The Sierra Nevada bio-region contains a rich diversity of species due to a diverse climate, topography, geologic history, and closeness to several regional floras (Minnich 2007). To the north, the Great Basin, Cascade Range and Klamath Mountains influence ecosystems. The Great Valley of California lies to the west, and the Great Basin and Mojave Desert lie to the east within the bio-regional analysis area. To the south are the mountains of southern California. About half of California's 7,000 plant species occur in the Sierra Nevada. Four hundred occur *only* here. Similarly, 60% of the state's animals occur here (Graber 1996), about 70 species (Sierra Nevada Conservancy 2012c).

Snags and large trees are highly variable in the landscape. Overall, large tree density and extent vastly is lower compared to historic conditions, particularly for foothill and montane pine and mixed conifer forests. Recent, large high severity fires further reduced large trees, and often trees more than 200 years old. It will take many years to replace these trees. Recent concentrations of these fires on the Plumas and Lassen National Forests have resulted in large areas that had few large trees to begin with and now have only scattered remaining large trees. Large tree mortality and vigor have been reported, particularly in the southern Sierra Nevada, attributed to increased forest density, ozone, and climate change (Van Mantgem and Stephenson 2007).

In unburned forests, large snags tend to be low density, and smaller snags can be higher density. In burned forests, there may be extensive areas of snags of all sizes in concentrations not typical of the

natural range of variability (Safford 2013b). The latter pattern is most prevalent in montane pine and mixed conifer forests, but more uncommon and uncertain relative to the natural range of variability in upper montane forests (Meyer 2013a).

Information on the occurrence and extent of specific habitats is limited, and the ecological condition is more uncertain for them than for common forest types. It is important to look at them because they often serve as "hotspots" for uncommon, rare, or diverse species. Similarly, understory herbs and grasses often occur in patches at a fine-scale that is not mapped, such as forested openings or rock outcrops. These elements of biodiversity will be covered in more detail at the individual forest scale during the forest plan revision process, where it is possible to distinguish and describe them adequately.

Aspen groves provide key habitat for a number of animal species, and are associated with numerous plants. They are highly fragmented. Other special habitats, including Bristlecone pine and giant sequoia illustrate the very limited distribution of these unique and well-loved plant communities. Recently burned patches can attract and support many species, in particular birds. The pattern of recently burned areas is vastly different in montane forests than the evidence from NRV indicates (Safford 2013). The patches are larger across continuous areas but vastly decreased as smaller patches, particularly within-stand scale (North 2012).

This uniformity, along with absence of low to moderate intensity fire, has resulted in a vast reduction in fine-scale forest complexity (Chapters 1 and 3, WIKI). Small, sunny openings, favored by some plants, are relatively rare. Areas cleared of dense, deep leaf and needle litter are uncommon, impeding germination of some types of plants. Shrubs and herbs that need sun or fire to flower or develop vigorous foliage are scraggly or decadent. As a result, understory animals, such as rodents and songbirds that depend on these plants, are decreased. The trend for homogenization and lack of fire to invigorate understory plants will continue. On the other hand, the trend is for larger patches of uniform, early aged, or early seral vegetation to develop after fire. This can be good for the plants and animals in these habitats. The patches are often very large, however, compared to historic patterns, and are widely distributed, limiting movement of species between them, or "connectivity".

A substantial proportion of key landscape areas of aquatic conservation concern, critical habitat for yellow-legged frogs and old forest mosaics (Franklin and Fites-Kaufman 1996) also have low fire resiliency. These are areas where concentrations of uncommon, ecologically important species and habitats are in otherwise good ecological condition.

Ecosystem Resilience

The ability of ecosystems to "absorb" or "bounce back" from sudden changes, for example large, intense fire, or long-term trends such as population growth or climate change, and still function with ecological integrity is called "resilience".

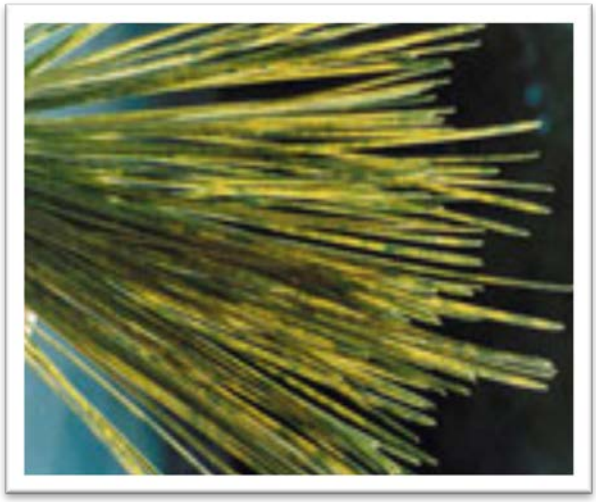
Air Quality

The major pollutants causing ecological harm in the Sierra Nevada are ozone, which can be toxic to plants, and nitrogen deposition, which can induce undesirable effects on terrestrial and aquatic ecosystems (Bytnerowicz et al. 2013; Chapter 2, WIKI). Other airborne pollutants of concern are black carbon, particulate matter, pesticides, and heavy metals. Direct effects are hard to determine until they reach chronic levels. More critical are synergistic effects, and interaction with other stressors, such as

drought or invasive species, in influencing ecological integrity. This is more difficult to assess, but important to understand before thresholds are crossed and ecosystem conditions cannot be readily restored. Ozone and nitrogen deposition interact with other environmental stressors, especially drought and climate change, to predispose forests to impacts of pests and diseases.

Ecosystem critical load is defined as a concentration of air pollutants or total deposition of pollutants above which specific negative effects may occur. Critical loads are based on ecosystem responses rather than regulatory guidelines (Pardo et al. 2011). Critical loads for nitrogen established by Fenn et al. (2010) are exceeded in many places in the Sierra Nevada bio-region. In addition, a California Energy Commission report examined nitrogen deposition ecosystem impacts for 48 different ecosystems in California. Both the report and scientific investigations concluded that nitrogen deposition threatens many ecosystems across the state, including in the bio-region. Specific impacts include increased invasive plants, altered lichen communities, and altered mountain lake chemistry (Fen et al. 2010, Weiss 2006).

Ozone can directly damage leaves and needles of plants. Pines are particularly sensitive (Bytnerowicz et al. 2013). Trees and lichen are the most commonly studied plants, and damage to these has been increasing over time. In 1977, damage in the southern Sierra Nevada was approximately 20% of sample trees, doubling in 2000. In the central and northern Sierra Nevada, damage to trees is less apparent but still slight. The primary effect of ozone damage is to increase the vulnerability of the plants to stress from drought, insects and pathogens and other stressors. Increased needle turnover can occur with fewer needles on the trees to generate carbohydrates, the energy source for trees. More needle drop to the ground can increase fuels and fire hazard.



Photos of ponderosa pine with ozone damage

The picture on the left shows a close up of a clump of ponderosa pine needles displaying heavy ozone damage. Instead of being a solid green, they have more than half of the needles replaced by mottled yellow color, indicating that chlorophyll, essential for life-sustaining photosynthesis, is damaged. The picture on the right shows damaged ponderosa pine trees in Sequoia and Kings Canyon National Park. The picture includes several ponderosa pine trees that are middle aged, with shrubby oak in the foreground. The tree on the right has a normal amount of foliage, with a bright green color to its needles. The tree on the left is missing more than half of its needles, and the needles that remain are a yellowish green. As summarized by Bytnerowicz et al. (2013), nitrogen affects plant health like ozone does, but it also affects the chemistry of lakes, other water bodies, and soil. For forests, there are effects on individual tree growth and health, as well as forest community composition, and carbon cycling. Specific effects are difficult to predict, because most of them are also influenced by other factors. Nitrogen can have a fertilizing effect, increasing above ground plant growth, but it can have negative effects on resilience to drought because of decreased root growth. Combined ozone and nitrogen can cause more rapid needle or leaf turnover, increasing surface litter levels and potential fire intensity.

Effects to streams, ground water and lakes are varied. Overall, at this time, levels of nitrogen deposition are thought to be buffered by soils and vegetation (Hunsaker et al. 2013; Bytnerowicz et al. 2013). However, "researchers have suggested that high-elevation lakes throughout the region may be experiencing eutrophication" (Fenn et al. 2003, Sickman et al. 2003). Eutrophication is when algae or other lake biota increase and use up more oxygen, reducing habitat for fish. This can be a natural process, where a lake is gradually filled in, becomes a swamp and then a meadow. However, fertilization from nitrogen may speed up this process where it would not normally occur.

Restoration Pace and Scale

The essence of ecological restoration is what is left on the land, not what is taken away. Ecological restoration embraces a revised perspective on how lands are managed in two key ways: restoring ecosystems where they have been degraded; and ensuring resilience into the future given the trends for climate, drought, and fire. Only through resilience can forest and water ecosystems provide habitat for plants and animals, the plants and animals themselves, and ecosystem services such as water, recreation, fire resilience, and carbon regulation—all important pieces of ecological integrity.

Many landscapes, distributions of plants and animals, and fire patterns have been drastically altered by human management in the last century. Some of the forests, meadows, and stream sides have been degraded. Putting out fires was a good strategy for saving individual trees, but made forests overcrowded, susceptible to large, high intensity fires and vulnerable to and drought and insects. Large trees, especially fire and drought resistant pines, were selectively harvested, which reduced habitat for some animals, plants, and fungi.

Intensive grazing in the late 1800s and early 1900s degraded meadows and resulted in streams that sunk far below natural levels, removing natural flooding that sustained water-loving plants and animals. Roads and trails were built through meadows and streams without erosion-sensitive design. Extensive water development, including diversions and dams, supported a nationally important agricultural industry and growing cities and communities in California, but at the expense of natural flooding cycles that sustained stream and riversides, and water plant and animal communities.

Invasive plants and animals rode the wave of these uses, taking advantage of the fur of livestock, or areas cleared with logging or grazing to gain entry. Once there, they expanded and invaded other areas, often dominating and displacing native plants and animals. Humans helped introduce and spread many non-native plants and animals that compete and often entirely displace native plants and animals.

Management of forests, meadows, rivers, and lakes in recent decades has been more careful and science-based, but has not kept pace with changes in climate, fire, and sustaining the needs of people. Weather is getting hotter and drier, increasing the intensity and length of fire season. Forests continue to get more overcrowded, and demands for recreation opportunities in the bio-region grow. A steadily growing presence of people has broken up the continuity of animal habitat, impeding movement of wide-ranging ones like deer, fisher, or mountain lions. Other plants and animals, with more constricted living areas, have had habitat removed all together. The rich diversity of plants and animals that draw many people to the area are considered threatened or vulnerable to stressors like climate change.

Federal and state agencies which have land management responsibilities have tried to keep up with changing ecosystem conditions and human needs. Understanding the complexities of natural ecosystems and how to balance human uses will continue to evolve, and science is always changing. The important task of sustainability for future generations is a central goal. In the past several decades, as fires have become more uniformly intense , and climate has become hotter and drier (Chapter 3, WIKI), there is a need to increase the speed (pace) and breadth (scale) of management that restores forest, (North 2013, Collins and Skinner 2013, Keane 2013, Zielinski 2013), shrub, grass, and water ecosystems (Long et al., Hunsaker et al. 2013) so that they can withstand these changes and still provide for native plants and animals, and other services ecosystems provide like water, recreation, and rural community sustenance.

Specific strategies for increasing the pace and scale of ecosystem restoration have been identified recently. Strategies for land-based (terrestrial) and water-based (aquatic) ecosystems have focused on averages or "normal" conditions. An example of this is from flood zones. Typically, zoning is focused on the average "100" year flood line. However, when the "200" year flood comes, homes are flooded and levies are ruptured. With longer, hotter fire seasons already here (Westerling 2006), and increasing early and more erratic flooding alternating with very dry years (Null and Viers 2012), this "normal" average approach is ineffective and will become more so in the future. This tendency to manage for the "normal" condition, rather than the less likely but highly impactful events is human nature (Taleb 2007). What is normal is changing for water, fire and drought, and should be considered in forest management planning.

Water is of vital importance to numerous meadow and aquatic ecosystems, and these ecosystems have been identified as among the most vulnerable to climate change (Null and Viers 2012; Chapter 1, WIKI; Hunsaker et al. 2013; Sierra Nevada Conservancy 2012b; NPS 2013). Restoration of meadow condition has been identified as a priority by the State of California for maintaining and improving future water storage under drying climates. This will also benefit many species at risk from shrinking meadow habitats with warming climates (TACCIMO 2013). In a white paper prepared by the University of California Davis for the California Energy Commission, scientific models used to regulate water storage and releases from dams and diversions changed from one based on "water year type" where climates are considered stationary, to one where changes are assumed.

For forest resiliency to fire and drought, several broad restoration strategies will be important to achieve sustainability of plant and animal habitat, as well as to the stability of carbon cycling, reducing poor air quality from large, high intensity wildfires, and ensuring the capacity to maintain forest resilience to future climate changes. First, much more extensive areas of the landscapes, especially forested need to be restored to more resilient conditions (Chapters 1 and 3, WIKI; Collins and Skinner 2013).

Currently a small fraction, less than 5%, of the landscape has had some form of treatment for restoration. This small amount has not been effective in restoring forests so that when intense fires burn through during the hottest and driest, or windiest weather, habitat and ecological integrity is maintained. While strategically placed fuel treatment zones reduce fire intensity and spread, and improve effectiveness of firefighting, they only affect a small part of the landscape. Reduction of forest density and increasing forest patchiness or "heterogeneity" across more of the landscape in the lower and middle elevations will be needed to effectively change fire intensity and tree kill to levels that provide for ecological integrity. Fire prediction models do not account for the more extreme, explosive fires that are becoming more common (Brown et al. 2004, Westerling et al. 2006, Westerling and Bryant 2008). One tool is currently in development by Westerling and others as part of a USDA research grant. It links the probability of very large, very severe fires with changing climate and proportion of the landscape in fire resilient states (condition classes – Barrett et al. 2010) (Westerling, personal communication).

Although the landscape nature of fires and wildlife habitat connectivity have long been recognized in national forest and other land management plans in the bio-region, they often have great detail on individual species sites, or forest stand characteristics over the short-term in guiding management. Lack of focus on the big picture over the landscape limits the ability to reach sustainability goals. One approach currently in progress, are landscape "adaptive management" projects (USFS 2010b, 2011). There are proposals to spread these across more large landscapes (Aplet and Gallo 2013). The scope of the changes needed to address changes in large fire intensity and resilience to drought will require even more extensive adaptive management, with rapid, real-time focused monitoring and adjusting. Trends in

larger, more frequent fires with early spring snowmelt are already occurring (Westerling, personal communication, in progress) and may have impacts ahead of large, formal adaptive management experiments being completed.

Working Together

As the Chief of the Forest Service described in a January 2010 speech, in order to restore and maintain ecological integrity, we need to work at a scale that takes an "all-lands approach," bringing together landowners and stakeholders across boundaries to decide on common goals for the landscapes they share. Government agencies increasingly recognize the need to work across jurisdictions to effectively restore the ecological integrity of degraded systems.

It is not always easy to collaborate, given declines in agency staffing and resources, and there can be challenges in the process. The Forest Service plans to continue to collaborate with stakeholders and find new ways to engage the public in our work and with each other. For example, Fire Learning Networks foster collaboration across organizations and administrative boundaries to develop landscape-scale restoration plans for fire-prone ecosystems. There is recognition that more and more the importance of working with tribes and incorporating Traditional Ecological Knowledge into restoration efforts. In 2006, the Forest Service and the Bureau of Land Management, in partnership with the California Indian Basket Weavers Association and the California Indian Forest and Fire Management Council, finalized a Charter and the Native Plant Gathering Policy. The policy provides traditional practitioners an opportunity to access plants and work together to provide and promote ecosystem health on the lands managed by these agencies. Our tribal partners have learned over thousands of years that sustainability is critical to their own survival. Tribes managed forest products to provide for their own livelihood, and the forests were thriving when the influx of European settlers arrived. Tribes maintained watersheds and forest stands for more than just the timber resources. Their dependency on salmon stocks, acorns, deer and other food sources were tied directly to success in their management principles.
In addition, it will be import that the voices of all parties are heard. As described in Winter et al. (2013b, p.10), "the population of the Sierra Nevada represents a small portion of the statewide population, and it is thus a numerical minority centered in a highly valued social-ecological and historical context. Statewide or regional decisions to address majority interests may adversely impact human and non-human populations and ecosystems in the Sierra Nevada, sometimes in ways that put long-term sustainability at risk. Competition for scarce ecosystem services and opportunities will remain a challenge for management of the forests in the Sierra Nevada For many, recreation and tourism in the Sierra Nevada is a way to learn about the area's many features and to develop a connection to places within it. These connections may be instrumental in efforts to reduce demand on ecosystem services delivered far downstream, such as water drawn from the Sierra Nevada to be used in southern California, or the need to manage transportation in ways that reduces the transport of pollutants into the synthesis area."

Benefits to People from Functioning Ecosystems

Despite the many benefits they provide, many ecosystems in the bio-region, the species, and their respective ecological processes are being negatively impacted by development trends, rising population, habitat fragmentation, intensification of human activity, and the effects of climate change. It has been estimated that by 2040, almost 20% of the Sierra Nevada private forests and rangelands could be affected by projected development (Duane 1996). These effects are of concern from an ecosystem services

perspective, as they have resulted in diminished, interrupted, suspended, or redirected flows of ecosystem services and the benefits that they provide to people. Successfully addressing emerging deficits in ecosystem services requires stemming decline in ecosystem service production, as well as ensuring ecosystem service use is not wasteful or needlessly impactful to the systems that provide them. As a result, the Forest Service's commitment to restoration based-management includes "commitment to a renewed focus on the sustainable delivery of ecosystem services" (USFS Region 5 2013b p.1).

When ecosystem services are interrupted or lost, the benefits to people are reduced and this affects the quality of our lives. The 1996 Sierra Nevada Ecosystem Project estimated the value of some of the ecosystem services provided in the bio-region (Stewart 1996). This estimate focused on commodity services directly tied to existing economic markets and determined that the bio-region produces approximately $2.2 billion worth of commodities and services annually. This amount would be around $3.2 billion in today's dollars. Water accounts for most of this estimate and provides tremendous value to people around the state who depend on this water daily. Other forest based commodities account for a smaller portion but the benefits are more local in nature. Most of the water value accrues to water rights holders and beneficiaries outside of the region. Although the infrastructure to hold, divert, and channel the water is very valuable, relatively little direct employment is needed locally to operate and maintain these facilities. The other resource-based sectors such as timber, grazing and recreation involve many more employees and have greater visibility in the local economies.

These estimated dollar value estimates are significant, and yet comprise only a portion of the value of the ecosystem services that are provided by resources in the bio-region. Ecosystem services such as cultural heritage, sense of place, aesthetics and biodiversity contribute to improving the quality of our lives but do not have a monetary or dollar value that is easily attached to them. This does not make them any less valuable or important to us (Chapter 7, WIKI). It is clear that a loss of ecological integrity that results in a loss of these valuable services is an important consideration in maintaining the benefits people obtain from the national forests in the plan area.

Many ecosystem services are provided simultaneously by landscapes across the bio-region. As a result these landscapes provide an immense value to people both monetary and non-monetary. For example, an area that is providing wildlife habitat, rangeland for grazing and carbon sequestration may also be home to important sites that support cultural heritage, protect water quality and provide recreational opportunities. These landscapes providing the benefits of multiple services are where complementary and conflicting relationships between these services and their value will be an important consideration in the management of ecological integrity. In addition, this realization of the importance of ecological integrity across broad landscapes in providing value to people highlights the fact that conservation of these services does not stop at administrative and political boundaries. The coordinated management of ecosystem health across different agencies, as well as between public and private stakeholders, and the inclusion of this collaboration up front is a critical component of forest plan revision in the bio-region.

One threat to ecological integrity is air pollution and this can have a dramatic effect on the ability of these landscapes to provide ecosystem services. The major pollutants causing ecological harm in the bio-region are ozone, which can be toxic to plants, and nitrogen deposition, which can induce undesirable effects on terrestrial and aquatic ecosystems (Byterowicz 2013). As a result, the benefits to people from these services that are dependent on functioning ecosystems are reduced through the loss of forest resources such as timber and through reductions in visitation to the area. In addition, reductions in forest health can result in reduced ecosystem function and more dead wood adds to fuels in the forests,

making areas more susceptible to fire. More details on the threat to the value of ecosystem services from fire are provided under the Fire Resilience theme.

Losing these benefits has an effect locally on quality of life, and also has impacts to economies that are dependent on forest activities, such as timber, grazing and recreation. For example, impacts of air quality currently pose threats to recreation along the western slopes of the southwestern Sierra Nevada, which experience frequent episodes of unhealthy air and haze that obstructs visibility (Cisneros et al. 2010). Any declines in visits has an impact on the local economies that rely on that visitation to support the local economy, and reduces the recreational and aesthetic opportunities available to people.

Forest-based commodities and recreational opportunities are not the only areas potentially affected by loss of ecological integrity. Ecological integrity also influences the ability of ecosystems to provide many social benefits that support the diversity of values that people and communities hold. The Sierra Nevada's history and culture have always been deeply connected to the land and its natural resources. For thousands of years, Native Americans have lived off the land, with a land ethic that included spiritual, philosophical and cultural dimensions (Anderson and Moratto 1996). They viewed humans as part of the natural system, helping to ensure abundance and diversity of plant and animal life. European settlers brought extensive changes to the landscape through mining, timber harvesting, ranching, farming, and water use, leading to long-lasting cultural views of the Sierra Nevada as a place valued for resource production (Walker and Fortmann 2003).

A shift in focus toward nature-based recreation and tourism brought new visitors to the area, including many urbanites looking for a new place to settle, away from city life. New residents brought new values to the bio-region, tied more with scenic and environmental values than with resource production (Walker and Fortmann 2003). The history of people in the Sierra Nevada not only had major impacts on the condition of the bio-region's ecosystems and their ability to recover from disturbances, such as wildfire, but also had long lasting effects on the values of individuals and communities in the region.

Healthy ecosystems help people and communities sustain diverse values and cultures. Maintaining ecological composition, structures, and functions allows for continued use of the land over the long-term for tribal uses, resource extraction, and recreation, as well as scenic beauty and existence values. However, the diversity of values also influences ecological integrity by putting more demands on forests in the bio-region. Increasing diversity occurring within and especially right outside the Sierra Nevada bio-region will add to the diversity of values and interests that already characterize visitors and residents in the Sierra Nevada and surrounding areas (Winter et al. 2013a). Increasing population growth across different parts of the bio-region and California as a whole, as well as increasing demand for outdoor recreation and raw materials, is expected to put more pressures on public lands and lead to increased conflict and competition for access (Cordell et al. 2004). People who live far away from the Sierra Nevada can also be affected by management decisions. Research shows that people living far from the Sierra Nevada hold substantial values for the region's ecosystems, and especially for their charismatic fish and wildlife (Long et al. 2013).

Recreation on national forests contributes to the physical, mental, and spiritual health of people. Quality recreation experiences are tied to people's expectations regarding the scenery and key attributes, which can be severely diminished or eliminated through subtle, incremental changes. The sustainability of scenic attributes is dependent on ecological integrity (Mattson and Mosier 2012). Visually, scenery in the bio-region appears largely intact; however, no estimates are available at this time to gauge scenic stability

at the bio-regional scale. As population growth and urbanization continues, particularly along the Sierra foothills, so too will the demand for associated infrastructure, such as utility line, cellular towers, and alternative energy exploration and development. In addition, major unplanned events like wildfire will continue to occur. These factors, along with the current pace of ecological restoration efforts are expected to result in the loss of scenic character for a substantial portion of national forest landscapes in the bio-region, affecting recreation experiences, as well as the sense of place of individuals and communities.

National forests can also provide educational and skill building opportunities through their conservation education and volunteer programs, along with training and work programs like the Youth Conservation Corps and California Conservation Corps. Efforts that help restore ecological integrity to degraded systems not only help to sustain healthy forests, but also healthy people and communities. "Ecological restoration offers an opportunity to communicate positive messages, values, and activities, while addressing ecosystem threats" (Charnley 2013, p.7). Volunteerism is growing in importance in recreation in California, which enhances both people's lives and landscapes (Roberts 2009). Themed days and special events like Coastal Cleanup, Public Lands Day, and National Trails Day increase the visibility of volunteering on public lands. New organizations and communication tools are helping to support increased involvement from new and different groups. Decreasing federal budgets will continue to affect the ability to sustain and grow volunteer, training, and work programs.

The removal of Native American management from the landscape has influenced and continues to influence Sierra Nevada forests. Resource management by Native Americans in the Sierra Nevada bio-region was long term and widespread, producing ecological and evolutionary consequences in the biota (Anderson and Moratto 1996, Blackburn and Anderson 1993). Therefore, many ecosystems in the Sierra are not self-maintaining islands that require only protection to remain in a "pristine" state. There is currently an ecological "vacuum," or disequilibrium, in the Sierra Nevada resulting from the departure of Native Americans from managing these ecosystems. The decline in biotic diversity, species extirpation and endangerment, human encroachment into fire-type plant communities like chaparral, and greatly increased risk of catastrophic fires are symptoms of this disequilibrium. Tribal communities within the Sierra Nevada present distinctive opportunities for mutually beneficial partnerships to restore ecologically and culturally significant resources, and to promote resilience.

Forest management restoration activities to improve the integrity and functioning of ecosystems not only provide benefits to people in terms of sustaining the ecosystem services discussed above, but also by contributing to the wellbeing of communities. Maintaining the local resources of capable infrastructure and workforce is necessary to the success of restoration, and also provides economic opportunities in these communities. Current policy for national forest management calls for such approaches that accomplish ecological restoration goals, while simultaneously producing forest products that can benefit local communities (USDA 2010, USFS 2007). More details on the important role of communities in forest restoration are provided under the Fire Resilience theme.

2004 Sierra Nevada Framework

Ecological integrity is not directly addressed in the current plan direction by that title. However, the 2004 Framework has many references to the preservation and restoration of ecosystems. In the Implementation section the Regional Forester states "My intention is to provide for ecological restoration of processes and enhance long-term *ecological integrity*, assure the most efficient and

appropriate use of government resources, minimize costs to holders of existing government contracts and permits, avoid disruptions to local communities, and reduce the likelihood of confusion."

COMMUNITY RESILIENCE

What are we trying to sustain at the bio-regional level?

1. **Opportunities that support the diversity of cultures and values**
2. **Connections to the land**
3. **Social interactions**
4. **Local economic opportunities from forest activities**
5. **Health, safety, education and skills**

As described in Charnley (2013, p.4):

> community wellbeing studies recognize that (1) wellbeing in forest communities was based on more than jobs and income, and included other quality of life attributes, such as health, safety, political participation, social equity, and access to social services; and (2) national forests can contribute to community wellbeing in multiple ways that include both commodities (e.g., timber, grazing, minerals, non-timber forest products) and amenities (e.g., outdoor recreation, scenic beauty, clean air and water, open space, forests and mountains) values associated with them.

Wellbeing in local forest communities depends on community capacity, or the ability to respond to internal and external stresses, create and take advantage of opportunities, and meet the needs of residents (Charnley 2013, p.4). Community capacity influences the ability of communities to prepare for and adapt to change and stressors such as wildland fire and climate change. Communities that are resilient are able to cope with, adapt to, and shape change (Charnley 2013, p.6). However, it is challenging to identify critical thresholds beyond which social systems will lose their resilience and break down (Charnley 2013, p.6).

In this section, there is discussion of aspects of national forest management in the bio-region that contribute to community wellbeing and resilience, as well as issues and trends influencing these aspects. Different types of communities are considered, including local communities within the Sierra Nevada, communities outside the Sierra Nevada that use national forests, and communities outside the Sierra Nevada bio-region that do not use national forests but benefit from them.

Weaving it Together

In the bio-region, communities are closely tied to the national forests and to the benefits that the forests provide. There are communities directly affected by what happens on the national forests, and there are communities far away which benefit from the ecosystem services provided by the forests.

Air quality is hugely important to the people who live in the Sierra Nevada. The health and welfare of residents and visitors is directly affected by smoke from fires, and by pollution from various sources.

Maintaining air quality is important to making sure the benefits to people from forest ecosystem services continue. Looking at the broad landscape is a chance to emphasize the benefits forests provide to air quality, but when the trees are at risk from intense fires, these benefits are threatened. The conundrum is between managed fires, which will benefit the landscape in the long run, and smoke which affects immediate air quality.

Many communities in and near the bio-region have very strong ties to what happens on the ground on our national forests. This is particularly true with timber, grazing and recreation activities. Communities in the bio-region are more economically vulnerable compared to California as a whole. This makes them less able to adapt when economic conditions change. Part of the work of the Forest Service and the direction from the Department of Agriculture is to support communities.

Residents of the bio-region have a connection with the land that is important to their lifestyle and heritage. Forest activities provide opportunities for jobs as well as tax revenues to local governments to pay for critical public services such as education, fire protection and transportation. Our focus on restoration can create jobs for people thereby contributing to local economies and the wellbeing of people and their families. Recreation opportunities bring visitors in which contributes to local economies and benefits everyone there, while maintaining an environment that local residents are happy in and attached to on their national forests. The forests are critical in providing tribal and cultural opportunities for residents of the bio-region. The ancient history of the tribes who live and work in the bio-region is important and extremely worthy of maintaining. Relationships between the Forest Service and the tribes have been built over time and must be fostered and used during the forest plan revision process to make sure tribal interests are given the important consideration they deserve. Forest management influences and contributes to community health, safety and labor force education and skills for the myriad of communities in the bio-region.

Opportunities that Support the Diversity of Cultures and Values

As described in Flora and Flora (2004), cultural capital includes the values and approaches to life that are passed on through generations. It is the filter through which people live their lives and how they view the world around them. It gives people their sense of identity and influences how they view the range of alternatives available to them in life. Supporting diversity in values and cultures helps people act positively toward themselves and their communities. In the Sierra Nevada, there are various ways that the Forest Service contributes to sustaining this diversity, which in turn benefits communities both inside and outside the bio-region.

Diverse Community Values

Forests across the bio-region support and influence a wide range of values and interests that communities have. This includes local residents, as well as communities outside the bio-region that directly and indirectly benefit from national forests in the Sierra Nevada. Additionally, Sierra Nevada forests are an integral part of Native American culture; traditions and values have been passed down through generations for thousands of years (McAvoy et al. 2004).

Many long-time residents in the Sierra Nevada maintain cultural ties to the traditional, resource-based economy of the region, and continue to view the local landscape as a source of production and livelihoods (Walker and Fortmann 2003). Ranchers who move their livestock seasonally have a long history in the Sierra Nevada, depend on Forest Service range, and have a strong commitment to and affection for the

lifestyle (Huntsinger et al. 2010). Management of these lands directly influences ranchers, affecting range vegetation and forage production and availability of land for range versus other uses (Huntsinger et al. 2010). Permitted livestock grazing on National Forest System land in California has decreased over the last few decades.

Timber harvest has long been an important part of the bio-region's cultural heritage and legacy. Since the late 1980s, timber harvest from national forests has steadily declined because of policy and legal constraints, restrictions on harvesting in unroaded areas, and appeals and litigation (Charnley and Long 2013, p.3). This decline led to job losses, mill closures, reduced payments in lieu of taxes to counties to fund schools and roads, and declines in Forest Service budget and staff (Charnley and Long 2013, p.9). While the majority of timber production in the Sierra Nevada now comes from private harvest, there has been increasing interest in developing new sustainable natural resource economies through restoration and biomass for energy production from public lands (Sierra Business Council 2007).

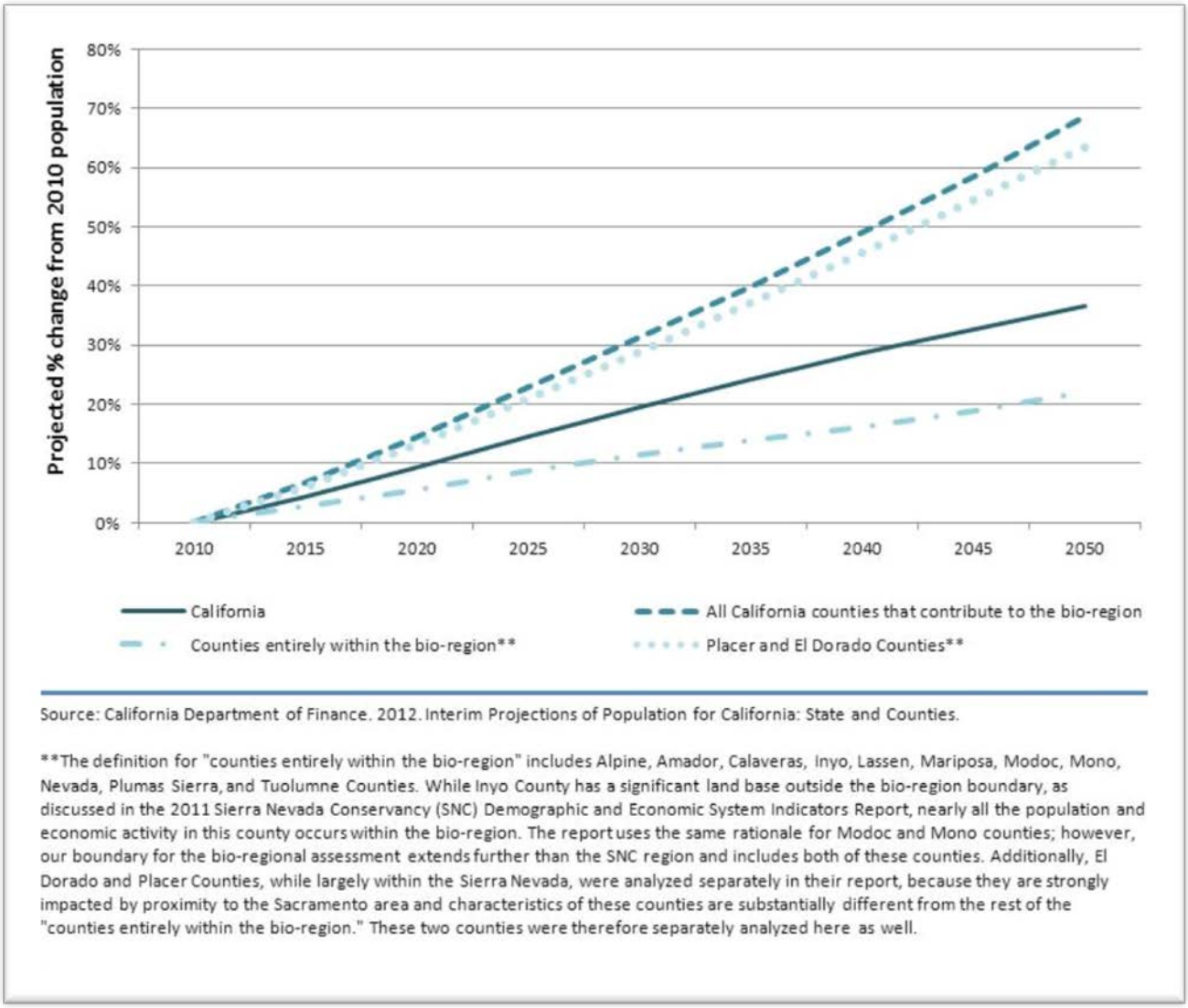
Recreation and tourism have a long history in the Sierra as well. Outdoor recreation is part of the identity of many Sierra Nevada communities, and demand for outdoor recreation opportunities continues to grow. Being outdoors is an important part of the California lifestyle in general, and national forests are part of an expansive network of local, state, and federal parks, forests, trails, and open space systems (Roberts et al. 2009).

Even beyond those who directly use national forests in the bio-region, "research has shown that people living far from the Sierra Nevada hold substantial values for the region's ecosystems and especially for their charismatic fish and wildlife (Long et al. 2013, p.12).

Management of National Forest System lands can influence community values by the opportunities provided on the land, and by contributions to environmental and aesthetic qualities of the region. The Forest Service is required to sustainably manage national forests for multiple uses and benefits. This means managing for the best combination of uses that benefit the public while ensuring productivity of the land and protecting the quality of the environment. This multiple use mandate supports a wide range of values that people and communities hold, but these uses and benefits have limits and interact with each other, and tradeoffs are necessary. Balancing across values and interests can be contentious and emotional for those involved.

While local residents in the Sierra Nevada share values around maintaining the rural and environmental qualities of the region to which National Forest System lands contribute (Sierra Business Council 1997), how people prioritize those values and how they fit in relation to other values can vary, affecting decisions and activities they choose to engage in (Jones et al. 2003). Tensions have long existed among various stakeholders, who compete for their interests regarding national forests in the Sierra Nevada. Population and settlement growth in the Sierra Nevada has largely been driven by a phenomenon known as amenity migration, referring to the movement of people from urban areas to Sierra Nevada forests for their amenity values, such as low crime, good schools, outdoor recreation opportunities, scenic beauty, and an overall improved quality of life (Loeffler and Steinicke 2007). Since the 1950s, a continuous influx of migrants from urban areas has influenced the culture of many rural and traditionally resource-based communities in the Sierra Nevada (Walker and Fortmann 2003). Newcomers are often less tied to natural resource production and more tied to scenic and rural qualities of the landscape, which can conflict with the views of long-time residents. As a result, long-time residents can feel a loss of social power and cultural identity (Walker and Fortmann 2003).

According to the Sierra Nevada Conservancy's (SNC) Demographic and Economy System Indicators Report (2011b), the twelve counties defined as lying entirely within the SNC boundary have experienced slowing population growth since 2001, and actual declines between 2007 and 2009. Between 2000 and 2006, people moving into these counties accounted for all the growth, and in 2008 and 2009, more people moved out of these counties than into them. Nevertheless, protecting scenery, outdoor recreation opportunities, and environmental quality will likely continue to encourage amenity migration in the future (Winter et al. 2013b, p.5). In addition, while major population growth for those counties defined as entirely within the Sierra Nevada is not projected over the next several decades, and growth in California overall has slowed, substantial growth is projected in many of the counties that contribute to the western boundary of the bio-region, especially around the southern end of the Sierra Nevada (Chapter 6, WIKI). This growth, along with demographic shifts, is expected to influence how people engage with national forests in the bio-region.



Projected population growth of counties within California and the bio-region from 2010 to 2050

This figure shows a line graph of population projections. The vertical y-axis displays the projected percent change in population compared to 2010 levels. The horizontal x-axis displays the year starting with 2010 on the left side and ending with 2050 on the right side. The population projection line for California increases from 0% to 37% between 2010 and 2050. Below that is the population projection line for counties entirely within the bio-region, which increases from 0% to 22% between 2010 and 2050. Above the line for California is the population projection line for all California counties that contribute to the bio-region, which is the steepest and increases from 0% to 69% from 2010 to 2050. Slightly below this line is the population projection line for Placer and El Dorado Counties, which increases from 0% to 64% between 2000 and 2010.

Increasing diversity, both in and outside the bio-region, will continue to influence community values. Though the Sierra Nevada is generally less diverse than the state as a whole, it is becoming more diverse.

According to Roberts et al. (2009), "No demographic trend is of greater importance to national forest managers and leaders than the immense growth of cultural diversity. California is home to more than one-third of the entire U.S. Asian American population and about 30% of all U.S. Latinos and Native Hawaiians or Pacific Islanders." As Winter et al. (2013a, p.8) point out:

> These dimensions of diversity add to the already diverse demographic, economic, and ethnic profile of Sierra Nevada communities. Both new and existing populations will challenge modes of outreach, engagement, and approaches to management. Particular attention will need to be paid attention to groups who may be underserved or underrepresented in opportunities to have their opinions heard, needs or interests represented in decisions about how places will be managed, and opportunities to use their public lands.

Movement into the Sierra Nevada by new residents and increasing cultural diversity will continue to challenge the agency's ability to manage for diverse interests. Additionally, balancing across multiple uses and benefits will continue to be influenced by ecological constraints, external drivers and stressors, policies and laws, and agency resource limitations.

National Forests as a Place to Learn about and Contribute to Cultural Legacy

Forests support cultural legacy through the various cultural connections that they provide. National forests provide residents and visitors in the Sierra Nevada various opportunities to connect with and learn about the region's history and culture. According to 2005-2009 National Visitor Use Monitoring (NVUM) data, 6.4% of visitors to forests in the bio-region visited historic sites, though only 0.1% cited this activity as the main reason for visiting a forest. Nationally, between 2000 and 2009, there was moderate growth in visiting historic sites (Cordell 2012). Maintaining cultural connections depends on being able to protect and know the condition of cultural and historic resources. However, many resources throughout the bio-region have not been identified or have not been evaluated. In addition, the agency is in the middle of a dramatic shift in philosophy regarding cultural resources to not only include material objects and features, but also broader, Native American definitions and uses. As such, there is little information regarding conditions and trends for these new types of cultural resources. Still, some general trends are expected to impact cultural and historic resources over the next several decades: climate change, population growth, increasing demand for recreation infrastructure, decreasing federal budgets, increasing looting and vandalism, unauthorized marijuana cultivation, increasing demand by Native American tribes for access to and use of traditional and sacred cultural resources and places, increasing demand for heritage tourism, and increasing fire suppression activities as a result of the expected increase in the frequency and severity of wildfire in the Sierra Nevada.

Sierra Nevada landscapes have long inspired artistic production and continue to inspire artists to contribute to the region's future legacy. John Muir is perhaps the most well-known for capturing the spirit and grandeur of the region in his writings, and Mark Twain, Jack London, Bret Harte, Mary Austin, and John Burroughs contributed significantly to describing the Sierra Nevada in prose and poetry (Duane 1999). The lives, stories, and poems of Beat Generation writers, including Allen Ginsberg, Jack Kerouac, and Gary Snyder, were also greatly influenced by the Sierra Nevada. In his world famous photographs, Ansel Adams captured the beauty and spirit of Sierra Nevada landscapes. Hundreds of art galleries and studios, music venues, and theaters are found throughout the Sierra Nevada, many of which are closely tied to the bio-region's natural and cultural history (National Geographic Society 2009). With population growth expected in various parts of the Sierra Nevada, demand for utility lines, cell towers,

and infrastructure for alternative energy development is expected to increase as well. This could result in losses in scenery, affecting artistic inspiration and sense of place. The health of local economies, and particularly the tourism industry, can also influence how well the arts thrive, which can contribute to the wellbeing of communities.

Native American Culture and Rights

Forests in the bio-region play an important role in supporting and protecting the rights and privileges of tribes that help them maintain their culture. Every national forest is carved out of ancestral Native American land, and Native American historical and spiritual connection to the land has not been extinguished or diminished despite these changes in title. As described in the Sierra Nevada Ecosystem Project report (Anderson and Moratto 1996), Native Americans have influenced Sierra Nevada landscapes over many generations. For thousands of years, their land use ethic included spiritual, philosophical, and economic dimensions. In Native American culture, humans are viewed as part of the natural system, helping to ensure abundance and diversity of plant and animal life. Native Americans practiced land management though burning, irrigating, pruning, selective harvesting, sowing, and weeding. Today, while most of their ancestral lands are occupied by others, tribes throughout the Sierra Nevada have maintained distinct ethnic identities. Many Native Americans participate in traditional activities, such as hunting, fishing, trapping, and gathering berries, and do not differentiate these activities into distinct categories, such as work, leisure, family, culture, and tradition (McAvoy et al. 2004). These activities carry on family and tribal traditions, provide sustenance for families, and continue a spiritual connection to the land and to animal and plant resources (McAvoy et al. 2004). These activities, and the places connected to them, have cultural, symbolic, and spiritual as well as functional meanings (McAvoy et al. 2004).

The Forest Service shares in the federal government's overall trust responsibility for federally recognized American Indian tribes and Alaska Natives. Tribes throughout California have the right to hunt, fish, and gather on tribal lands, as well as have access to water that supplies consumption, agricultural purposes, or resource protection. Some tribes have rights associated with treaties, and some tribes have other reserved rights. Tribal consultation is a formal, legally mandated process used for implementing a nation-to-nation relationship established by treaties and executive orders of the United States. It is very important for the National Forests to maintain a sense of history and relationship with the tribes, Information shared in consultation is part of the larger conversation and relationship, and it is not an isolated one-time contact. The ability to sustain their culture and way of life is dependent on access to cultural resources and sacred sites. Native American sacred sites are locations considered sacred by: Indigenous Americans, the citizens of the 110 California federally recognized tribes, the more than 50 non-federally recognized tribes petitioning for recognition, and a multitude of other Native Americans who may or may not be associated with a specific federally recognized tribe. Sacred sites are not identified or defined by the agency. Only the tribes and traditional practitioners can describe and tell us what is sacred on the landscape.

While California's indigenous people trace their ancestry back 9,000 to 14,000 years or more, and are sovereign governments, California Native Americans and their cultures are almost non-existent in the eyes of the American people and in terms of history and recognition by the federal government. Currently, there is a lack of understanding by visitors and managers toward Native American values and traditions, as well as a lack of understanding of treaty rights that give Native Americans unique use rights on National Forest System lands (McAvoy et al. 2004).

The Forest Service recognizes that National Forest System lands are also ancestral lands to many tribes, and that there is a need for effective relationships with these tribes, to engage in formal consultation, and to provide avenues for more communication and collaboration. The Forest Service may conduct activities that have a substantial impact on tribes. These include land management planning, grant programs, timber sales, mining, road building, recreational development and use, archaeological excavations, and energy development. Agency cultural training is currently being developed by the Washington Office of Tribal Relations specifically for the purposes of carrying out the recommendations within the Sacred Sites Report to the Secretary of Agriculture. Staff in the Washington Office is also working with Regional Tribal Relations Program Managers to develop broader training on tribal issues and needs. There is growing recognition that tribal communities within the Sierra Nevada present distinctive opportunities for partnerships to restore ecologically and culturally significant resources, and to promote resilience, as well as the importance of incorporating traditional ecological knowledge into management and monitoring (Charnley et al. 2013, p.19).

Non-tribal Harvesting of Special Forest Products

According to Richards (1996), harvesting non-timber forest products has been an important cultural activity for non-tribal communities as well. A wide range of non-timber forest products are gathered from Forest Service lands in the Sierra Nevada, including wild food plants, medicinal plants, floral greens, seeds and cones, posts, poles, firewood, transplants, and Christmas trees. New uses for and values toward special forest products have developed. The most frequently collected and most economically valuable products are in decline, while many "minor" products are either emerging or increasing. Some of these products may be intensely valued by particular sociocultural user groups, even disproportionately in relation to the amount harvested, the economic value received, and the ecological impacts on the landscape. Conversely, the collection of other special forest products may have unanticipated ecological or socioeconomic consequences depending on past, present, and future conditions of removal, including harvesting pressure. Ethnicity and different community traditions have played an important role in what special forest products are gathered in Sierra Nevada forests. According to 2005-2009 National Visitor Use Monitoring (NVUM) data for the bio-region, 2.1% of visitors participated in gathering forest products, though only 0.2% of visitors reported it as the main reason for visiting a forest. Tribal versus non-tribal gathering, however, is not differentiated. As mentioned in (Charnley and Long 2013 p.19), little information about non-tribal non-traditional forest product harvesting in California, and in the Sierra Nevada specifically, exists in the published literature. No monitoring or studies have been conducted or published by the Forest Service in California on ethno-botany.

Inclusive Politics and Government

The Sierra Nevada is an area that is extremely important to different people for various reasons. A host of groups and governments have a vested interest in what happens on National Forest System lands, which make up about 41% of the land base in the bio-region. By working together toward common goals across jurisdictions, we can be more efficient and effective with available resources. The Forest Service can help ensure broad participation in public processes, and that the voices of underrepresented or excluded groups are heard.

The ability to work across agencies and governments to address resources issues can influence the effectiveness of management across all jurisdictions, particularly in light of future uncertainties and change. A good example of this is invasive species management. Areas with high land use diversity and

subdivision of lands between management agencies make it difficult to effectively control invasive species without collective action (Winter et al. 2013a, p.11). Another example includes restoring the role of fire on the landscape, which requires major political support and coordination across various levels and agencies of government. "An all-lands approach to forest management calls for cooperation and collaboration with other landowners, creating an opportunity for the Forest Service to build relationships with its neighbors and to promote broad-scale restoration. Yet managing across ownership boundaries remains challenging" (Charnley et al. 2013, p.3). The Pacific Southwest Region has drafted partnership strategies that recommit the region to broader and more successful collaborations with external partners. The Region plans to expand the number, quality, and scope of partnership throughout the state, especially in areas related to water and watershed management, healthy forests, engaging youth, recreation, and volunteerism (USFS 2013).

Tribes throughout California have expressed their interest in working with the Forest Service to develop management strategies consistent with traditional management techniques. Our path toward diversity and inclusiveness includes the original inhabitants of these lands, as well as the variety of peoples who currently live and work around our national forests. For tribal economies to be successful, it is necessary to be diverse in reaching out, building infrastructure and developing a governmental structure. Tribes that participate actively in forest planning and are involved in Forest Service projects can create jobs and improve their own economies. The current consultation process may need to be improved so that all parties feel a true sense of engagement from the beginning, and the tribes want to be active participants. Effective consultation on forest management begins before lines are drawn on a map. Forest managers can most effectively begin this process by engaging tribal partners to discuss historical land treatment and how those lessons learned over thousands of years can help us develop long term strategies to restore the nation's forests. Traditional Ecological Knowledge and western science can be blended for successful outcomes on the landscape. Tribes should be consulted as early as possible in the development of policies, plans and actions that may have tribal implications. Tribes can be supportive partners for management decisions. Tribes can communicate their knowledge and belief in the benefits of thinning diverse stands and balancing within the ecosystem. Tribal partners can facilitate larger collaborative efforts between federal agencies. Tribes work with nearly all state and federal agencies, and have access to private funding and their own programs. Our recognition of their strength as partners will help us do the landscape scale restoration that is needed. Tribal partners are willing to partner with the agency to reach important restoration goals, and walking together as partners will be critical to success.

Promoting broad participation and involvement may continue to be a challenge. The sociopolitical environment in California, which includes high levels of regional diversity, racial and ethnic diversity, political distrust, and a trend toward civic disengagement, signifies more rather than less difficulty in reaching public consensus on policy issues (Winter et al. 2013c, p.7). These trends are not constrained to California, and in some cases, reflect a detachment, disconnection, and mistrust of anything "governmental" by a frustrated segment of the public (Winter et al. 2013c, p.7).

Increasing cultural diversity and increasing efforts to include underrepresented communities and youth in management discussion will require new ways of engaging stakeholders. "Given the projections of diversity of cultures and accompanying diversity of values that will continue to characterize visitors and residents in the Sierra Nevada and surrounding areas, engaging stakeholders in an ongoing and adaptive process for forest management practices and decision making is important" (Winter et al. 2013a, p.2).

The Forest Service, as required by the 1994 Executive Order 12898, continues to 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 (Council on Environmental Quality 1997). In addition, environmental justice at the U.S. Department of Agriculture means that, to the greatest extent practicable and permitted by law, all populations are provided the opportunity to comment before decisions are rendered on, are allowed to share in the benefits of, are not excluded from, and are not affected in a disproportionately high and adverse manner by government programs and activities affecting the environment and its impact on human health (U.S. Department of Agriculture 2012). For each forest going through forest plan revision in California, environmental justice concerns will be identified and addressed. New Forest Service guidance on doing an environmental justice analysis will be forthcoming in the very near future.

Connections to the Land

National forests in the Sierra Nevada play a major role in people's connection to nature and their sense of place. Many people in the Sierra Nevada feel a deep connection to the land and its history. This connection to the natural environment contributes to community attachment and wellbeing, especially in communities where public lands dominate the landscape (Brehm et al. 2004). Quality outdoor recreation experiences offer people a chance to develop connections to natural spaces and a foundation for stewardship that further protects the physical environment and contributes to community resilience (Winter et al. 2013a, p.2).

The places that people go when they visit national forests have important social meaning that relate to or depend on scenery (Mattson and Mosier 2012). People form varied and complex relationships with specific places that often hold emotional, symbolic, and spiritual meanings (Kruger et al. 2008). As described in Winter et al. (2013b, p.9), people whose connections to place are intertwined with their sense of self are likely to hold much stronger place attachments and may consider discussions of place as equal to self-determination and personal identity. Therefore, management actions may be of concern when viewed as a threat to one's self, or as a personal attack. Group identities may also be attached to a particular place, where meanings and management preferences for areas are intertwined with social identity. Native Americans have a deep sense of place meaning and attachment to areas in national forests that have been traditionally used by their people, and gathering and recreation activities continue to tie them to these special places (McAvoy et al. 2004).

Though differences vary across regions and cultures, people who visit national forests tend to share an expectation about the scenery, also known as "sense of place" (USFS 1995). A combination of physical, biological, and cultural images gives an area its positive scenic identity and contributes to sense of place. Scenic integrity is the degree to which these images are visibly disturbed (Mattson and Mosier 2012). The Native American community feels a close association with cultural and historic landscapes, and any activity that alters or degrades scenic integrity from more natural settings or those associated with cultural resources may affect potential cultural or historic landscapes or traditional cultural properties.

Based on Existing Visual Conditions (EVC) surveys from forest plan Environmental Impact Statements 1988-1992, over 80% of recreation settings are estimated to have a high scenic integrity level, meaning no disturbance or unnoticed disturbance. This provides a sense of scenery conditions across forests in the bio-region and their ability to contribute to the important relationships that individuals and

communities have with the places they visit, as well as to what newcomers are drawn to as their "place." People may also have connections to particular places for entirely different reasons, unrelated to scenic integrity. Visitor satisfaction from the National Visitor Use Monitoring (NVUM) survey can also provide some sense of people's ability to connect to the land through the quality of their experiences. A majority of visitors to the bio-region's national forests were satisfied with the elements most important to them for undeveloped areas, day use sites, and overnight use sights, including things like condition of the environment and scenery.

Increasing demand for recreation opportunities in the Sierra Nevada and conflict among different user groups may have an impact on people's ability to have high quality experiences on National Forest System lands. Reducing or limiting access to recreation on public lands by closing roads, campgrounds, RV parking, and trails can impact surrounding communities (Hurniston 2010). Changing recreation demands, due to demographic shifts, can also impact visitor satisfaction. Cultural diversity will continue to increase in California, particularly within Latino and Asian populations, and this trend will have implications for outdoor recreation planning and management (Winter et al. 2013b, p.11). Recreation and tourism opportunities may include more developed sites that accommodate extended family gatherings and support activities of interest to diverse groups (Roberts et al. 2009). As mentioned above, current forest management can create barriers to use and enjoyment by the growing population of ethnic minorities in California and the United States as a whole (Roberts et al. 2009). While visitor satisfaction data provide useful information about people who are already using the forest, it does not provide insight into those people who do not use the forests, or their level of connectedness with nature.

Americans, especially those who live in urban areas, are becoming more disconnected from the outdoors, weakening the commitment to stewardship of our shared natural legacy (Council on Environmental Quality et al. 2011). Children today spend less than half as much time outside as their parents did, and are "plugged in" to electronic devices for more than seven hours a day (Council on Environmental Quality et al. 2011). An emotional affinity toward nature is linked to the willingness of people to protect the environment, and positive emotional experiences with nature play an important role in developing that affinity, especially if they share those experiences with significant others (Müller et al. 2009). In addition, a positive connection to nature develops earlier in life and remains a stable trait throughout adulthood (Berk 2006).

Local surroundings are integral to the rural communities within the bio-region. The vegetation, plants, animals, resiliency of forests, grasslands and shrublands to fire, invasive plants and drought are all important aspects of ecological integrity that provide the setting and the means of living for people there. A person who grows up in a rural community takes for granted fishing or hunting (Chapter 8, WIKI), picnics, swimming in a river or lake, or finding a job that depends on local forests or rangelands, or on recreation visitors. The ecological integrity of landscapes around and near communities affects all of these. Large, high intensity wildfires increasingly threaten local communities, keep recreation users away, and make the landscape less visually pleasing. The fire resilience aspect of ecological integrity is important to communities (Chapter 3, WIKI). Overcrowded forests, or degraded meadows, decrease wildlife like deer or songbirds that people enjoy viewing. The biodiversity aspect of ecological integrity is also important to communities. People in local communities have been dependent upon surrounding natural areas for jobs for many years, and many stay because they like working outside in natural settings. Ecological restoration work provides an opportunity to benefit the very ecosystem health they depend on.

Social Interactions

Social interactions that build trust and get people working together benefit communities by contributing to a sense of common identity and shared future, which is critical for community prosperity and sustainability (Flora and Flora 2004). Social interactions with friends and family also help to pass on values and world views. The Forest Service plays a role in fostering and maintaining social interactions.

Opportunities for Spending Time with Friends and Family

According to a report by Roberts et al. (2009), being with friends and family is one of the main reasons Californians enjoy outdoor recreation. Social interaction with friends and family and experiences with features of a place define people's sense of place, attachment to place, and the feeling that a community attributes to a specific landscape (Eisenhauer et al. 2000, Kruger and Jakes 2003). In particular, socializing and spending time with family plays a major role in how and why California's Latino population recreate on federal lands. Studies have shown that Latino outdoor recreationists: enjoy all day, extended family social outings; are interested in an outdoor experience with a strong social recreation component; and identify having a good family experience as one of the most important features of a satisfying outdoor recreation excursion. The report also summarizes key findings on immigrants and outdoor recreation. Immigrants often look to recreation and leisure time to help maintain cultural traditions and to connect with other immigrants for mutual support and information sharing. While recent immigrants tend to recreate with family groups, second and later generations often pursue recreation with friends. The Latino emphasis on family and family values is maintained across generations and does not seem to diminish with increased time in the U.S.

However, the growing population of ethnic minorities in California is still underrepresented among visitors. The social benefits from recreating on National Forest System lands in the bio-region may not be as wide reaching as they could be. Differences in how people want to interact with the land and the role that socializing plays in theses interactions can affect and be affected by management. These factors can have an influence on people's ability to connect to the land and to each other.

Opportunities for People to Work Together and Build Community Capacity

Forests help establish community identity and promote civic involvement by bringing people together through collaboration. Natural areas can help establish community identity, social activity, and social participation (Karjalainen et al. 2010). Places help shape the identity of social groups who share common experiences and develop positive interpersonal relationships relative to a place; they can also inspire people to take collective action (Cheng et al. 2003). Natural resource management can also bring together diverse individuals and groups who may be able to discover common, place-based group identities, which can transform and sustain communities that have direct effects on natural resources (Cheng et al. 2003).

The Forest Service plays a key role in bringing people together to participate in forest planning and management. As laid out in Charnley et al. (2013, p.8), there are many social benefits of collaborative natural resources management. Collaboration on national forest management issues often takes place through community-based collaborative groups.

Benefits of this include:

- Creating a sense of shared ownership over large and complex environmental problems;
- Combining different forms of ecological knowledge and promoting better and shared understanding of natural resource management issues;
- Integrating economic and social concerns with ecological concerns so that they can be addressed together;
- Enhancing opportunities to pool resources and assets in addressing resource management issues;
- Improving working relationships between agencies, members of the public, and other stakeholders;
- Increasing community understanding of and support for land management.

However, there are various challenges to collaboration, including short tenures and high turnover of federal staff; concerns about accountability of managers when rural people believe that their livelihoods are at risk; strong ideological differences among stakeholders; concern about administrative burdens and regulatory limitations imposed by the National Environmental Protection Act and other federal environmental laws; skepticism among environmental groups about local collaboratives; and differential risks to landowners and managers due to scale (Charnley et al., p.5). High levels of regional diversity, increasing racial and ethnic diversity, political distrust, and a trend toward civic disengagement in California add to the challenge of bringing together diverse individuals and reaching consensus on any given issue (Winter et al. 2013b p.7).

An important trend is the increase in online interaction. There is an increasing trend toward internet tools and norms for collaborative natural resource management, and open government more generally. The use of the *Living Assessment* wiki site for forest plan revision is a good example. The trend toward "open government" and use of the internet to create a more inclusive, accessible environment is marked by transparency, participation, and two-way exchange of information, knowledge, and values. The U.S. Department of Agriculture has an open government plan and a website dedicated to the initiative.

Local Economic Opportunities from Forest Activities

The overall economic contribution of the bio-region is small when compared to the state as a whole – the bio-region comprises only 0.7% of the total value of California's economic production (Sierra Nevada Conservancy 2011b). The physical proximity of the communities in the bio-region to forests creates a natural connection and opportunity for forest activities to influence the economic contribution and the wellbeing of communities in this area. Traditionally, commodity-based economic sectors have played a big role in employment in these communities because sectors such as timber and grazing have a long history in the bio-region. Recreational opportunities on the forests and the visitors these opportunities draw also play a role in shaping employment as these communities develop their economies around providing visitor services (Steward 1996).

Forest-based activities also influence community wellbeing in the bio-region by generating local government revenues that are needed to fund critical public services such as fire protection, education and transportation (Chapter 6, WIKI). Examples of these key forest activities are in commodity sectors like timber and grazing, as well as in the non-commodity based recreation sector, which supports many job opportunities in the travel and tourism industry across the bio-region. In some places in the bio-

region, these activities make up a significant portion of the local economy and therefore forest management plays an important role in influencing the economic conditions in these communities.

Another contribution of forest activities to job creation is through Forest Service spending, which is potentially a direct investment into the local economy. This investment can support local jobs for forest activities and also provide local services, such as grocery stores, banks and restaurants, needed by these workers and their families.

The role of forest activities in providing job opportunities, contributing to local government revenues and effects of local Forest Service spending are discussed below.

Job Opportunities

The bio-region is more vulnerable economically than is the state as a whole. As a result, communities in the bio-region are less able to dampen and adapt to changes that may negatively affect local economies. This vulnerability varies from community to community. In general, there are fewer job opportunities in the counties of the bio-region, the job opportunities that exist are typically lower paying than are jobs across the state, the residents have lower incomes and receive less of this income from current employment, thus relying more on their retirement savings, Social Security and public assistance programs. In addition, some local economies in the bio-region lack diversity across economic sectors. As a result, they are dependent on only a few specific sectors to support a large percentage of local employment. Such a concentration of employment in just a few sectors creates volatility and the potential for boom and bust cycles in these communities when businesses in the same major industry group are all expanding or contracting at the same time.

Forest management plays a role in influencing conditions in these forest sectors. To address emerging ecological concerns, the Forest Service adopted ecosystem management as its management paradigm. Thus, forest management contributes to community wellbeing not only in terms of traditional forest commodities such as timber and grazing, but also through ecological restoration and through forest amenities such as recreation, scenic beauty, clean air and water, and cultural heritage. Creating job opportunities in these areas would help to reduce unemployment, increase earnings and develop a more diverse employment base, lessening the economic vulnerability in the bio-region and improving the capacity of these communities to adapt to change. (Kusel 2001, Nadeau et al. 2003, Sturtevant & Donoghue 2008, Charnley 2013, Walker and Salt 2006, Charnley and Long 2013, Chapter 6, WIKI).

This potential outcome is consistent with current Forest Service direction from the U.S. Department of Agriculture (2010) to generate jobs through recreation and natural resource conservation, restoration, and management in rural areas, from the 2012 Planning Rule to contribute to social and economic sustainability, thereby supporting communities and rural job opportunities, and from the Forest Service Pacific Southwest Region Ecological Restoration Implementation Plan to consider socioeconomic dimensions of restoration to support vibrant and prosperous rural communities (Charnley 2013, USFS 2013).

At the same time, this approach to management helps maintain a local workforce in these communities with the capacity to carry out the forest management work that is needed to improve and restore ecological integrity and resilience in forest ecosystems (Kelly and Bliss 2009). More details on the important role of communities in forest restoration are provided under the Fire Resilience theme.

Historically, federal forest management was important in contributing to community stability in the bio-region by providing stable employment and income in the local timber industry. However, federal forest management alone cannot ensure this community stability as jobs in the forest products industry are influenced by market conditions and changes in technology that are outside the control of forest management. As a result, National Forests cannot expect to ensure community economic wellbeing through their management actions alone (Charnley 2013). That said, strategies can be developed that allow forests to achieve management objectives while simultaneously considering the effects on local wellbeing (USFS 2013).

Developments in the bio-region during the 1990s saw a dramatic decline in timber production on national forest lands as a result of concerns about old growth forest ecosystems, watershed health, and threatened species (Berck et al. 2003, Charnley et al. 2006). This declining timber production had an adverse effect on the economies of local communities through reductions in workforce and declines in the forest product infrastructure available to process timber. More details on timber and communities are provided under the Fire Resilience theme.

Across the bio-region, forest commodity sectors make up a much smaller percentage of total employment. As of 2010, timber and mining in the counties of the bio-region made up only 0.7% and 0.5% of employment respectively. Trends in the timber industry have seen reductions in the local workforce and the infrastructure available to process timber and biomass. Maintaining this capacity locally is critical to community welfare. Timber harvested in the bio-region and then transported out of the bio-region for processing takes the jobs and economic benefits away from local communities (Chapter 6, WIKI). Future timber harvests throughout the bio-region are dependent on the demand for wood products, which fluctuates in response to both regional and international economic conditions, the pace of new home construction and future decisions on restoration activities (Chapter 8, WIKI).

Grazing on forest lands has also been a traditional forest activity in local economies that has declined in recent years due to market conditions as well as environmental concerns that limit the herd size authorized in Forest Service grazing permits. Public rangelands on the forests are used for seasonal cattle and sheep grazing as ranchers often have a greater demand for year-round forage than can be supported on their privately owned base property lands. The seasonal nature of the valley and foothill rangelands led to the tradition of moving animals from the private base ranches to the higher elevation summer public land ranges to round out the annual forage needs for their livestock. Therefore, access to these public lands is critical in determining the viability of ranching operations. The number of permitted head grazed on National Forests system lands has decreased by more than 50% since 1980 and this means fewer economic opportunities are available in this sector (Chapter 8, WIKI). Agricultural jobs, which include grazing, make up around 3% of employment in the counties of the bio-region.

Even though contributions of forest commodities to employment is small across the bio-region, production on national forest lands continues to make an important contribution to local economies in some parts of the Sierra Nevada (Charnley 2013). Across the bio-region, a concentration of timber production is prevalent in the northern Sierra Nevada counties, and grazing is found mainly in the northern and eastern Sierra Nevada, as well as in the oak woodland ecosystems of the western edge of the bio-region.

The central and southern portions of the bio-region are where recreation and tourism dominate some local economies in and around the central and southern portions of the bio-region. Recreation, tourism

and travel make up a much larger portion of the workforce than do timber and grazing, accounting for 18% of all employment in the counties of the bio-region. In terms of the number of jobs created, recreation is the most influential of forest-based activities. These service jobs have a lower average wage, so while more jobs are created by recreation, they pay less. More details on the importance of recreation in supporting communities are provided under the Sustainable Recreation theme. Trends show that employment across forest activity sectors has been fairly stable over the last decade except for the expected fluctuations during the recent recession (Chapter 6, WIKI).

The recent recession had a large impact in the state and in the bio-region, with unemployment doubling in both areas from 2007 to 2010 (Sierra Nevada Conservancy 2011b). The counties of the bio-region have a higher average annual unemployment rate, lower average earnings per job, and lower per capita income than does the state as a whole. Households in the bio-region also receive a smaller percentage of their income from their jobs and more from payments such as Social Security and public assistance (Chapter 6, WIKI). These social transfer payments were the fastest growing income component throughout the entire bio-region from 2001 to 200. This is a similar growth rate as the state as a whole. The percentage of income obtained from labor increased faster in the bio-region over this time period than it did across the state. However, median household income in the bio-region increased by just 2% last decade, compared to the state as a whole, which increased by 4%, thus resulting in a widening of the income gap between those living in the bio-region and the rest of the State (Sierra Nevada Conservancy 2011b).

The bio-region is more economically vulnerable, but there are differences in this vulnerability across the various bio-regional sub-areas. The counties in the northern portion of the bio-region have lower than average earnings and a larger percentage of income resulting from retirement savings and Social Security. This is because the area has a higher percentage of retirement-age people over the last decade. The counties of the southern portion of the bio-region have a lower than average per-capita income and a higher percentage of this income is from public assistance programs such as Supplemental Security Income (SSI), public cash assistance and food stamps. This follows from the finding that poverty in this area is the highest in the bio-region and is much higher than the state as a whole. The counties of the central portion of the bio-region have a lower than average unemployment, higher than average earnings and higher than average per-capita income. Comparing these measures reveals that the economy in the central portion of the bio-region is healthier overall than the economy of the bio-region as a whole (Chapter 6, WIKI).

Contributions to Local Government Revenues

Key sources of local government revenue from forest activities are the sales tax collected on commodities and services, as well as the direct revenue received from the Payments In-Lieu of Taxes (PILT) and Secure Rural Schools and Community Self-Determination Act (SRS) programs. Current conditions and expected future trends in constrained government budgets suggest that these revenues are important as they allow local governments to provide public services such as fire protection, education and transportation that is important in maintaining wellbeing in communities.

Under federal law, county governments are compensated through Payments in Lieu of Taxes (PILT) for reductions to their property tax bases from National Forest System land. These lands cannot be taxed, but may create demand for services such as fire protection, police cooperation, or simply longer roads to skirt the federal property. For National Forest System lands, counties receive federal payments for timber and other resources through either the traditional 25% revenue sharing agreement, or through the

Secure Rural Schools and Community Self-Determination Act (SRS). Given decreases in timber production and timber prices, counties have typically favored the higher payments from SRS since its introduction in 2000. Originally scheduled to sunset in 2006, SRS was renewed by Congress in 2007, 2008 and 2012. Each time payments were reduced. The future of SRS is uncertain given that it has not yet been renewed for FY 2013 and all payments may revert to the original 25% revenue sharing framework if not renewed (Chapter 6, WIKI). In addition, there is uncertainty given the current federal government budget sequester as PILT payments are scheduled to be reduced below the levels counties were expecting to receive this year (Chapter 6, WIKI, Salazar 2013).

All of the counties in the bio-region received some level of payment in lieu of taxes (PILT) in FY 2009. Looking at these PILT revenues as a percentage of total county revenues shows a small contribution for the bio-region as a whole (around 0.5%) but a more important contribution for specific counties, particularly in Modoc where PILT accounted for 5.7% of all county revenue, Plumas (5.7%), Siskiyou (4.3%), Sierra (4.2%), Lassen (4.1%), Inyo (3.3%), Alpine (3.0%), and Tuolumne (2.5%) counties (HChapter 6, WIKI). Given limited and strained local government budgets, any loss of revenue can have a noticeable effect on the quantity and quality of services that can be provided.

Data on timber tax revenues show that they contribute a very small percentage of the total county revenues for the bio-region as a whole (0.01%). A study which estimated the percentage of the county sales tax revenue dependent on visitor-related spending found that this is a very important source of revenues for counties, particularly in Mariposa where the sales tax from visitor spending accounts for 61.4% of all sales tax revenue collected. The others are Mono (57.9%), Alpine (33.3%), Sierra (29.9%), Plumas (24.9%) and Inyo (20.8%) (Dean Runyan and Associates 2012). While national forests do contribute to travel and tourism in the bio-region, and therefore, can influence this transient tax revenue, there are other recreational opportunities that also drive this tourism, such as the National Parks, and therefore all of this revenue cannot be attributed to visitors to national forests alone (Chapter 6, WIKI).

Not only are forest activities important in supporting local government revenues through PILT and sales taxes, but these revenues are also important in supporting local forest activities. These government revenues pay for the education necessary to develop a local work force and also for the transportation infrastructure that the businesses engaged in forest based activities rely on to transport their goods. In addition, the incentives that are provided by local governments help to support forest activities. An example is Williamson Act funding – a state program reducing property tax rates to encourage the conservation of agricultural lands– and its importance in sustaining ranching in the bio-region. Budget cuts have already resulted in dramatic reductions to the funding of this program and continued decreases brings into question ranchers' ability to maintain the profitability of their businesses. Not only would the potential business closures result in economic consequences from lost job opportunities, but also would result in social consequences as a result of impacts to the culture of the bio-region as ranching as a lifestyle is lost. Such a transformation could also result in commercial development of large areas of current rangeland throughout the state, thus increasing the development pressures in the wildland-urban interface area of the bio-region and the ecological problems that brings (Wertzel et al. 2012). This interesting example shows the complex integration of economic, social and ecological factors that influence forest management in the bio-region (Chapter 8, WIKI).

Forest Service Spending in Local Economies

Forest Service spending from 2006 through 2012 by the National Forests in the bio-region has increased mostly as a result of increases in the budgets for wildland fire management – spending for fuel reduction and fire preparedness (USFS 2012c). An important consideration of this spending in contributing to local community wellbeing is how much is actually spent locally to support businesses and to create job opportunities in these communities. Forest managers have the opportunity to think strategically about this local spending and the mechanisms available to ensure local economic benefit (Charnley 2013, Charnley and Long 2013).

Health, Safety, Education and Skills

Individual skills, abilities, and knowledge, or human capital, contribute to a person's ability to support themselves, contribute to their families, and strengthen their communities (Flora and Flora 2004). Formal and informal education, training, and experience contribute to human capital, as well as health. The Forest Service has a role in helping to maintain human capital in the bio-region and beyond.

Human Health

Forests in the bio-region provide basic necessities for life, like clean air and water, and many physical and mental health benefits. Forested watersheds in California provide an abundant supply of clean water that supports a broad range of downstream uses (California Department of Forestry and Fire Protection 2010). The controlled release of snowmelt throughout the spring and summer helps to control winter flooding in the valleys, and provides irrigation for food crops and water to keep recreation and other businesses and industries thriving through the summer. This water also provides hydropower to light homes, and quality drinking water to meet the needs of residents throughout California (Sierra Nevada Conservancy 2011a).

Climate change is expected to impact water flow and timing in the Sierra Nevada (Jardine and Long 2013, p.5). As population grows throughout the state, demand for water in California grows, while the supply remains the same (California Department of Forestry and Fire Protection 2010). Pressures from California's agricultural and urban areas are being resisted by groups interested in preserving biodiversity and environmental quality in the Sierra Nevada, and who view the continuous and rising export of water to other regions as undesirable in the long run (Mittelbach and Wambem 2003). Population growth has led to increased competition for water among various uses within the Sierra Nevada, including in-stream flows for aquatic species, water recreation, hydropower, domestic uses, and national forest and special use permit site uses. According to a 2010 assessment of Sierra Nevada watersheds using the Forest Service Watershed Condition Framework, 63% were classified as "functioning properly" and 36% were classified as "functioning at risk" (Chapter 2, WIKI). Sierra Nevada watersheds face significant threats including fire, poorly planned development, and unauthorized recreation (Sierra Nevada Conservancy 2011a). National forests have generally provided a high level of water quality protection for Sierra Nevada headwaters. Of the water bodies on National Forest System lands within the Sierra Nevada, only Lake Tahoe was listed as one of the "top threatened watersheds" by the CALFire Forest and Range Assessment Program Report.

Participation in recreation activities is the way most people have come to know their national forests, and contributes greatly to the physical, mental, and spiritual health of people (USFS 2010a). As described in Winter et al. (2013a, p.2), "the connections between human health and forests hold great potential for improvement of wellbeing." People who feel connected to nature are not only more likely to protect

nature, but also more likely to feel satisfied with their lives (Mayer and Frantz 2004). Eighty-four percent of the Californians polled in the most recent Comprehensive Outdoor Recreation Plan (CORP) statewide survey said outdoor recreation was an "important" or "very important" contributor to their quality of life (Roberts et al. 2009).Nature-based outdoor recreation has been increasing nationally (Cordell 2012). A stable public land base, a declining private natural land base, and increasing numbers of outdoor recreation enthusiasts are expected to result in increased conflicts and declines in the quality and number of per person recreation opportunities, especially on public lands near large and growing population centers (USFS 2012f). In California, activities such as off-highway vehicle recreation, mountain biking, boating and adventure recreation, have increased dramatically in recent years; while at the same time population growth, urbanization and alternative energy production compete for suitable lands (California Department of Forestry and Fire Protection 2010). Cordell et al. (2004) expect that socioeconomic trends across the U.S. will put disproportionate pressure on public lands for recreation and raw materials, and lead to increased conflict and competition for access.

Forests have a positive impact on air quality through deposition of pollutants to the vegetation canopy, reduction of summertime air temperatures, and decrease of ultraviolet radiation (Karjalainen et al. 2010). In the foothills and the southern Sierra, increased industrial and automobile pollution is of particular concern. Pollution from the Central Valley goes up the western slopes of the Sierra Nevada, creating hazy, unhealthy conditions for people in foothill communities up to elevatios of over 6,000 feet(Cahill et al. 1996). In multiple locations in the Sierra Nevada, especially the western slopes adjacent to the highly polluted California Central Valley, studies have pointed to elevated ozone levels that exceed public health standards (Cisneros et al. 2010). People in these areas are exposed to higher ozone concentration. The elderly, young, and people with respiratory conditions are at greater risk from degraded air quality. Air pollution in many high Sierra communities is also attributed to local sources, namely wood fires in towns like Truckee and Mammoth Lakes during winter months, which push particulate levels into an unhealthy range (Sierra Business Council 1997). Air pollution in the Sierra Nevada is largely outside the control of the Forest Service, aside from our influence on smoke through fire management.

Community Safety and Resilience to Wildfire

The Forest Service helps communities in the bio-region stay safe through wildfire prevention and suppression. Shifted fire regimes compounded with climate change, species invasions, population growth, and increased development in the wildland urban interface (WUI), can have serious negative consequences on human wellbeing (Winter et al. 2013a). According to McCool et al. (2007), wildland fires have a variety of impacts on individuals, families, neighborhoods, social groups, and communities. They can lead to: death, increased stress, health problems related to smoke, psychological impacts, emotional impacts, increased community tension and conflict, and decreased opportunities for recreation. As described in Long et al. (2013, p.5), intense, large, and long-lasting wildfires are likely to result in air quality that exceeds levels put in place to protect human health. Uncharacteristically large and severe fires may also cause erosion and reorganization that can eliminate vulnerable aquatic population, degrade water quality, reduce capacity of downstream reservoirs, and increase the risk of flood. Large wildfires can increase the release of heavy metals in soils, which have likely built up over time through atmospheric deposition and mining activity, which likely introduced heavy metals into the ecosystem as well (Winter et al. 2013a, p.9).

A concentration of California's high priority landscapes in terms of community safety, defined as high wildfire threat together with human infrastructure assets, is located in the Sierra Nevada bio-region

(California Department of Forestry and Fire Protection 2010). With the migration of more people into Sierra Nevada communities, more people are exposing themselves and their families to unnecessary personal risk, particularly to the danger of wildfire. Many newer residents are unfamiliar with the safety problems associated with building in certain locations (Sierra Business Council 1997). People living in high fire risk areas tend to be unduly optimistic about the degree of risk involved (Winter et al. 2013a, p 7). Landowners are not typically liable for failure to take risk reduction actions on private property (Yoder and Blatner 2004). Still, community involvement in wildfire planning is extensive in California, as evidenced by community wildfire protection plans, local and regional Fire Safe Councils, Resource Conservation Districts and community participation in Firewise Communities/USA program (California Department of Forestry and Fire Protection 2010). Agency strategies can directly impact how fires are managed and how communities prepare for, recover from, and understand wildland fires. Collaborative approaches to fire management and risk reduction has helped with effective risk management. Education about the ecological role of fire, including high-severity fire, is also important in helping people be more accepting of fire and smoke. It may be that many people's distaste for fire and smoke stems from a belief that wildfire only has negative outcomes. The reality is that fire can also have extremely beneficial outcomes.

National Forests as a Place to Learn and Build Skills

Forests can provide opportunities for people, especially young people, to learn about forests and management and to build valuable skills. There is increased attention on poverty in rural communities in the Sierra Nevada, and connections between wellbeing and ecological quality. There is an income gap between those people living within the Sierra Nevada and the rest of the state (Sierra Nevada Conservancy 2011b). The poverty rate of the counties that contribute to the Sierra Nevada bio-region is higher than the state as a whole (Headwaters Economics 2012a). The impacts of poverty can be longstanding and affect cognitive and socio-emotional processes influencing life-long development and outcomes in adulthood (Evans and Rosenbaum 2008). While a greater percentage of people in the Sierra Nevada have a high school degree than the state, the percentage of people with a college degree is lower than state levels. National forests can provide educational and skill-building opportunities. For example, since 1970, the Youth Conservation Corps (YCC) has operated as a summer employment program for a diverse group of young people aged 15 through 18 who work, learn, and earn together by doing projects on public land. The program is administered by the Forest Service, the U.S. Fish and Wildlife Service, and the National Park Service. Another example is the California Conservation Corps, which has crews that work with the Forest Service to receive training and work experience in forestry and firefighting. Finally, the Forest Service Central California Consortium is a program focused on environmental education, minority outreach, and recruitment. It serves the greater San Joaquin Valley, and its purpose is to educate underserved rural communities on natural resources and to encourage them to use public lands. The program has established Hispanic and Asian components with African-American and Native-American programs being established in the near future.

2004 Sierra Nevada Framework

Community resilience is not directly addressed in the current plan direction. However, there is guidance on working to be responsive to the needs of those communities most directly affected by Forest Service management.

One of the reasons the 2001 Framework was amended by the 2004 Framework was to reduce the risk of wildfire to communities in the wildland urban interface. The decision includes managing hazardous fuels in and around communities, combined with strategic placement of fuels treatments across broad landscapes to modify wildland fire behavior.

This decision also addresses the need to retain industry infrastructure by allowing more wood by-products to be generated from fuels treatments and dead and dying trees to be harvested during salvage operations. It acknowledges that the Forest Service has a role to play in providing a wood supply for local manufacturers and sustaining a part of the employment base in rural communities. In some cases, these wood by-products will also help to offset the cost of fuels treatments.

The decision affirms that authorized recreation businesses contribute significantly to the economic base of communities and counties that rely on national forest recreation for employment, wages, and taxes.

The 2004 Framework recognized the value of recreational pack stock use and commercial livestock grazing and provides for flexibility to develop local management strategies that protect resources while allowing reasonable uses.

The 2004 Framework adopts an integrated vegetation management strategy with the primary objective of protecting communities and modifying landscape-scale fire behavior to reduce the size and severity of wildfires. This would provide for the removal of some medium-sized trees to increase the likelihood of accomplishing program goals with limited funding. The Framework acknowledges the role that the Forest Service plays in providing a wood supply for local manufacturers and sustaining a part of the employment base in rural communities. This strategy addresses the need to retain industry infrastructure by allowing wood by-products to be generated from fuels treatments and for dead and dying trees to be salvaged after wildfires. This active approach to vegetation and fuels management accepts the risks of temporarily changing some habitat for California spotted owls and other species to reduce the future risk of wildfire to habitat and human communities.

The 2004 Framework calls for line officers to increase their collaborative efforts within the communities of the Sierra Nevada. Much of this effort focuses around implementing the Healthy Forest Restoration Act and the National Fire Plan.

The 2004 Framework directs the Forest Service to work with tribal governments and tribal communities to develop mutually acceptable protocols for government-to-government and tribal community consultations. These protocols will emphasize line officer and tribal official roles and responsibilities.

WHAT ARE THE CONCLUSIONS?

This assessment synthesizes existing information related to social, economic, and ecological conditions and trends across the Sierra Nevada. While forest-level assessments are required by the 2012 Planning Rule, there is no requirement for a Bio-Regional Assessment. Based on input from stakeholders, information was gathered and conclusions formed at this large scale to help guide forest plan revisions, and help identify overarching themes. It was conducted rapidly, using readily available information and existing data. It highlights both our current knowledge as well as information gaps.

The Bio-Regional Assessment looked at systems and sustainability for *water quality and quantity, fire resilience, sustainable recreation, ecological integrity and community resilience.* There are pieces of the sustainability puzzle throughout each theme. For each theme, there are conditions and trends where drivers and stressors have influence and cause stability, deterioration or improvement. Our intent was to highlight these trends. Gaps in information were identified. This information will be used in the next phase of the planning process.

What did we learn?

WATER QUALITY AND QUANTITY

Increasing population, with accompanying increasing demand for water use, will put increasing pressure on water quantity and lead to more conflict over water uses.

Water emanating from the forests is of high quality.

On forests, there is the potential for water quality problems. Implementation of best management practices appears to be effective in decreasing adverse water quality problems.

People love to recreate around water. More people will result in demand for more water-based recreation, in turn putting more strain on already compromised riparian ecosystems.

Climate change will likely change the pattern and flow of water, adding stress to aquatic and terrestrial ecosystems.

Lack of fire in the riparian zone creates less patchiness, less diversity of plants and structure, and fewer animals. If minimal management in riparian zones continues, the trend will be away from natural riparian ecosystem function.

Increased conifer, overall vegetation density and uniformity in riparian areas result in higher intensity fires across large areas. With climate change come more frequent uncharacteristic fires, and this is likely to continue.

Water storage and flood control infrastructure have caused many negative effects in aquatic ecosystems. However, increased management and oversight, where possible, reduces adverse impacts.

Population growth increases the spread of aquatic invasive species. Additionally non-native fish species are planted, impacting the food cycle and health of native aquatic species.

Pesticide drift from valley agriculture may add stress to aquatic amphibians and contribute to their decline.

FIRE RESILIENCE

Predicted trends are for longer fire seasons, drier and hotter conditions, and persistent trends of over-dense and uniform vegetation. These all lead to trends in extensive high severity fires during the peak fire season. Fires are increasingly outside the range of variation of historic fire regimes for most ecosystems.

Fires can lead to death, increased personal stress, problems with health from smoke, psychological and emotional impacts, increased community tension and conflict, destruction of property, interruption to businesses, and decreased opportunities for recreation. Uncharacteristic wildfire is increasing in the bio-region, which leads to increased adverse impacts on people.

Uncharacteristic fire disrupts ecosystems and threatens the sustainability of forest benefits through interruptions and lower quality of ecosystem services provided by the forests. Wildland fires are becoming larger, more frequent and of greater severity, which will lead to reductions in ecosystem benefits.

Nearly half of the Critical Aquatic Refuges (CARS), 2/3 of the goshawk and fisher locations, and more than 80% of the spotted owl and pine marten sites are in landscapes with low to very low fire resilience. It is clear that a high percentage of important landscapes are under a threat from uncharacteristic fire.

There is a significant absence of low and moderate severity fire, in these strongly fire adapted forests of the Sierra Nevada resulting in denser, more continuous vegetation.

Restoration to lessen fire threats to wildland urban interfaces, reduce large, high severity fires, or reintroduce low to moderate severity fire means addressing far more acres than are currently managed. It is estimated that current treatment rates, including wildfires of all severities, is at a rate less than 20% of what burned historically.

Sequestering carbon is an important job of forest ecosystems and provides increased benefit globally by reducing atmospheric greenhouse gases.

The cost of fire management and suppression make up a larger and larger portion of forest budgets in the bio-region. This is likely to continue. With limited budgetary resources available for management, this increase in fire spending reduces the ability of forests in the bio-region to take care of other management needs that also threaten the sustainability of ecosystem services.

Population growth and more demand for housing results in increased development in the wildland urban interface across California. More people in these areas means greater risk to communities and more impact from fire.

As a result of the combination of heavy forest fuels and increased development in the wildland urban interface, California has experienced significantly more frequency and intensity of wildfires, and the associated impacts on communities.

Wildfires result in lower air quality and can impact human health. Unmanaged wildfires cause the highest levels of smoke. Extensive absence of fire has resulted in even greater smoke emissions when

uncontrolled wildfires burn because of high, accumulated fuel levels, burning when temperatures are hottest, and combustion is greatest.

Managed fires, and prescribed fires where smoke is managed, produce emissions, although these emissions are at generally lower levels than wildfires, and may reduce overall emissions in the long run.

The increased risk of catastrophic fires in the Sierra Nevada is thought to be a result of the absence of Native Americans in the management of these ecosystems.

The practice of suppressing fires has negatively impacted ceremonial traditions, and may negatively impact salmon species and subsistence and commercial fisheries as well.

Fire can be targeted at specific locations to enhance willows, acorns, and feeding locations for wild game, as well as to reduce insect infestations that damage traditional food sources or species gathered for traditional purposes.

Sound restoration work to retain and restore ecological resilience in the face of wildfire is being conducted; however, as wildland fires are becoming larger, more frequent and of greater severity, impacts from disturbances seem to be outpacing the benefits of this work.

Given the desire to increase the pace and scale of restoration, building or maintaining a robust local workforce and infrastructure is necessary to support the logistics and economics of restoration.

The revenue generated through stable local markets for timber and non-timber biomass from restoration activities can help offset the costs of achieving Forest Service restoration goals.

Maintaining local wood processing infrastructure in the bio-region is an important strategy for maintaining favorable economics for accomplishing ecological restoration goals, while sustaining jobs in the local wood products industry.

Any major reduction in fire suppression and fuel loading, as well as restoring the role that fire plays on the landscape, is heavily dependent on increased local, regional, and national political support.

Increased development in the wildland urban interface has added complexity to fire management, with firefighting resources redirected toward defending homes, instead of making progress on the fire line.

SUSTAINABLE RECREATION

Recreation on national forests contributes to the physical, mental, and spiritual health of people.

A wide range of recreation activities draws people from around the world to forests. These activities provide enjoyment to visitors and benefit the local economies that provide goods and services to these visitors. The intensity of this use is expected to go up.

Jobs in travel and tourism make up a high percentage of all employment in many communities throughout the bio-region, particularly the central and southern areas. However, these are generally lower paying jobs.

In addition to the economic contribution of spending to supporting jobs in communities, the counties in the bio-region receive revenue from sales tax from visitor spending, and this money supports critical county services.

Demand is going up for the Forest Service and other land management agencies to provide more and higher quality recreational opportunities in the bio-region. At the same time, Forest Service budgets are decreasing and fewer resources are available to maintain existing recreational facilities or to develop new ones.

A declining Forest Service budget to maintain the quality of existing facilities and to create new opportunities that visitors to the bio-region are looking for decreases the sustainability and quality of life in local communities.

Declining federal budgets could lead to the decline of existing facilities, resulting in a lower quality of experience.

Communities who depend on visitor income to support their economies are dependent on the Forest Service maintaining a high quality of recreational experience so that people continue to visit.

Community-based stewardship and public land volunteerism is on the rise nationally.

Privately owned special uses are another way that that the Forest Service may be able to meet the increased demand for existing and new recreational opportunities. The number of recreation special use permits issued annually is stable at this time

ECOLOGICAL INTEGITY

Overall resilience of forests to drought and fire has changed considerably. The Giant Sequoia National Monument, and the Tahoe, Stanislaus, Sierra and Sequoia National Forests are particularly vulnerable to climate change because the wetter areas that they depend on are expected to shrink.

Red fir forests are both in and outside the natural range of variability and are among the most vulnerable to climate change. Structure has shifted with homogenization, increases in small and medium trees, and decreases in large trees.

Eastside yellow pine and mixed conifer forests, westside montane pine and mixed conifer forest structure and fire regimes are outside the natural range of variability, with denser trees, more uniform forests, and larger, higher intensity fires.

Pinyon-Juniper woodlands and sagebrush are prevalent across the eastern portion of the bio-region, dominating where it is driest. Some aspects of these are in the natural range of variability and others are far outside of it.

A large portion of the bio-region, the montane pine and mixed conifer forests, are relatively productive in terms of vegetation growth, but because they are dry, decomposition is slow. This results in increasing fuels for fire and the likelihood of high intensity crown fires and widespread insect outbreak beyond natural range of variability levels.

Rate of vegetation change and carbon dynamics are important considerations with restoration. Offsetting reduced future wildfire carbon emissions from mechanical and fire treatment is debated for the relative tradeoffs.

The ability for species to move throughout a landscape is important for overall population viability and integrity. Expansion of the non-native, invasive cheatgrass reduces and fragments habitat. Overall forest cover is generally intact across much of the bio-region, but is typically more uniform in density and size. There are far fewer blocks of forest with old forest and very limited and shrinking forests with fine-scale mosaics of openings that support sun-loving plants and the animals that live or eat there. Fragmentation or breaks in connectivity from large, high severity fire, urbanization, and invasive plants all affect the ability of species to shift in response to climate change.

Uniformity in forest composition, along with the absence of low to moderate intensity fire, has resulted in a vast reduction in fine-scale forest complexity and decreased biodiversity.

The major pollutants causing ecological harm in the Sierra Nevada are ozone, which can be toxic to plants, and nitrogen deposition, which can induce undesirable effects on terrestrial and aquatic ecosystems. Ozone and nitrogen deposition interact with other environmental stressors, especially drought and climate change, to predispose forests to the impacts of pests and diseases.

Large, high intensity fires threaten to set back large areas of older or mature forest to early seral, fragmented habitat.

Despite the many benefits they provide, many ecosystems in the bio-region, the species, their respective ecological processes and ecosystem services are being negatively impacted now and in the future by development trends, rising population, habitat fragmentation, intensification of human activity, and the effects of climate change.

One threat to ecological integrity is air pollution. This can have a dramatic effect on the ability of these landscapes to provide ecosystem services.

Ecological integrity also influences the ability of ecosystems to provide many social benefits that support the diversity of values that people and communities hold. Healthy ecosystems help people and communities sustain diverse values and cultures.

National forests can also provide educational and skill building opportunities through their conservation education and volunteer programs, along with training and work programs.

The removal of Native American management from the landscape has influenced and continues to influence Sierra Nevada forests.

Forest management restoration activities to improve the integrity and functioning of ecosystems not only provide benefits to people in terms of sustaining ecosystem services, but also increase the wellbeing of communities.

Increasing the pace and scale of management that restores forest, shrub, grass, and water ecosystems will increase the ability of these systems to withstand changes and still provide for native plants and animals and other ecosystem services.

Currently less than 5% of the landscape is under any sort of restoration treatment. Treating a small fraction of the landscape does not substantially improve the ecological integrity of forests or increase habitat resilience to high intensity fires during the hottest and driest, or windiest weather.

Although it is not always easy to collaborate, given declines in agency staffing and resources, and recognizing that there can be challenges in the process, the Forest Service plans to continue to collaborate with stakeholders and find new ways to engage the public in our work and with each other.

COMMUNITY RESILIENCE

The Sierra Nevada bio-region has a rich history and culture that has always been deeply connected to the land and its natural resources, beginning when Native Americans settled here thousands of years ago.

There is still a lack of understanding regarding Native American values and traditions and their unique rights on National Forest System lands, which help sustain their culture.

The physical proximity of the communities in the bio-region to forests creates a natural connection and opportunity for forest activities to influence local economies and wellbeing.

National forests in the bio-region contribute to community identity, promoting civic involvement and social activity.

Forest-based activities influence community wellbeing in the bio-region by generating local government revenues needed to fund critical public services such as fire protection, education and transportation.

Another contribution of forest activities to job creation is through Forest Service spending, which is potentially a direct investment into the local economy.

The bio-region is more vulnerable economically than California as a whole.

Across the bio-region, the trend is a reduction in the local workforce and the infrastructure available to process timber and biomass.

Grazing on forest lands has been a traditional forest activity in local economies that has declined in recent years due to market conditions and environmental concerns that limit the herd size authorized under grazing permits.

Commodity production on national forest lands continues to contribute to local economies in some parts of the Sierra Nevada.

The bio-region is more economically vulnerable than California as a whole, but there are differences in this vulnerability across the various bio-regional sub-areas.

Local government revenue comes from sales tax on forest activities, as well as Payment in Lieu of Taxes (PIL) and Secure Rural Schools (SRS). Current conditions and expected trends in government budgets suggest that these revenues are important, as they allow local governments to provide public services such as fire protection, education and transportation, important to maintain wellbeing in communities.

Government revenues pay for the education necessary to develop a local work force and the transportation infrastructure businesses engaged in forest-based activities rely on to transport their goods.

From 2006 through 2012, forest spending in the bio-region increased mostly as a result of increases in budgets for wildland fire management. An important consideration is how much is actually spent locally to support businesses and create jobs in these communities.

Renewable energy use generated from hydropower, biomass, geothermal, solar and wind facilities on forest lands is another important commodity. This energy potential has increasing value as California looks to diversify its energy portfolio and reduce carbon emissions from energy generation.

Communities in and around the Sierra Nevada are continuously changing. They are becoming more culturally and ethnically diverse, which is expected to influence national forest outreach, engagement, and approaches to management.

Urban communities beyond the bio-region boundary also depend on and benefit from national forests in the bio-region. However, there is a growing disconnect between these communities, especially urban youth, and the outdoors. Increasing people's connection to national forests has the potential to benefit individual health and well-being, as well as to strengthen people's understanding of forest ecosystems and the importance of stewardship.

Where do we go from here?

Identifying the major bio-regional conditions and trends creates a foundation for a conversation with stakeholders. It helps develop the more local and focused forest assessments. It serves as an information resource that informs the need for changing existing forest plans. . The Bio-Regional Assessment, along with the forest assessments, the continuously updated *Living Assessment* and new science will be used to develop desired conditions, objectives, standards and guidelines and land suitability for the Sierra Nevada forests under forest plan revision,

There is a shared understanding of the various viewpoints and science relating to these complex issues. The Bio-Regional Assessment reflects information shared by both the public and the Forest Service and serves as a concise foundation to help everyone focus on topics appropriate to plan revision

REFERENCES

Ahearn, D.S.; Sheibley, R.W.; Dahlgren, R.A. [and others]. 2005. Land use and land cover influence on water quality in the last free-flowing river draining the western Sierra Nevada, California. Journal of Hydrology. 313: 234-247.

Anderson, M.K. 2006. The use of fire by Native Americans in California. In: Fire in California's ecosystems. Berkeley, CA: University of California Press: 417-430.

Anderson, M.K.; Moratto, M.J. 1996. Native American land-use practices and ecological impacts. In: Sierra Nevada Ecosystem Project (SNEP): Final Report to Congress. Davis, CA: University of California, Centers for Water and Wildland Resources: 557-609. Vol. II, Assessments and Scientific Basis for Management Options.

Aplet, G.; Gallo, J. 2013. Applying Climate Adaptation Concepts to the Landscape Scale: Examples from the Sierra and Stanislaus National Forests. The Wilderness Society Report.

Backiel, A.; Gorte, R.W. 1992. Congressional Research Service Report for Congress: Clearcutting in the National Forests.

Barbour, M.G. 2007. Closed-Cone Pine and Cypress. In: eds Barbour, M. G., Keeler-Wolf, T., & Schoenherr, A. A. Terrestrial vegetation of California. Berkeley, CA: Univ of California Press.

Barbour, M.G.; Keeler-Wolf, T.; Schoenherr, A. A. 2007. Terrestrial vegetation of California. Berkeley, CA: Univ. of California Press.

Barbour, M.G.; Pavlik, B.; Drysdale, F.; Lindstrom, S. 1993. California's changing landscapes: diversity and conservation of California vegetation. Sacramento: California Native Plant Society

Barrett, S.; Havlina, D.; Jones, J. [and others]. 2010. Interagency Fire Regime Condition Class Guidebook. Version 3.0 Interagency Landfire Group: USDA Forest Service, US Department of the Interior, and The Nature Conservancy.

Berck, P.; Costello, C.; Fortmann, L. [and others]. 2003. Poverty and employment in forest-dependent counties. Forest Science. 49 (5): 763-777.

Berk, L. 2006. Development through the lifespan. Boston, MA: Allyn & Bacon.

Blackburn, T.C.; Anderson, M.K., eds. 1993. Before the wilderness: native Californians as environmental managers. Menlo Park, CA: Ballena Press.

Boerner, R.E.; Huang, J.; Hart, S.C. 2008. Fire, thinning, and the carbon economy: Effects of fire and fire surrogate treatments on estimated carbon storage and sequestration rate. Forest Ecology and Management, 255(8): 3081-3097.

Bradford, D.F.; Knapp, R.A.; Sparling, D.W. [and others]. 2011. Pesticide distributions and population declines of California, USA, alpine frogs, Rana muscosa and Rana sierra. Environmental Toxicology and Chemistry. 30: 682-691.

Brehm, J.M.; Eisenhauer, B.W.; Krannich, R.S. 2004. Dimensions of community attachment and their relationship to well-being in the amenity-rich rural West. Rural Sociology. 69(3): 405-429.

Brooks, M.L.; Minnich, R. 2006. Southeastern desert bioregion. In: Fire in California Ecosystems, NG Sugihara, JW van Wagtendonk, J. Fites-Kaufman, KE Shaffer, and AE Thode (eds.). Berkeley, CA: University of California Press.

Brown, T.C.; Froemke, P. 2009, Estimated mean annual contribution to water supply from units of the National Forest System (NFS) of the U.S. Forest Service: USDA Forest Service Rocky Mountain Research Station.

Brown, T.J.; Hall, B.L.; Westerling, A.L. 2004. The impact of twenty-first century climate change on wildland fire danger in the western United States: an applications perspective. Climatic Change, 62(1-3), 365-388.

Burns, D.; Vitvar, T.; McDonnell, J. [and others]. 2005. Effects of suburban development on runoff generation in the Croton River basin, New York, USA. Journal of Hydrology. 311(1–4): 266–281.

Bytnerowicz, A.; Fenn, M.E.; Long, J.W. 2013. Air Quality Chapter 8 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Cahill, T.S; Carroll, J.J.; Campbell, D; Gill, T.E. 1996. Air Quality. In: Sierra Nevada Ecosystem Project (SNEP): Final Report to Congress. Davis, CA: University of California, Centers for Water and Wildland Resources: 1227-1261. Vol. II, Assessments and Scientific Basis for Management Options.

California Department of Finance. 2012. Interim Projections of Population for California: State and Counties.

California Department of Fish and Game. 2008. California Aquatic Invasive Species Management Plan. Sacramento, CA.

California Department of Fish and Game. 2011. California Natural Diversity Database (CNDDB), List of Special Animals. Biogeographic Data. January 2011. California

California Department of Forestry and Fire Protection [CALFIRE]. 2010. California's Forests and Rangelands: 2010 Assessment. Sacramento, CA: Fire and Resource Assessment Program.

California Department of Parks and Recreation. 2002. Recreational Trails Plan, Phase 1. Sacramento, California.

Centers for Water and Wildland Resources. 1996. Status of the Sierra Nevada. Sierra Nevada Ecosystem Project : Final Report to Congress . Davis, CA: University of California, Center for Water and Wildland Resources.

Charnley, S. 2013. Strategies for Job Creation through Forest Management. Chapter 9.4 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report.

Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Charnley, S.; Donoghue, E.M.; Stuart, C. [and others] 2006. Northwest Forest Plan, the first 10 years (1994-2003): Socioeconomic monitoring results. Gen. Tech. Rep. PNW-GTR-649. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Charnley, S.; Long, J.W. 2013. Managing Forest Products for Community Benefit. Chapter 9.5 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Charnley, S.; Long, J.W.; Lake, F.K. 2013. Collaboration. Chapter 9.6 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Charnley, S.; Sheridan, T.E.; Nabhan, G.P. In press. Stitching the West Back Together: Conserving Working Landscapes and Biodiversity in the American West. Chicago: University of Chicago Press.

Chavez, D.J.; Olson, D. 2011. Visitor survey results: Giant Sequoia National Monument day use study 2009-2010. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Cheng, A.S.; Kruger, L.E.; Daniels, S.E. 2003. "Place" as an Integrating Concept in Natural Resource Politics: Propositions for a Social Science Research Agenda. Society & Natural Resources. 16(2): 87-104.

Cisneros, R.; Bytnerowicz, A.; Schweizer, D. [and others]. 2010. Ozone, nitric acid, and ammonia air pollution is unhealthy for people and ecosystems in southern Sierra Nevada, California. Environmental Pollution. 158(10): 3261-3271.

Collins, B.; Skinner, C. 2013. Fire and Fuels. Chapter 4.1 in Long, J.W.; Quinn-Davidson, L., and Skinner, C.N., tech. editors. Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Cordell, H.K. 2012. Outdoor recreation trends and futures: a technical document supporting the Forest Service 2010 RPA Assessment. Gen. Tech. Rep. SRS-150. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 167 p.

Cordell, H.K.; Bergstrom, J.C.; Betz, C.J.; Green, G.T. 2004. Dominant socioeconomic forces shaping the future of the United States. In: Manfredo, M.J.; Vaske, J.J.; Bruyere, B.L.; Field, D.R.; Brown, P.J., eds. Society and Natural Resources: A Summary of Knowledge. Jefferson, MO: Modern Litho: 349-361.

Corey, L.; Fjeld, P.; Serat, W. 1970. Distributional patterns of ddt residues in the Sierra Nevada mountains. Pesticides Monitoring Journal. 3: 204-211.

Council on Environmental Quality. 1997. Environmental Justice: Guidance Under the National Environmental Policy Act. Washington, D.C.

Council on Environmental Quality; Department of Agriculture; Department of the Interior; Environmental Protection Agency. 2011. America's Great Outdoors: A Promise to Future Generations.

Davidson, C. 2004. Declining downwind: amphibian declines in California and historic pesticide use. Ecological Applications. 17:587-597.

Davidson, C.; Bernard, M.D.; Shaffer, H.B. [and others] 2007. Effects of chytrid and carbaryl exposure on survival, growth, and skin peptide defenses in foothill yellow-legged frogs. Environmental Science and Technology. 41:1771-1776.

de Groot, R.; Wilson, M.A.; Boumans, R.M. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecol. Econ. 41, pp.393–408.

Dean Runyan and Associates. 2012. California Travel Impacts by County, 1992-2010 2011 Preliminary State & Regional Estimates April 2012 p.149.

Dissmeyer, G., ed. 2000. Drinking water from forests and grasslands: a synthesis of the scientific literature. Gen. Tech. Rep. SRS–39. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 246 p.

Domagalski, J.L.; Knifong, D.L.; Dileanis, P.D. [and others]. 2000. Water Quality in the Sacramento River Basin, California, 1994-98: U.S. Geological Survey Circular 1215, Sacramento, CA, 36 pp.

Duane, T.P. 1996 Human Settlement, 1850-2040. In Sierra Nevada Ecosystem Project: Final report to Congress, vol. II, chap 11. Davis: University of California, Centers for Water and Wildland Resources.

Duane, T.P. 1999. Shaping the Sierra: Nature, Culture, and Conflict in the Changing West. Berkeley, CA: University of California Press.

Egoh, B.; Reyers B.; Rouget M. [and others]. 2008. Mapping ecosystem services for planning and management. Agriculture, Ecosystems and Environment. Elsevier B.V., 6 p.

Eisenhauer, B.; Krannich, R.; Blahna, D. 2000. Attachments to Special Places on Public Lands: An Analysis of Activities, Reason for Attachments, and Community Connections. Society & Natural Resources. 13(5): 421-441.

Elmore, A.J.; Mustard J.F.; Manning S.J. 2003. Regional patterns of plant community response to changes in water: Owens Valley, California. Ecological Applications 13: 443 – 460.

Environmental Protection Agency [EPA]. 1999. Biodiversity Recovery Plan Chapter 2: The Values of Biodiversity. Chicago Wilderness Biodiversity Plan. Great Lakes Ecosystem Program. 5 p.

Eschtruth, A.K.; Battles, J.J.; Saah, D.S. 2013. Five Needle Pines. Appendix 9 in: A natural resource condition assessment for Sequoia and Kings Canyon National Parks. Natural Resource Report NPS/SEKI/NRR—2013/XXX. Eds. Sydoriak, C.A., J.A. Panek, J.J. Battles, and K.R. Nydick. Visalia, CA.

Estes, B. 2013a. Historic Range of Variability for Chaparral in the Sierra Nevada and South Cascades. Unpublished document on file. USDA Forest Service, Pacific Southwest Region. Vallejo, CA.

Evans, G.W.; Rosenbaum, J. 2008. Self-regulation and the income-achievement gap. Early Childhood Research Quarterly. 23(4): 504-514.

Fellers, G.M.; McConnell, L.L.; Pratt, D.; Datta, S. 2004. Pesticides in mountain yellow-legged frogs (Rana muscosa) from the Sierra Nevada mountains of California, USA. Environmental Toxicology and Chemistry. 23:2170-2177.

Fenn, M.E.; Allen, E.B.; Weiss, S.B.; [and others]. 2010. Nitrogen critical loads and management alternatives for N-impacted ecosystems in California. Journal of Environmental Management. 91: 2404-2423.

Fenn, M.E.; Haeuber, R.; Tonnesen, G.S.; Baron, J.S, [and others]. 2003. Nitrogen Emissions, Deposition, and Monitoring in the Western United States. Bioscience. April. vol. 53 (4). P 391.

Fenn, M. E.; Poth, M.A.; Bytnerowicz, A.; Sickman, J.O.; Takemoto, B. 2003. Effects of ozone, nitrogen deposition, and other stressors on montane ecosystems in the Sierra Nevada. In: Bytnerowicz, A., M. Arbaugh, R. Alonso (eds). Ozone Air Pollution in the Sierra Nevada: Distribution and Effects on Forests. Developments in Environmental Science 2, Elsevier, Amsterdam: 111-115.

Ferranto, S.; Huntsinger, L.; Getz, C. [and others]. 2011. Forest and rangeland owners value land for natural amenities and as financial investment. California Agriculture. 65(4): 184-191.

Fites-Kaufman, J.A.; Bradley, A.F.; Merrill, A.G. 2006. Fire and plant interactions. In: Fire in California's ecosystems. Berkeley, CA: University of California Press. 94-117.

Fites-Kaufman, J.A.; Rundel, P.; Stephenson, N.; Weixelman, D.A. 2007. Montane and subalpine vegetation of the Sierra Nevada and Cascade ranges. In: Terrestrial Vegetation of California. Berkeley, CA: University of California Press . 456-501.

Flannigan, M.D.; Stocks, B.J.; Wotton, B.M. 2000. Climate change and forest fires. Science of the Total Environment. 261: 221-229.

Flora, C.B.; Flora, J.L. 2004. Rural Communities, Legacy and Change. Boulder, CO: Westview Press.

Folke, C. 2006. Resilience: The emergence of a perspective for social-ecological systems analysis. Global Environmental Change. 16. pp.253-267

Food and Agricultural Organization of the United Nations [FAO]. 2008. Forests and water quantity. in Forests and Water. FAO Forestry Paper 155. 92 p

Foster Wheeler Environmental Corporation. 2000. Watershed Assessment Upper Mokelumne River, Volume I-Watershed Assessment; Prepared for Sierra Pacific Industries.

Franklin, J.F.; Fites-Kaufman, J.A. 1996. Assessment of late-successional forests of the Sierra Nevada. In: Sierra Nevada Ecosystem Project. Final report to Congress. Davis, CA: University of California, Centers for Water and Wildland Resources. Vol. 2pp. 627–662.

Fried, J. 2013. Forest Researcher, Pacific Northwest Station, Portland, OR. Personal communication, April.

Fryjoff-Hung; Viers. 2012. Sierra Nevada Multi-Source Meadow Polygons Compilation (v 1.0), Center for Watershed Sciences, UC Davis. December 2012.

Graber, D.M. 1996. Status of terrestrial vertebrates. In: Sierra Nevada Ecosystem Project: Final report to Congress. Davis, CA: University of California, Centers for Water and Wildland Resources. Vol. 2. Pages 709 – 734.

Gross, S.; Coppoletta, M. 2013. Historic Range of Variability for Meadows in the Sierra Nevada and Southern Cascades. Unpublished document. USDA Forest Service, Pacific Southwest Region. Vallejo, CA.

Hageman, K.J.; Simonich, S.L.; Campbell, D.H. [and others]. 2006. Atmospheric deposition of current-use and historic-use pesticides in snow at national parks in the western United States. Environmental Science and Toxicology. 40:3174-3180.

Hammer, R.B.; Radeloff, V.C.; Fried, J.S.; Stewart, S.I. 2007. Wildland-urban interface housing growth during the 1990s in California, Oregon, and Washington. International Journal of Wildland Fire. 16(3): 255-265.

Hanson, C.T.; North, M.P. 2008. Postfire woodpecker foraging in salvage-logged and unlogged forests of the Sierra Nevada. The condor,110 (4), 777-782.

Havlick, D. 2002. No place distant: roads and motorized recreation on America's public lands. Washington, DC: Island Press. 253 p.

Headwaters Economics. 2012a. Economic Profile System - Human Dimensions Toolkit (EPS-HDT). Reports were run in 2012, which used 2006-2010 American Community Survey data from the U.S. Census Bureau.

Headwaters Economics. 2012b. A Profile of Federal Land Payments. Percentage calculations made using Headwaters' PILT values and the total revenues from the FY 2009 California State Controllers County Report.

Heckmann, K.E.; Manley, P.N.; Schlesinger, M.D. 2008. Ecological integrity of remnant montane forests along an urban gradient in the Sierra Nevada. Forest Ecology and Management. 255(7): 2453-2466.

Hopkinson , P.; Hammond, M; Bartolome, J. [and others]. 2013 . Meadows. Appendix 13 in: National Park Service. 2013. A natural resource condition assessment for Sequoia and Kings Canyon National Parks. Natural Resource Report NPS/SEKI/NRR—2013/XXX. Eds. Sydoriak, C.A., J.A. Panek, J.J. Battles, and K.R. Nydick. Visalia, CA.

Hunsaker, C.; Long, J.W.; Herbst, D. 2013a. Watershed and Stream Ecosystems. Chapter 6.1 in Long, J.W.; Quinn-Davidson, L., and Skinner, C.N., tech. editors. Science Synthesis to Promote Resilience of Social-Ecological Systems in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Hunsaker, C.; Long, J.W.; North, M. 2013b. Forested Riparian Areas. Chapter 6.2. in Long, J.W.; Quinn-Davidson, L., and Skinner, C.N., tech. editors. Science Synthesis to Promote Resilience of Social-Ecological Systems in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Huntsinger, L.; Forero, L.C.; Sulak, A. 2010. Transhumance and pastoral resilience in the Western United States. Pastoralism. 1(1): 9-36.

Hurniston, G. 2010. Jobs, Economic Development, and Sustainable Communities: Strategizing Policy Needs and Program Delivery for Rural California. Davis, CA: U.S. Department of Agriculture.

Hurteau, M.D.; North, M. 2010. Carbon recovery rates following different wildfire risk mitigation treatments. Forest Ecology and Management. 260(5), 930-937.

Hurteau, M.D.; Stoddard, M.T.; Fule, P.Z. 2011. The carbon costs of mitigating high-severity wildfire in southwestern ponderosa pine. Global Change Biology, 17(4), 1516-1521.

Husari, S. J.; McKelvey, K. S. 1996. Fire management policies and programs. In : Sierra Nevada ecosystem project: Final report to Congress. Davis, CA: University of California, Centers for Water and Wildland Resources. Vol. 2, pp. 1101-1118.

Husari, S.J.; Nichols, T.; Sugihara, N.G.; Stephens, S.L. 2006. Fire and Fuel Management. In: Fire in California Ecosystems. Berkeley, CA: University of California Press.

Jardine, A.; Long, J.W. 2013. Synopsis of Climate Change. Chapter 1.3 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Johnson, H. 2011. Just the Facts: California's Population. San Francisco, CA: Public Policy Institute of California.

Jones, A. 2000. Effects of cattle grazing on North American arid ecosystems: a quantitative review: Western North American Naturalist 60(2): 155-164.

Jones, R.E.; Fly, J.M.; Talley, J.; Cordell, H.K. 2003. Green Migration into Rural America: The New Frontier of Environmentalism? Society & Natural Resources. 16(3)

Karjalainen, E.; Sarjala, T.; Raitio, H. 2010. Promoting human health through forests: overview and major challenges. Environmental Health and Preventive Medicine. 15(1): 1-8.

Kattelmann, R.; Embury, M. 1996. Riparian areas and wetlands. In: Sierra Nevada Ecosystem Project: Final report to Congress. Davis, CA: University of California, Centers for Water and Wildland Resources. Vol. 3.

Kauffman, J.B.; Krueger, W.C. 1984. Livestock impacts on riparian ecosystems and streamside management implications…a review: Journal of Range Management 37(5):430-437.

Keane, J. 2013. California Spotted Owl: Scientific Considerations for Forest Planning. Chapter 7.2 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to Promote Resilience of Social-Ecological Systems in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Kelly, E.C.; Bliss, J. 2009. Healthy forests, healthy communities: an emerging paradigm for natural resource-dependent communities? Society and Natural Resources. 22 (6): 519-537.

Klinger, R.C.; Brooks, M.L.; Randall, J.M. 2006. Fire and invasive plant species. In: Fire in California's ecosystems, 499-519.

Kondolf, G.; Mathias, R.; Kattelmann, R.; Embury, M.; Erman, D. 1996. Status of Riparian Habitat. In: Sierra Nevada Ecosystem Project: Final report to Congress, vol. III. Davis, CA: University of California, Centers for Water and Wildland Resources.

Kratzer, C.R.; Shelton, J. 1998. Water Quality Assessment of the San Joaquin-Tulare Basins, California: Analysis of Available Data on Nutrients and Suspended Sediment in Surface Water, 1972-1990: U.S. Geological Survey Professional Paper 1587, 93 pp.

Kruger, L.E.; Jakes, P.J. 2003. Special Section - Sense of Place - The Importance of Place: Advances in Science and Application. Forest Science. 49(6): 819.

Kruger, L.E.; Mazza, R.; Stiefel, M. 2008. Amenity migration, rural communities, and public lands. In: Donoghue, E.M.; Sturtevant, V.E., eds. Forest community connections: implications for research, management, and governance. Washington, DC: Resources for the Future: 127-142.

Kusel, J. 2001. Assessing Well-Being in Forest Dependent Communities. Journal of Sustainable Forestry. 13(1-2): 359-384.

Lake, F.K.; Long, J.W. 2013. Fire and Tribal Cultural Resources. Chapter 4.2 in Long, J.W.; Quinn-Davidson, L., and Skinner, C.N., tech. editors. Science Synthesis to Promote Resilience of Social-Ecological Systems in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Lenihan, J.M.; Bachelet, D.; Neilson, R.P.; Drapek, R. 2008. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. Climatic Change, 87(1), 215-230

Lenihan, J.M.; Drapek, R.; Bachelet, D.; Neilson, R.P. 2003. Climate change effects on vegetation distribution, carbon, and fire in California.Ecological Applications, 13(6), 1667-1681.

Lindenmayer, D.B.; Fischer, J. 2006. Habitat fragmentation and landscape change: an ecological and conservation synthesis. Island Press.

Loeffler, R.; Steinicke, E. 2006. Counterurbanization and Its Socioeconomic Effects in High Mountain Areas of the Sierra Nevada (California/Nevada). Mountain Research and Development. 26(1): 64-71.

Loeffler, R.; Steinicke, E. 2007. Amenity migration in the U.S. Sierra Nevada. Geographical Review. 97(1)

Loheide, S.P.; Lundquist, J.D. 2009. Snowmelt-induced diel fluxes through the hyporheic zone. Water Resources Research, 45(7).

Long, J.W.; Pope, K.; Mathews, K. 2013a. Wet Meadows. Chapter 6.3 in Long, J.W.; Quinn-Davidson, L., and Skinner, C.N., tech. editors. Science Synthesis to Promote Resilience of Social-Ecological Systems in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Long, J.W.; Skinner, C.N.; North, M.P. [and others]. 2013b. Integrative Approaches. Chapter 1.1 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Long, J.; Quinn-Davidson, L.; Skinner, C. [and others]. 2013c. Post-wildfire Management. Chapter 4.3 in Long, J.W.; Quinn-Davidson, L., and Skinner, C.N., tech. editors. Science Synthesis to Promote Resilience of Social-Ecological Systems in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Los Angeles Department of Water and Power [LADWP]. 2010. Urban Water Management Plan.

Mattson, D.; Mosier, J. 2012. USFS Scenery Management. Slides from presentation on 5/22/2012.

Mayer, F.S.; Frantz, C.M. 2004. The connectedness to nature scale: a measure of individuals' feeling in community with nature. Journal of Environmental Psychology. 24: 503–515.

Mayhead, G.; Tittman, P. 2012. Uncertain future for California's biomass power plants. California Agriculture. 66 (1): 6-7.

McAvoy, L. 2002. American Indians, Place Meanings, and the Old/New West. Journal of Leisure Research. 34(4).

McAvoy, L.; Shirilla, P.; Flood, J. 2004. American Indian gathering and recreation uses of national forests. Proceedings of the 2004 Northeastern Recreation Research Symposium. 81-87 p.

McConnell, L.L.; LeNoir, J.S.; Datta, S.; Sieber, J.N. 1998. West deposition of current-use pesticides in the Sierra Nevada mountain range, California, USA. Environmental Toxicology and Chemistry. 10:1908-1916.

McCool, S.F.; Burchfield, J.; Williams, D.R. [and others]. 2007. Social science to improve fuels management: a synthesis of research on the impacts of wildland fires on communities. Gen. Tech.

Rep. NC-269. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 36 p.

McKelvey, K.S.; Skinner, C.N.; Chang, C.R. [and others]. 1996. An overview of fire in the Sierra Nevada. In Sierra Nevada ecosystem project: Final report to Congress. Davis, CA: University of California, Centers for Water and Wildland Resources. Vol. 2, pp. 1033-1040.

Merriam, K. 2013. Natural Range of Variation in Hardwood Vegetation in the Sierra Nevada, California over the Holocene Epoch. Unpublished document. USDA Forest Service, Pacific Southwest Region, Vallejo, CA.

Meyer, M. 2013a. Natural Range of Variation in Red Fir Vegetation in the Sierra Nevada and South Cascades, California. Unpublished document. USDA Forest Service, Pacific Southwest Region, Vallejo, CA.

Meyer, M. 2013b. Natural Range of Variation in Subalpine Vegetation in the Sierra Nevada and South Cascades, California. Unpublished document. USDA Forest Service, Pacific Southwest Region, Vallejo, CA.

Pollan, M. 2007. Our Decrepit Food Factories. New York Times Magazine. Retrieved 2011-11-13.

Miller, J.D.; Safford, H.D. 2012. Trends in wildfire severity 1984-2010 in the Sierra Nevada, Modoc Plateau and southern Cascades, California, USA. Fire Ecology, 8(3), 41-57.

Miller, J.D.; Safford, H.D.; Crimmins, M.; Thode, A.E. 2009. Quantitative evidence for increasing forest fire severity in the Sierra Nevada and southern Cascade Mountains, California and Nevada, USA. Ecosystems, 12(1), 16-32.

Minnich, R.A. 2007. Climate, paleoclimate, and paleovegetation. In: Terrestrial Vegetation of California, 3, 43-70.

Mittelbach, F.G.; Wambem, D. 2003. Competition for natural resources in California's Sierra Nevada. California Policy Options: 89-109.

Morgan, T.A.; Brandt, J.P.; Songster, K.E. [and others]. 2012. California's forest products industry and timber harvest, 2006. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 48 p.

Morgan, T.A.; Keegan III, C.E.; Dillon, T. [and others] 2004. California's forest products industry: a descriptive analysis. Gen. Tech. Rep. PNW-GTR-615. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Moyle, P.B. 1996. Status of aquatic habitat types. In: Sierra Nevada Ecosystem Project, Final Report to Congress. Davis, CA: University of California, Centers for Water and Wildland Resources. Vol. 2. Pages 945-952

Moyle, P.B.; Katz, J.V.E.; Quiñones, R.M. 2011. Rapid decline of California's native inland fishes: A status assessment. Biological Conservation 144:2414–2423

Müller, M.M.; Kals, E.; Pansa, R. 2009. Adolescents' Emotional Affinity toward Nature: A Cross-Societal Study. The Journal of Developmental Processes. 4(1): 59-69.

Nadeau, S.; Shindler, B.A.; Kakoyannis, C. 2003. Beyond the economic model: assessing sustainability in forest communities. In: Shindler, B.A., Beckley, T.M. and Finley, M.C., eds. Two paths toward sustainable forests: public values in Canada and the United States. Corvallis: Oregon State University Press: 60-74. Chapter 4.

Nagel, T.A.; Taylor, A.H. 2005. Fire and persistence of montane chaparral in mixed conifer forest landscapes in the northern Sierra Nevada, Lake Tahoe Basin, California, USA 1. The Journal of the Torrey Botanical Society, 132(3), 442-457.

National Geographic Society. 2009. Sierra Nevada Geotourism MapGuide.

National Park Service. 2013. A natural resource condition assessment for Sequoia and Kings Canyon National Parks. Natural Resource Report NPS/SEKI/NRR—2013/XXX. Eds. Sydoriak, C.A., J.A. Panek, J.J. Battles, and K.R. Nydick. National Park Service, Visalia, CA.

National Renewable Energy Laboratory [NREL]. 2005. Assessing the Potential for Renewable Energy on National Forest System Lands. January. 123p.

National Research Council. 2000. Watershed management for potable water supply: assessing the New York City strategy. Washington, DC: National Academy Press. 530 p.

Neary, D.G.; Ryan, K.C.; DeBano, L.F., eds. 2005 (revised 2008), Wildland fire in ecosystems: effects of fire on soils and water. General Technical Report RMRS-GTR-42, Vol.4., Ogden, UT: USDA Forest Service, Rocky Mountain Research Station, 250 pp.

Noon, B. R. 2003. Conceptual issues in monitoring ecological resources. Monitoring ecosystems: interdisciplinary approaches for evaluating ecoregional initiatives. Island Press, Washington, DC, USA, 27-71

Noon, B.R., McKelvey, K.S.; Dickson, B.G. 2009. Multispecies conservation planning on U.S. federal lands. Pages 51–84 inJ. J. Millspaugh and F. R. Thompson, III, editors. Models for planning wildlife conservation in large landscapes. Academic Press, New York, New York.

North, M. 2012. Managing Sierra Nevada Forests. Gen. Tech. Rep. PSW-GTR-237. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

North, M. 2013. Forest Ecology. Chapter 2.0 in Long, J.W.; Quinn-Davidson, L., and Skinner, C.N., tech. editors. Science Synthesis to Promote Resilience of Social-Ecological Systems in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

North, M.; Collins, B.M.; Stephens, S. 2012. Using fire to increase the scale, benefits, and future maintenance of fuels treatments. Journal of Forestry, 110(7), 392-401.

North, M.; Hurteau, M.; Innes, J. 2009. Fire suppression and fuels treatment effects on mixed-conifer carbon stocks and emissions.Ecological Applications, 19(6), 1385-1396.

Null, S.E.; Viers, J.H. 2012. Water and Energy Sector Vulnerability to Climate Warming in the Sierra Nevada: Water Year Classification in Non-Stationary Climates. Prepared for: California Energy Commission by University of California, Davis. White paper from the California Energy Commission's California Climate Change Center. CEC-500-2012-015.

Ode, P.R. 2007, Ecological condition assessment of California's perennial wadeable streams: Report to the State Water Resources Control Board's Non-Point Source Program: California Department of Fish and Game Aquatic, Bioassessment Laboratory, Rancho Cordova, CA.

Ode, P.R.; Kincaid, T.M.; Fleming, T.; Rehn, A.C.. 2011. Ecological Condition Assessments of California's Perennial Wadeable Streams: Highlights from the Surface Water Ambient Monitoring Program, Perennial Streams Assessment (PSA) (2000-2007). Sacramento, CA: State Water Resources Control Board's Non-Point Source Pollution Control Program, Surface Water Ambient Monitoring Program , California Department of Fish and Game Aquatic Bioassessment Laboratory, and the U.S. Environmental Protection Agency.

Outdoor Industry Association; Western Governors' Association; Motorcycle Industry Council [and others]. 2012. Outdoor Recreation Economy, A Snapshot of the Economic Impact of Outdoor Recreation in the West.

Pardo, L.H.; Fenn, M.E.; Goodale, C.L. [and others]. 2011. Effects of nitrogen deposition and empirical nitrogen critical loads for ecoregions of the United States. Ecological Applications, 21(8), 3049-3082.

Parks, C.G.; Radosevich, S.R.; Endress, B.A. [and others] 2005. Natural and land-use history of the Northwest mountain ecoregions (USA) in relation to patterns of plant invasions. Perspectives in Plant Ecology, Evolution and Systematics, 7(3): 137-158.

Patterson, T.M. 2013. Ecosystem Services. Chapter 9.2 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Pope, K.; Long, J.W. 2013. Lakes: Recent Research and Restoration Strategies. Chapter 6.4 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to Promote Resilience of Social-Ecological Systems in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Postel, S.; Carpenter, S. 1997. Freshwater ecosystem services. In: Daily, G., ed. Nature's services: societal dependence on natural ecosystems. Washington, DC: Island Press: 195–214.

Rahn, M. 2009. Wildfire Impact Analysis, Fire Impact Analysis, Spring 2009. San Diego, CA: San Diego University.

Ratliff, R.D. 1985. Meadows in the Sierra Nevada of California: state of knowledge. Gen. Tech. Rep. PSW-84. Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, Albany, CA.

Rector, J.R.; MacDonald, L.H. 1986. Water yield opportunities on National Forest lands in the Pacific Southwest Region: Proceedings of the California Watershed Management Conference, November 18-20, 1986, West Sacramento, CA, p. 68-73.

Reilly, T.E. 2008. Ground-Water Availability in the United States: U.S. Geological Survey Circular 1323. Denver, CO: U.S. Geological Survey. p. 84.

Richards, R.T. 1996. Special forest products harvesting in the Sierra Nevada. In: Sierra Nevada ecosystem project: final report to Congress, vol. III. Davis, CA: University of California: 787-884.

Riegel, G.M.; Miller, R.F.; Skinner, C.N.; Smith, S.E. 2006. Northeastern plateaus bioregion. In: Fire in California's ecosystems. Berkeley, CA: University of California Press.

Roberts, N.S.; Chavez, D.J.; Lara, B.M.; Sheffield, E.A. 2009. Serving culturally diverse visitors to forests in California: a resource guide. Gen. Tech. Rep. PSW-GTR-222. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 76 p.

Rollins, M.G. 2009. LANDFIRE: a nationally consistent vegetation, wildland fire, and fuel assessment. International Journal of Wildland Fire, 18(3), 235-249.

Romin, L.A.; Bissonette, J.A. 1996. Deer: vehicle collisions: status of state monitoring activities and mitigation efforts. Wildlife Society Bulletin, 276-283.

Russell, W.H.; McBride, J.R. 2001. The relative importance of fire and watercourse proximity in determining stand composition in mixed conifer riparian forests. Forest Ecology and Management 150: 259-265.

Safford, H.D. 2013a. Natural Range of Variability Assessments for the Sierra Nevada Bioregional Assessment. Unpublished document. USDA Forest Service, Pacific Southwest Region, Vallejo, CA.

Safford, H.D. 2013b. Natural Range of Variation for Yellow Pine and Mixed Conifer Forests in the Assessment Area. Unpublished document. USDA Forest Service, Pacific Southwest Region, Vallejo, CA.

Salazar, K. 2013. A Letter to County Commissioners on the Sequester Impacts to PILT. Department of the Interior. March 6.

Sawyer, S. 2013. Natural Range of Variation in Non-meadow Riparian Zones. Unpublished document. Safford, H.D. 2013. Natural Range of Variation for Yellow Pine and Mixed Conifer Forests in the Assessment Area. Unpublished document. USDA Forest Service, Pacific Southwest Region, Vallejo, CA.

Schoenherr, A.A. 1992. A natural history of California. Berkeley and Los Angeles: University of California Press.

Schultz, C.A.; Sisk, T.D.; Noon, B.R.; Nie, M.A. 2013. Wildlife conservation planning under the United States Forest Service's 2012 planning rule. The Journal of Wildlife Management. Vol.77 (3): 428–444.

Schultz, P.W. 2011. Conservation Means Behavior. Conservation Biology 25(6): 1080-1083.

Schwartz, M.W.; Porter, D.J.; Randall, M.; Lyons, K.E. 1996. Impacts of Nonindigenous plants. In Sierra Nevada Ecosystem Project: Final report to Congress. Davis, CA: University of California, Centers for Water and Wildland Resources. Vol. II Pages 1203 –1226.

Shaffer, K.E.; Laudenslayer Jr., W.F. 2006. Fire and animal interactions. In: Fire in California's ecosystems. Berkeley, CA: University of California Press. P. 118-144.

Sickman, J.O.; Leydecker, A.L.; Chang, C.C.; Kendall, C., [and others].2003. Mechanisms underlying export of N from high-elevation catchments during seasonal transitions. Biogeochemistry, 64(1), 1-24.

Siegel, R.B.; DeSante, D.F. 1999. The draft avian conservation plan for the Sierra Nevada Bioregion: conservation priorities and strategies for safeguarding Sierra bird populations. Version 1.0. Point-Reyes, CA. Institute for Bird Populations report to California Partners in Flight.

Sierra Business Council. 1997. Planning for prosperity: building successful communities in the Sierra Nevada. Truckee, CA: Sierra Business Council.

Sierra Business Council. 2007. The State of the Sierra. Truckee, CA: Sierra Business Council.

Sierra Nevada Conservancy. 2011a. Strategic Plan. In: N. R. A. State of California, Sierra Nevada Legacy, editor., Auburn, CA.

Sierra Nevada Conservancy. 2011b. System Indicators - Demographics and Economy.

Sierra Nevada Conservancy. 2011c. System Indicator Report - Land Conservation and Wildlife Habitat.

Sierra Nevada Conservancy. 2012a. System Indicator Report - Forest Health and Carbon Storage.

Sierra Nevada Conservancy. 2012b. System Indicator Report - Water and Air Quality and Climate.

Skinner, C.N.; Chang, C.R. 1996. Fire regimes, past and present. In: Sierra Nevada ecosystem project: final report to congress. Davis, CA: University of California, Centers for Water and Wildlands. Vol. 2, pp. 1041-1069.

Skinner, C.N.; Taylor, A.H. 2006. Southern Cascades bioregion. In: Fire in California Ecosystems. Berkeley, CA: University of California Press.

Slayton, M. 2013. Sagebrush and Pinyon-Juniper Natural Range of Variation. Unpublished document. USDA Forest Service, Pacific Southwest Region. Vallejo, CA.

Smith, N.; Deal, R.; Kline, J.D. [and others]. 2011. Using ecosystem services as a framework for forest stewardship: executive summary. Gen. Tech. Rep PNW GTR-852. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 46 p.

Spencer, W.; Rustigian-Romsos, H. 2012. Decision support maps and recommendations for conserving rare carnivores in the interior mountains of California. Unpublished report. Corvallis, OR: Center for Conservation Biology.

Springsteen, B.; Christofk, T.; Eubanks, S. [and others]. 2011. Emission reductions from woody biomass waste for energy as an alternative to open burning. J. Air and Waste Mgt. Assoc. 61:63-68.

Stanford, J. A.; Hauer, F.R. 1992. Mitigating the impacts of stream and lake regulation in the Flathead River catchment, Montana, USA: An ecosystem perspective. Aquatic Conservation: Marine and Freshwater Ecosystems 2:35– 63.

State of California Resources Agency. 2009. California Outdoor Recreation Plan 2008. California State Parks.

Stephens, S.L.; Martin, R.E.; Clinton, N.E. 2007. Prehistoric fire area and emissions from California's forests, woodlands, shrublands, and grasslands.Forest Ecology and Management, 251(3), 205-216.

Stephens, S.L.; McIver, J.D.; Boerner, R.E. [and others]. 2012. The effects of forest fuel-reduction treatments in the United States. BioScience, 62(6), 549-560.

Stewart, W. 1996. Chapter 23 Economic Assessment of the Ecosystem from Status of the Sierra Nevada Volume III Assessments, Comissioned Reports, and Background Information. Wildland Resources Center Report No. 38. University of California Davis. June.

Sturtevant, V.E.; Donoghue, E.M. 2008. Community and forest connections: continuity and change. In: Sturtevant, V.E.; Donoghue, E.M., eds. Forest community connections: implications for research, management, and governance. Washington, DC: Resources for the Future: 3-44.

Sugihara, N. 2013. U.S.D.A. Pacific Southwest Region, Regional Fire Ecologist. Personal communication. April 2013.

Sugihara, N.; Van Wagtendonk, J.; Fites-Kaufman, J.A.; 2006a. Fire as an Ecological Process. In:Fire in California Ecosystems. Berkeley, CA: University of California Press.

Sugihara, N.; Van Wagtendonk, J.; Shaffer, K.E.; Fites-Kaufman, J.A.; Thode, A.E., eds. 2006b. Fire in California Ecosystems. Berkeley, CA: University of California Press.

TACCIMO (Template for Assessing Climate Change Impacts and Management Options)-Sierra Nevada Vulnerability Assessment Working Group. 2013. A Vulnerability Assessment Workshop for Focal Resources of the Sierra Nevada: Workshop Proceedings, March 5-7, 2013. Climate Adaptation Project for the Sierra Nevada. Prepared by EcoAdapt.

Taleb, N.N. 2010. The black swan: The impact of the highly improbable. New York, NY: Random House. 366 p.

Trimble, S.W.; Mendel, A.C. 1995. The cow as a geomorphic agent: Geomorphology 13: 233-253.

U.S. Department of Agriculture. 2010. Strategic Plan: FY 2010-2015. Washington, DC: U.S. Department of Agriculture.

U.S. Department of Agriculture. 2012. Environmental Justice Strategic Plan 2012-2014. Washington, D.C.: 15 p.

U.S. Department of Agriculture Forest Service [USFS]. 1976. Forests and Water: effects of forest management on floods, sedimentation and water supply. General Technical Report PSW-18/1976. 121 p.

U.S. Department of Agriculture Forest Service [USFS]. 1995. Landscape Aesthetics, A Handbook for Scenery Management. Washington, DC: U.S. Department of Agriculture, Forest Service.

U.S. Department of Agriculture Forest Service [USFS]. 2000. Water and the Forest Service, United States Department of Agriculture, Washington Office, FS-660. January.

U.S. Department of Agriculture Forest Service [USFS]. 2001. Draft Environmental Impact Report for Forest Plan Revision, Sierra Nevada. Vallejo, CA: Pacific Southwest Region.

U.S. Department of Agriculture Forest Service [USFS] 2007. USFS Forest Service Strategic Plan FY 2007-2012. Washington DC: U.S. Department of Agriculture Forest Service.2011

U.S. Department of Agriculture Forest Service [USFS]. 2008. "The U.S. Forest Service An Overview" Washington D.C.

U.S. Department of Agriculture Forest Service [USFS]. 2009. Best Management Practices Monitoring Report. Vallejo, CA: Pacific Southwest Region.

U.S. Department of Agriculture Forest Service [USFS]. 2010a. Connecting People with America's Great Outdoors, A Framework for Sustainable Recreation. Washington, DC: U.S. Department of Agriculture, Forest Service.

U.S. Department of Agriculture Forest Service [USFS] 2010b. Dinkey Creek Restoration Project. Clovis, CA: Sierra National Forest.

U.S. Department of Agriculture Forest Service [USFS]. 2011a. National Report on Sustainable Forests-2010.

U.S. Department of Agriculture, Forest Service [USFS]. 2011b. Water Quality Management Handbook. R5 FSH 2509.22 – Chapter 10, Vallejo, CA. December. 241 p.

U.S. Department of Agriculture Forest Service [USFS] 2011c. Last Chance Restoration Project. Foresthill, CA: Tahoe national Forest.

U.S. Department of Agriculture Forest Service [USFS]. 2011d. From the Forest to the Faucet: Drinking Water and Forests in the US – Methods Paper, Washington DC. United States Department of Agriculture, October.

U.S. Department of Agriculture Forest Service [USFS]. 2012a. USDA Policy and Procedures Review and Recommendations: Indian Sacred Sites. Washington, DC: U.S. Department of Agriculture, Forest Service

U.S. Department of Agriculture Forest Service [USFS]. 2012b. National Forest Statement of Receipts (ASR-13-2) for Fiscal Year 2011.

U.S. Department of Agriculture Forest Service [USFS]. 2012c. Giant Sequoia National Monument: Final Environmental Impact Statement. Vallejo, CA: U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Region.

U.S. Department of Agriculture Forest Service [USFS] 2012d. Forest Service Western Core Data Tables. McClellan, CA: Forest Inventory Program.

USDA Forest Service [USFS]. 2012e. FY 06-12 planning and budget spreadsheet. Region 5 Program Development, Budget and Accountability 2012.

USDA Forest Service [USFS]. 2012f. Future of America's Forests and Rangelands. U.S. Department of Agriculture, Forest Service, Washington, DC.

U.S. Department of Agriculture Forest Service [USFS]. 2013. Ecological Restoration Implementation Plan. Vallejo, CA: U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Region.

U.S. Department of Agriculture Office of the Chief Economist [USDA OCE]. 2012. Frequently Asked Questions – Effects of Climate Variability and Change on Forest Ecosystems. **http://www.usda.gov/oce/climate_change/effects_2012/FAQ_forest111512.htm**. (13 May 2013)

U.S. Department of Labor. 2012. Bureau of Labor Statistics, Quarterly Census of Employment and Wages. Washington, D.C.

University of Florida Institute of Food Agricultural Sciences Extension [UF IFAS Extension]. 2007. Watershed Management Frequently Asked Questions. http://waterquality.ifas.ufl.edu/FAQs/FAQs-watershed.htm#Functions-1. (13 May 2013)

Vaillant, N.; Noonan-Wright, E.; Dailey, S. [and others]. 2013. Effectiveness and longevity of fuel treatments in coniferous forests across California. Final Report, Project ID: 09-1-01-1 to Joint Fire Science Program.

Van de Water, K.M.; North, M. 2011. Stand structure, fuel loads, and fire behavior in riparian and upland forests, Sierra Nevada Mountains, USA; a comparison of current and reconstructed conditions. Forest Ecology and Management 262: 215-228.

Van de Water, K.M.; Safford, H.D. 2011. A summary of fire frequency estimates for California vegetation before Euro-American settlement. Fire Ecology, 7(3), 26-58

Van Mantgem, P.J.; Stephenson, N.L. 2007. Apparent climatically induced increase of tree mortality rates in a temperate forest. Ecology Letters, 10(10), 909-916.

Van Mantgem, P.J.; Stephenson, N.L.; Byrne, J.C. [and others]. 2009. Widespread increase of tree mortality rates in the western United States. Science, 323(5913), 521-524.

Van Wagtendonk, J.W.; Fites-Kaufman, J.A. 2006. Sierra Nevada bioregion. In: Fire in California's ecosystems. Berkeley, CA: University of California Press. P. 264-294.

Verner, J.; McKelvey, K.S.; Noon, B.R. [and others], technical coordinators. 1992. The California spotted owl: a technical assessment of its current status. Gen. Tech. Rep. PSW-GTR-133. Albany, CA: Pacific Southwest Research Station, Forest Service, US Department of Agriculture, 285.

Viers, J.H.; Rheinheimer, D.H. 2011. Freshwater conservation options for a changing climate California's Sierra Nevada. Marine and Freshwater Research 62:266-278.

Walker, B.; Salt, D. 2006. Resilience thinking: Sustaining ecosystems and people in a changing world. Washington: Island Press.

Walker, P.; Fortmann, L. 2003. Whose landscape? A political ecology of the 'exurban' Sierra. Cultural Geographies. 10(4): 469-491.

Walker, B.; Salt, D. 2006. Resilience thinking: Sustaining ecosystems and people in a changing world. Washington: Island Press. 174 p.

Webster, K.M.; Halpern, C.B. 2010. Long-term vegetation responses to reintroduction and repeated use of fire in mixed-conifer forests of the Sierra Nevada. Ecosphere, 1(5), art9.

Weiss, S.B. 2006. Impacts of Nitrogen Deposition on California Ecosystems and Biodiversity. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2005-165.

Weiss-Penzias, P.; Jaffe, D.A.; Swartzendruber, P. [and others]. 2006. Observations of Asian air pollution in the free troposphere at Mount Bachelor Observatory during the spring of 2004. Journal of Geophysical Research: Atmospheres (1984–2012), 111(D10).

Weixelman, D.A. 2013. USFS Region 5 long term range monitoring project report. Unpublished document. Vallejo, CA: Pacific Southwest Region.

Wertzel W.I.; Lacher, D.; Swezey, S. [and others]. 2012. Analysis reveals potential rangeland impacts if Williamson Act eliminated. California Agriculture. 66(4) pp. 131-136. October-December.

Westerling, A.L.; Bryant, B.P. 2008. Climate change and wildfire in California. Climatic Change, 87(1), 231-249.

Westerling, A.L.; Bryant, B.P.; Preisler, H.K. [and others]. 2011. Climate change and growth scenarios for California wildfire. Climatic change, 109(1), 445-463.

Westerling, A.L.; Hidalgo, H.G.; Cayan, D.R.; Swetnam, T.W.. 2006. Warming and earlier spring increases. Science,313(5789), 940-943.

Western Governors Association Biomass Taskforce. 2006. Clean and Diversified Energy Initiative.

Wiedinmyer, C.; Hurteau, M.D. 2010. Prescribed fire as a means of reducing forest carbon emissions in the western United States. Environmental science & technology, 44(6), 1926-1932.

Wiens, J.A.; Hayward, G.D.; Hugh, D.; Giffen, C. 2012. Historical environmental variation in conservation and natural resource management. Wiley-Blackwell.

Winter, P.L.; Long, J.W.; Lake, F.K. 2013a. Sociocultural Perspectives on Threats, Risks, and Health. Chapter 9.3 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors.

Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Winter, P.L.; Long, J.W.; Lake, F.K. 2013b. Broader Context for Social, Economic, and Cultural. Chapter 9.1 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Winter, P.L.; Long, J.W.; Charnley, S. 2013c. Social/Economic/Cultural Components (Preface). Chapter 9.0 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to support Forest Plan Revision in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 504 p.

Yang, D.S.; Conroy, C.J.; Moritz, C. 2011. Contrasting responses of Peromyscus mice of Yosemite National Park to recent climate change. Global Change Biology, 17(8), 2559-2566.

Yoder, J.; Blatner, K. 2004. Incentives and timing of prescribed fire for wildfire risk management. Journal of Forestry. 102(6): 38-41.

York, R.A.; Stephenson, N.L.; Meyer, M. [and others]. 2013. Giant Sequoia. Appendix 11 in: National Park Service. 2013. A natural resource condition assessment for Sequoia and Kings Canyon National Parks. Natural Resource Report NPS/SEKI/NRR—2013/XXX. Eds. Sydoriak, C.A., J.A. Panek, J.J. Battles, and K.R. Nydick. Visalia, CA: National Park Service, Sequoia & Kings Canyon National Park.

Zedler, J. 2003. Wetlands at your service: reducing impacts of agriculture at the watershed scale. Frontiers in Ecology and Environment. 1(2): 65–72.

Zielinski, B. 2013. The Forest Carnivores: Fisher and Marten. Chapter 7.1 in Long, Jonathan W.; Quinn-Davidson, Lenya, and Skinner, Carl N., tech. editors. Science Synthesis to Promote Resilience of Social-Ecological Systems in the Sierra Nevada and Southern Cascades. Draft Final Report. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Ziemer, R. 1986. Water Yields from Forests: An Agnostic View presented at the California Watershed Management Conference, November 18-20 1986 West Sacramento, CA. 5 p.

Zipperer, W. 2002. Urban influences on forests. In: Macie, E.A.; Hermansen, L.A., eds. Human influences on forest ecosystems: the southern wildland urban interface assessment. Gen. Tech. Rep. GTR-SRS-55. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 73–91.

Zybach, B.; Dubrasich, M.; Brenner, G. [and others]. 2009 U.S. Wildfire Cost-Plus-Loss Economics Project: The "One-Pager" Checklist. Wildland Fire Lessons Learned Center. Fall.

HELPFUL LINKS

US Forest Service Pacific Southwest Region Plan Revision website:

http://www.fs.usda.gov/main/r5/landmanagement/planning

USFS Plan Revision website:

http://www.fs.usda.gov/planningrule

Sierra Cascades Dialog:

www.fs.usda.gov/goto/r5/SierraCascadesDialog

Our Forest Place:

http://ourforestplace.ning.com/

The Living Assessment:

http://livingassessment.wikispaces.com/

PSW Science Synthesis:

http://www.fs.fed.us/psw/publications/reports/psw_sciencesynthesis2013/index.shtml

History page for Sierra Nevada Forest Planning:

http://livingassessment.wikispaces.com/Brief+History+of+Sierra+Nevada+Forest+Planning

USFS Pacific Southwest Region Ecological Restoration

http://www.fs.usda.gov/detail/r5/landmanagement/?cid=STELPRDB5308848

NON-DISCRIMINATION STATEMENT

Non-Discrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the bases of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, or all or part of an individual's income is derived from any public assistance program, or protected genetic information in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases will apply to all programs and/or employment activities.)

To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (PDF) within 45 days of the date of the alleged discriminatory act, event, or in the case of a personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form (PDF), found online at http://www.ascr.usda.gov/complaint_filing_cust.html, or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter to us by mail at U.S. Department of Agriculture, Director, Office of Adjudication, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, by fax (202) 690-7442 or email at program.intake@usda.gov.

Persons with Disabilities

Individuals who are deaf, hard of hearing or have speech disabilities and you wish to file either an EEO or program complaint please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

Persons with disabilities who wish to file a program complaint, please see information above on how to contact us by mail directly or by email. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.) please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

All Other Inquiries

For any other information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices for specific agency information.

R5-MB-257 May 2013